

More Data, Less Energy

Making Network Standby More Efficient
in Billions of Connected Devices

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Foreword

We check email on smart phones while travelling on the metro. At home or in the office, we use computers, laptops and tablets, and can pick up documents from any printer connected to the network. At home, we watch television on demand and never miss the start of our favourite show. Soon, even more of our appliances will be connected to networks – enabling us to, for instance, send messages to our coffee makers to have a fresh cup waiting when we get home.

Without question, the ability to be “connected” 24 hours a day, 7 days a week is revolutionising our society: we can do many more things more efficiently and collaborate across the globe in real time. But three other angles to this transformation are largely overlooked.

First, consumer demand to be connected is driving manufacturers to redesign a myriad of devices to ensure they can “interact” through networks – even though their primary functions (e.g. cooling our food, making our morning coffee or keeping our homes warm and secure) haven’t changed.

Second, everything that is connected is now *always on*. Televisions and computers are classic examples. In order to be “ready for action” at any given moment, they need to be in standby mode, which means they draw energy every minute of every day. In many such devices, standby is a misnomer; it “suggests” the device has gone to sleep and is “almost off”. In reality, most network-enabled devices draw as much power in this mode as when activated to perform their main tasks.

The end result – the third overlooked angle – is the rapidly rising energy demand from literally billions of devices that remain “on” but may be used for only a few minutes or hours per day. Currently, the estimate for global electricity wasted in this way by network-enabled devices is 400 terawatt hours (TWh) per year. Consumers pay in direct energy costs for this power, while the energy sector is forced to find the means to generate enough power to keep pace with demand. Addressing this energy waste, through technology and policy solutions already available, could lead to energy savings that correspond to the annual electricity generated by 133 mid-size coal-fired power plants (500 megawatts each), each requiring 1.4 million tonnes of coal per year.

Clearly, the time to take action is now. In the absence of market incentives for energy efficiency in network-enabled devices, policy is the right place to start. The IEA’s experience in leading the 1-watt standby policy initiative, which called on countries to stem the growing electricity demand of stand-alone appliances and equipment in standby mode (i.e. powered off but still drawing electricity continuously) proves that collective effort can make a real difference, in a relatively short time. The Standby Power Annex of the IEA Implementing Agreement for Energy Efficient End-use Equipment (4E) has been working to identify solutions for tackling network standby since 2009. Thus, we are pleased to be publishing this guidebook jointly.

*This publication is produced under my authority
as Executive Director of the IEA.*

Maria van der Hoeven,
Executive Director
International Energy Agency

Mike Walker,
Chairman
IEA Implementing Agreement for
Energy Efficient End-use Equipment (4E)

Executive summary

The hidden energy cost of information and communication technology

In 2013, a relatively small portion of the global population relied on more than 14 billion network-enabled devices in homes and offices. As more people use a wider range of devices for increasingly diverse purposes, the total is expected to skyrocket to 50 billion network-enabled devices by 2020. Left unchecked, by 2025 the corresponding energy demand would soar to 1 140 terawatt hours per year (TWh/yr) – more than the current annual electricity consumption of Canada and Germany combined. A vast majority of this energy would be consumed when devices are “ready and waiting”, but not performing any particular function.

In their current state, network-enabled devices carry an inherent paradox. They have enormous potential to deliver diverse efficiencies across many sectors and services, yet they fall far short of their own potential to be energy efficient. Technical solutions to reduce the energy cost of connectivity exist but policies are needed to drive their implementation. This publication lays the foundation for optimising the benefits of a digitalised society while substantially reducing the associated energy footprint. The vision of low-power networked homes and offices aims to ensure that “energy efficient” is a core characteristic of “smart”.

Network connectivity is rapidly spreading across all types of devices and has been heralded as a key advance towards more sustainable energy supply and use. Recent advances in information and communication technology (ICT) open new potential to optimise operations in various areas, such as: transportation and logistics, building management, manufacturing, and the distribution and consumption of electricity. ICT-enabled solutions can contribute to both energy security and universal energy access. At the consumer level, individuals have ready access to much more diverse kinds of data and information, from audio/visual entertainment to applications that allow them to better track many aspects of daily life or access services remotely. Many appliances and equipment that previously delivered relatively simple functions in isolation can now be controlled remotely and are able to interact with other devices. The uptake of network-enabled devices – which being in “network standby” mode are “always on” – is projected to expand exponentially, possibly reaching 50 billion by 2020, rising towards 100 billion by 2030 and 500 billion over the following decades (OECD, 2012).

As the range of network-enabled devices expands, individuals and societies benefit from faster access to multiple types of data and services; however, being “connected” is causing associated global electricity demand to grow at an alarming rate. The designation of ICT now spans a wide array of end-use products.

One category includes all the devices designed to process and transmit data: network equipment, network infrastructure, networks themselves and smart network-connected systems as a whole. A second broad category – edge devices – refers to equipment such as printers and set-top boxes that are not needed in network operation, but now respond to network signals. All of these technologies consume power even when not in use. Globally, in 2008, network-enabled devices consumed about 420 TWh of electricity corresponding to the current electricity consumption of France; by 2013, this demand had already grown to 616 TWh, surpassing the current electricity consumption of Canada

(Bio Intelligence Service, 2013). As the number of devices and services incorporating network capacity into their design grows rapidly, the estimated global energy demand of network-enabled devices is expected to reach around 1 140 TWh by 2025 (Bio Intelligence Service, 2013).

On the end-use level, uptake of these devices in households and businesses will drive up electricity bills. On the global scale, uptake will drive up electricity demand and the corresponding need for more energy infrastructure. To give a sense of the steep increase, the 1 140 TWh projected by 2025 would correspond to 6% of current total final global electricity consumption and exceed the current electricity consumption of Russia. Considering that recent projections indicate market demand for network-enabled devices will expand at a faster rate than anticipated, the related energy demand could grow even more quickly than forecast.

Recent and projected trends raise the energy demand of network standby to an issue that warrants immediate attention. Currently, many of these devices are not optimised in terms of energy management; most must be “fully on” to maintain network connections, i.e. they are not able to power down and still provide network connectivity. Although ICT can enable energy efficiency across all sectors, at present there is little market incentive to ensure that network-enabled devices themselves are energy efficient. In fact, up to 80% of their electricity consumption is used just to maintain a network connection. While the quantity of electricity used by each device is small, the anticipated massive deployment and widespread use makes the cumulative consumption considerable.

The opportunity for significant energy savings potential

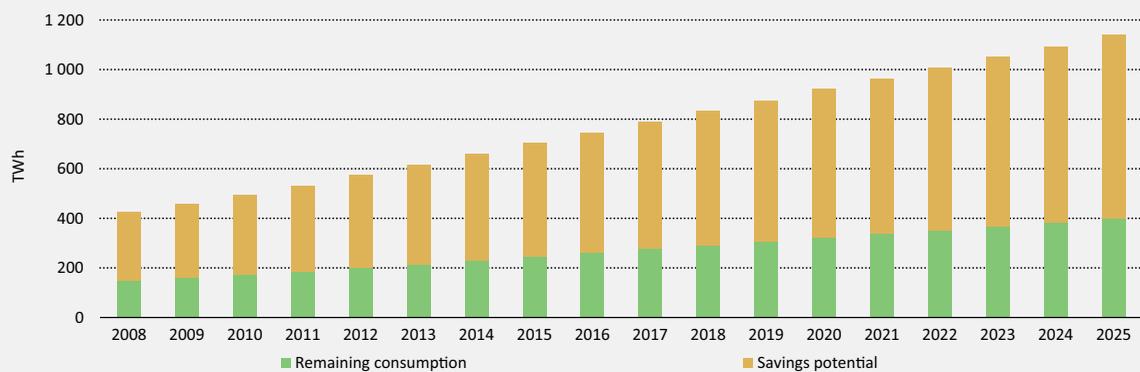
Analysis by the International Energy Agency (IEA) shows that implementing best available technologies and solutions could cut electricity demand by more than 60%. A range of technologies and solutions can be implemented to enable devices to power down or reduce energy requirements without losing their ability to provide the services that network connectivity enables. Further development of hardware, software, communication protocols and technical standards that support energy efficiency will also play a key role. In many cases, these solutions could be implemented with minimal additional effort or cost to manufacturers or consumers.

Better aligning energy consumption with the actual performance of functions holds potential for substantial energy savings. A key step towards realising this potential is to ensure that, when not performing primary functions (such as transmitting or recording TV shows, heating up food or water), such devices power down to low power modes as quickly as possible and remain in these modes for as long as possible. The global energy efficiency potential that could be unlocked by powering down network-enabled devices and reducing standby electricity consumption is estimated at almost 600 TWh annually by 2020 – more than the current electricity consumption of Canada and Finland combined.¹

¹ Corresponding to the annual electricity supplied by 200 mid-sized coal-fired power plants.

Figure I.1

Current and projected global network-enabled device electricity consumption and savings potential



Notes: Domestically and professionally used network-enabled devices, connected to external or internal networks. Savings potential is estimated on the difference between the best available technology and the average device on the market. Projections start with 2012.

Source: Bio Intelligence Service, 2013, Inputs provided.

Key point

Use of network-enabled devices is certain to rise dramatically. Strategic action now can constrain the associated electricity demand.

Solutions and actions to improve energy efficiency

The IEA Guiding Principles for Energy Efficient Networks and Efficient Network-connected Products outline the main approaches for effective network standby technology and policy. While making each network-enabled device more energy efficient is vital, full energy savings potential can only be realised through

integrated, systemic approaches that address energy consumption of specific types of functions and define efficient behaviour across the network for hardware, software and communication protocols. Technical solutions include software and hardware modifications that enable devices to power down while still maintaining a network connection or to power down but stay responsive to the network so as not to lose connectivity. Other hardware and software solutions enable devices to scale electricity requirement to actual work carried out, thereby reducing energy draw when less data need to be processed and transmitted. In some cases, changes in network communication protocols or network architecture are needed to make it possible for devices to use energy efficient features. Mobile products are front-runners in this area – some of which provide network connectivity for as little as 0.5 milliwatts (mW) – clearly showing that it is possible to deliver network connectivity at virtually 0 watts, provided strong drivers are in place.

The development and implementation of solutions to address network standby requires actions by a large range of stakeholders, each of which has distinct roles to play. Yet all must also work together; opportunities and outcomes depend very much on actions taken by other stakeholders along the value chain.

- **Policy makers**, in developing policies and measures for different parts of the value chain to engage in energy efficiency and ensure that the pre-conditions are in place to develop and implement energy efficient devices and systems, can provide incentives and establish market drivers.

- **Standard development organisations and intellectual property providers** create the foundations and technical standards to enable and support energy efficient software and hardware solutions.
- **Software and hardware developers** design solutions that can be used by manufacturers of devices.
- **Device manufacturers** bring together software and hardware solutions, thereby determining the energy performance and energy efficiency features of devices.
- **Network designers** establish the terms on which devices can connect to networks and how they need to operate to be part of a network; they also ensure that network communication supports energy efficiency in all connected devices.
- **Service providers** that provide Internet or other digital services to end users manage bulk purchases and deploy large quantities of devices; they can be instrumental in creating a market for more energy efficient devices.
- **Telecommunications industry** ensures the development and implementation of network design that supports energy efficiency.
- **Consumers** can, with proper guidance, make energy efficient purchasing decisions and adjust the settings of their devices to reduce energy consumption.

Why a leading role for policy

In the absence of strong market drivers for energy efficiency, concerted global policy action is needed to curb escalating electricity demand from devices in network standby mode. Governments need to act promptly to address network standby and avoid unnecessary energy waste. Existing policies and procedures for stand-alone standby (e.g. as used for televisions) are not directly transferable to network standby, but some elements of that policy framework provide opportunity for quickly implementing the foundation to support long-term changes. Governments worldwide are starting to address network standby consumption through multiple policy instruments. Some measures are already underway: The Republic of Korea and the European Union have policies in place. The United States is starting to address this issue in one device category via a voluntary agreement with industry, and Switzerland is piloting a consumer awareness programme involving service providers. A range of policy options is available; including:

- **Minimum energy performance requirements (MEPS)** set power limits to which devices must comply to be able to be sold on the market.
- **Energy labels** provide information to consumers on the energy performance of devices.
- **Voluntary agreements** between industry and governments rely on voluntary participation but once a company signs up, it needs to comply with a set of requirements or objectives.
- **Incentives and awards** provide motivation for industry or other stakeholders (e.g. for research communities to develop energy efficient solutions).
- **Consumer awareness campaigns** provide targeted information to help users optimise device settings or their usage patterns in order to save energy.
- **Certification schemes** are standardised ratings displayed on devices that provide comparable information about the energy performance of one device against others in the same or a similar category.

Initially, the easiest course of policy action is to start by amending existing policies to cover network standby. Over time, more innovative approaches should be explored including approaches supported by enhanced systems for monitoring device energy use, such as energy reporting through networks.

Importance of global co-operation to implement a plan of action

The global nature of ICTs warrants policy and technology co-operation across the entire value chain, implying engagement of all stakeholders. Since the technology that drives the network and most network-enabled devices are traded in the global market place, international co-operation and the pooling of resources among governments is the most effective approach. Governments and industry should work together to enable co-ordinated investment to develop test procedures and methodologies, as well as further research into the precise operations and energy requirements of network-enabled devices.

On the heels of success with the 1-watt plan for standby, which is attributed to global co-operation involving all stakeholders, the IEA proposes a new action plan. The IEA has joined forces with the IEA Implementing Agreement for a Co-operating Programme on Energy Efficient End-use Equipment (4E) and the Clean Energy Ministerial Super-efficient Equipment and Appliance Deployment (SEAD) initiative to develop a plan of action for network standby. This plan lays the foundation for optimising the benefits of a digitalised society while substantially reducing the associated energy footprint. The exchange of knowledge and experiences, along with sharing of resources and data, will accelerate progress in developing common methodologies and policies. The action plan sets out three key recommendations to governments:

Develop policies with clear and measurable energy efficiency objectives to:

- promote power management in network-enabled devices
- stimulate reduced energy consumption in low power modes with network connectivity
- help consumers reduce the energy consumption of their networked devices
- stimulate the development and uptake of solutions that promote energy efficiency in network-enabled devices and systems.

Intensify international co-operation to develop technical foundations for policy making, including three **key considerations**:

- energy efficiency metrics
- data collection and data sharing
- development of international standards for definitions, metrics and test procedures.

In working towards establishing or supporting international initiatives to promote energy efficiency in the broader context of digital economies, governments should focus their efforts on two goals:

- establishing an international policy platform to enable dialogue, information sharing, tracking trends and the joint development of solutions.

- establishing an international policy and industry platform to facilitate enhanced dialogue on ensuring that network-enabled devices and systems are energy efficient and to keep pace with technology trends such that energy efficiency becomes a strategic priority in development, deployment and use of such devices and equipment.

Achieving this plan and the vision of low-power networked homes and offices, and ensuring that “energy efficient” is a core characteristic of “smart”, rests on the initiative of governments and other stakeholders to take action. Priority areas are to establish global governance and strategic co-ordination; accelerate international standardisation and other processes needed to develop policy and technical solutions; develop national plans to ensure the implementation of these solutions; and establish ongoing operational co-operation.

How this publication sets the stage

This publication provides an overview of trends, impacts on energy demand, technical solutions and policy options. It is organised in three parts:

- Chapters 1 and 2 provide the background and context. Chapter 1 describes ICT and communication network trends and evolution, and provides insights into the very recent but rapidly developing market for network-enabled devices. Chapter 2 discusses the impact of these developments on the energy sector and electricity savings potentials.
- Chapters 3 through 5 describe how these energy efficiency potentials can be achieved. Chapter 3 explores the range of technical solutions that can be implemented to achieve these electricity savings. Chapter 4 gives an overview of the range of stakeholders that need to be involved in developing and implementing these solutions. Chapter 5 examines available policy options that can be used to stimulate the development and uptake of solutions, illustrated by examples of policies already in place. More in-depth material related to technical foundations needed for policy making is found in Annex A.
- Chapter 6 makes the case for international co-operation and co-ordination to accelerate energy efficiency progress. It sets out an action plan that clearly itemises what needs to be done and identifies who needs to do what – particularly in this early stage of launching a global policy initiative that cuts across so many sectors and type of devices. Finally, Chapter 7 presents overall conclusions and recommendations.

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² Formerly the IEA Implementing Agreement for Efficient Electrical End-use Equipment, launched in 2008, 4E is a government-led group established to share information, better understand the impacts of different policy approaches and undertake joint research to improve the policies for efficient appliances and equipment. 4E projects tackle government policy questions as they emerge, using the collective experience of energy end-use efficiency policy and technical experts drawn from its 12 Contracting Parties. Through international benchmarking, the 4E Standby Power Annex has highlighted the impacts of policies on standby power and collaborated with the IEA and other groups to describe best practice. In 2014, IEA 4E launched a new Annex known as the Electronic Devices and Networks Annex (EDNA) that will continue international collaborative work on efficient connected devices and networks.

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Think you understand “standby”? Think again!

In 2010, more than 160 million cable TV set-top boxes were “plugged in and ready for action” in the United States alone. Thanks to their ability to link to networks, they could respond to signals from other devices and start, for example, recording a favourite show when no one was home.

Despite being in “standby mode”, all of these boxes drew their full fill of electricity all the time, regardless of whether or not anyone was watching TV or recording a broadcast.

Standby power refers to the electricity consumed by appliances and devices while waiting to perform their primary functions.

Collectively, these set-top boxes consumed an estimated 18 TWh of electricity – equivalent to the annual output of six 500 MW coal-fired power plants or exceeding the total electricity consumption of Iceland. And they cost US consumers about USD 2 billion in electricity bills (NRDC, 2011).

All of the set-top boxes were connected to TVs or other display devices (personal computers, laptops, etc.) that also had to be standing by. More wasted energy; more unnecessary costs.

By 2012, close to 15 billion devices, ranging from TVs and personal computers to 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 “off”.

By 2030, the global figure for network-enabled devices could skyrocket to 100 billion. Under current modes of operation, keeping that many lines of communication open all the time would add up to a lot of energy consumed for no real gain.

Which explains why the IEA is calling for a global initiative to address the issue of standby power for network-enabled devices.

In this publication, network standby refers to the central challenge arising from network-enabled devices – that is, how to curb the exponential growth in wasted energy they represent. Addressing the challenge covers two interrelated areas:

- how to get network-enabled devices to power down to low power modes
- how to ensure that such devices remain in the lowest power mode possible, for the longest period of time possible, without compromising functions or services.

Connectivity delivers clear benefits, but comes at an energy cost

Online technologies, such as broadband connectivity, wireless mobility, cloud computing, e-commerce, social media and sensors, already touch many aspects of daily life, particularly in industrialised countries.

Everyone agrees that network access across an increasingly diverse range of devices is transforming society – the most positive effect being vastly improved access to information.

To date, no one seems to be giving much thought to the energy required for this 24/7 connection.

2:1 ratio of network-enabled devices to people on the planet in 2012

80% of the TVs sold on the US market today are “smart” TVs – i.e. they can connect to the Internet

50 billion projected number of network-enabled devices globally by 2020, reaching 500 billion in the following decades

80% percentage of energy use by some network-enabled devices just to maintain connectivity

What will the future hold: Increased demand or substantial savings?

Each network-enabled device draws energy all the time, as does the entire network infrastructure that keeps devices connected. Equipping all such devices with energy efficient components, and enabling the ability to drop to low power modes when

not performing their primary functions, can slash their overall energy demand. While some devices need to be fully operational all the time, others can be made to power down without negative impacts on their ability to provide network-related functions and services.

Threat of increased energy demand

616 TWh global electricity consumption of network-enabled devices in 2013

2X projected growth in energy demand of network-enabled devices worldwide between 2012 and 2025

6% of current total final electricity consumption will be used by network-enabled devices by 2025 – if steps are not taken to improve energy efficiency

Potential for energy savings

65% the energy used by network-enabled devices could be saved by implementing best available technologies and solutions

739 TWh electricity savings per year by 2025 – the potential for reduction in network standby power demand – more than the current total final electricity consumption of Canada, Denmark, Finland and Norway combined

For sources and notes relevant to this material, see Annex E.

Device operation *à la mode*

Traditionally, electrically powered devices were either “off” or “on”, and drew power only when a human hand flipped a physical switch.

Today, people rely on a wider range of devices to serve many more functions, and want them to be “ready for action” at the blink of an eye. These devices often provide multiple functions in a single unit. To meet this demand for instant start-up and fast connections, devices typically have “standby” as an additional “state” or “power mode”.

Mode, as used in this publication, refers to the collection of functional states through which any given device provides primary or secondary functions; all modes – including “off” – have associated power requirements. Network connectivity can be added or dropped independently of the particular mode the device is in.

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.
-

Speaking of device functions...

Like a smart phone with a constantly growing suite of available applications, many network-enabled devices can serve multiple purposes. The tasks they perform are typically divided into two categories:

- Primary functions include the range of tasks for which the device – including both hardware and software – was primarily designed and is used. The primary functions of a personal computer, for example, range from word processing to graphic design to mathematical calculations.

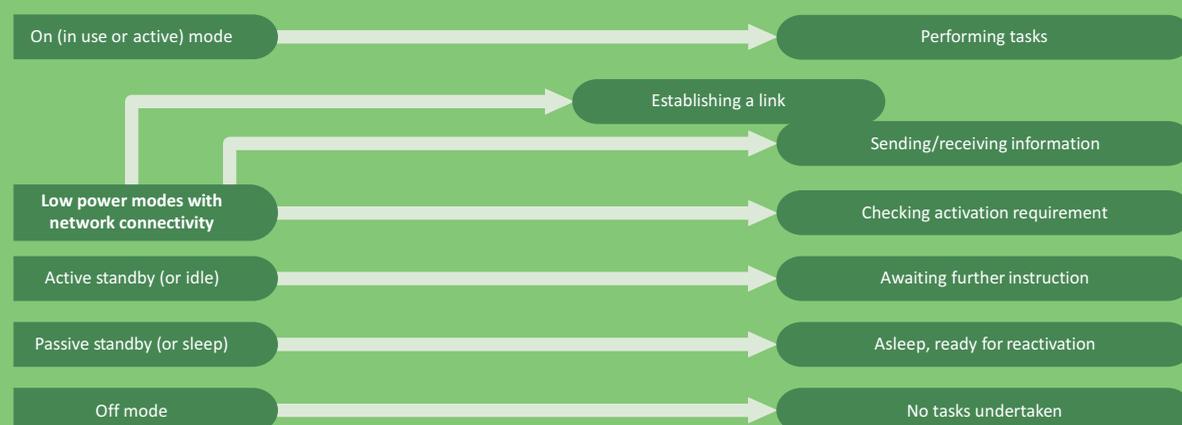
- Secondary functions comprise the tasks that enable a device to participate in a network to share inputs and outputs with other devices, as well as convenience features that are not necessary to operation but enhance it in some way. Increasingly, devices have numerous secondary functions (such as the following) running in the background:

- maintain signal reception capability (for remote control, telephone or network signal)

- provide sensor-based functions (such as monitoring temperature or other conditions)
- power an internal clock
- charge batteries
- provide continuous display of information or status
- maintain the ability to move to other modes or states by remote switch (including remote control), internal sensor or timer.

Devices can carry out many primary functions without a network connection (e.g. word processing by a computer, placing telephone calls on a smart phone); for such devices, network functions are usually secondary functions. For network equipment, such as routers, modems and switches, the network function is the primary function. It is often the case that secondary functions facilitated by network connections enhance primary functions.

Low power modes with network connectivity



For sources and notes relevant to this material, see Annex E.

A short history of standby power

Stand-alone standby

It began simply enough. In 1956, the remote control allowed viewers to control their televisions without leaving their easy chairs – turning the TV on or off, or switching from one channel to another. By the 1980s, remote control became a selling feature in diverse appliances and equipment for home and office.

Once people grew accustomed to remote control and additional convenience features such as continuously on displays, standby functionality quickly spread beyond consumer electronics and office equipment to microwave ovens, washing machines, dishwashers and even rice cookers.

Most microwave ovens aptly illustrate the convenience feature on a stand-alone standby device. The oven's primary function is to heat

food, but virtually all models have a built-in clock. Heating food requires 100 times more power than running the clock. But a microwave is typically “on” as an oven only 1% of the time; over its lifetime, far more energy is used to run the clock display than to cook food.

Network-enabled standby

A second revolution occurred in the 1990s when invention of the Internet created the capacity for devices to interact through network connections. A quick timeline of Internet firsts illustrates how quickly it passed from small-scale innovation to global domination.

Technology development at breakneck speed

1971 The first e-mail ever was sent.

1976 The Queen of England sent her first e-mail.

1990 The World Wide Web was established.

1990 The Internet toaster went online, one of the first devices operated remotely through Internet connection.

1991 First “connection” between a coffee pot and a webcam, located in corridor of a computer lab, gave employees a live image (128×128 greyscale) of the coffee's current status.

1993 First commercial software that allowed graphical access to content on the Internet.

The phrase “information and communication technology (ICT)” has since become a catch-all to encompass any technology that enables users to access, store, manipulate and transmit information. Continual advances in ICT have brought other devices into the family of network-enabled devices.

The end result is that standby mode is present across all device categories including white goods (large appliances), ICT, home entertainment and small appliances. And all electronic devices with external power supplies draw standby power, all the time.

Standby convenience has a cost

In 1986, energy experts rang the alarm bell, identifying standby power of stand-alone devices as a source of significant energy waste. Today, with the explosion of network-

enabled devices, the energy wasted by devices not being actively used but still drawing power is growing at a rapid rate.

1% to 2% estimated share of standby power in global total final electricity consumption in 1986

5% estimates share of standby power in residential electricity use in the United States in 1998

10% estimated share of standby power in residential electricity use in Australia in 2005

16% share of standby power in residential electricity use in the United Kingdom in 2012

USD 1 billion/yr total cost to US consumers for keeping TVs and VCRs idle, but ready for action in the early 1990s

USD 3 billion/yr total US consumers paid for this “leaking” electricity across all devices with standby functionality in the early 1990s

100 billion kWh/yr volume of US electricity consumption currently attributed to standby power.

USD 10 billion/yr current cost to US consumers of standby power

AUD 1.1 billion Australian cost of standby energy; average household cost of AUD 236/yr

6.5 million tonnes CO₂ emissions related to Australian standby, equivalent to annual emissions of 1 million cars

For sources and notes relevant to this material, see Annex E.

Massive ICT deployment set to up the ante

Standby trends have exponential impacts

Technical advances are rapidly increasing the volume and speed at which data and information are transmitted. This increase

is also driving up energy demand, at unprecedented rates. Consider the potential or projected increases across five major trends:

Global online population

2.73 billion number of people connected to the Internet in 2013

< 40% percentage of global population connected in 2013

439 million households with wireless home networks in 2011

750 million number of households with Internet access in 2013

5 billion global population connected in 2020

800 million projected number of households with wireless home networks in 2016 (42%)

Business demand for online services

21% expected compound annual growth rate (CAGR) for business Internet Protocol (IP) traffic, 2012-17

134⁽²⁰⁰⁰⁾ | 355⁽²⁰¹¹⁾ million number of computers (laptops and desktop PCs) sold globally in 2000 and 2011; In 2011, 74% of computers were sold for business

Residential demand for online services

10 average number of network-enabled devices per home with two teenagers in OECD countries in 2013

16 projected average number of networked devices per US home in 2015

25 projected average per home with two teenagers in OECD countries in 2017

50 projected average per home in 2022

Move towards smart grids and demand response

90 million number of installed smart meters in 2011

490 million projected total installed by 2015

Deployment of smart homes and home automation

1.8 million number of home automation systems installed globally in 2011

12 million projected installations by 2016

More devices coming online

Early ICT definitions focussed primarily on personal computers. But new devices entering the market and the convergence of appliance functions have blurred the traditional distinction between ICT equipment and consumer electronics (Coleman et al., 2012). Smart devices, such as phones and TVs that create crossover with ICT are being taken up at unprecedented rates (Owen, 2007).

Today, ICT functions and services are being integrated in industry, buildings, transport systems and the energy sector. Any of the following devices might be network-enabled, and thus participate in information exchange.

More user uptake

The Internet is the most pervasive global network, and as such the network of greatest relevance to network standby energy consumption. Over the past two decades, the number of Internet users has expanded rapidly; yet on the global scale, less than 40% of the population is currently on line. The potential for future growth exceeds the access already achieved.

By 2017, global traffic volumes are expected to reach 13.8 petabytes (PB) every five minutes, with the gigabyte-equivalent of all movies ever made crossing the Internet every three minutes (Cisco, 2013b).

Growing number of Internet users

3 million number of Internet users globally in 1990

2 billion number of Internet users globally in 2010

2.73 billion number of Internet users globally in 2012

1.6/sec rate at which new Internet users go online in China alone – reflecting exponential growth from 2.1 million in 1998 to 564 million in 2012

Grasping the scale of data volumes

1 byte consists of 8 bits and is equal to 1 character of text; 10 bytes equals one word

1 MB (megabyte) 4 books, each being 200 pages

1 GB (gigabyte) 7 minutes of high definition (HD) TV video (4.7 GB in a standard DVD-R)

1 PB (petabyte) 500 billion pages of printed text or over 2 000 years of 4-minute songs playing non-stop

For sources and notes relevant to this material, see Annex E.

Understanding what's what in the networked world

Before diving into strategies to reduce the energy draw of network-enabled devices, a detour into the, so far, muddy zone of definitions is warranted. Considering the vast number of stakeholders across the global market, it is not surprising that terminology is sometimes vague.

But collective effort to solve such a large-scale problem requires clarity at the most basic level.

The definitions below (as well as those in the extensive Glossary) establish how terms are used in this publication, and perhaps set the stage for global agreement that will help avoid ambiguity, misunderstanding and potential conflicts.

Without any intent to be prescriptive, the IEA simply aims to ensure that everyone involved in the effort to develop solutions is speaking the same language. Establishing internationally accepted definitions is fundamental to setting international standards that can, in turn, be incorporated into policy development.

What are networks?

In the simplest sense, a digital or data network is structure that allows transmission of information between two or more connected devices. Delving deeper, however, digital networks quickly become exceedingly complex and multi-layered. The main types of networks include:

- **Local area networks** (LANs) are small networks that cover a single home or a building.

- **Wide area networks** (WANs) are large networks that cover a larger geographic area such as a whole city or district. The Internet is a wide area network.

Networks can interconnect with other networks and all can contain sub networks. Devices such as computers or TVs, for example, can be connected wirelessly via a “Wi-Fi” sub-network, which is then connected to a wider network (e.g. the Internet) via a Wi-Fi transceiver. Devices that are connected to networks are heterogeneous and play different roles.

How do networks connect?

Two main mechanisms allow networks to connect and exchange information; increasingly, homes and businesses use a combination of technologies to meet networking needs.

- **Wired networks** use Ethernet cables or other cables, including the electrical or coaxial cabling already installed in existing buildings.

- **Wireless networks** use radio waves, with a common example being Wi-Fi.

What are network-enabled devices?

Three main types of devices provide the functionality of networks.

- **Edge devices** include end-user equipment and appliances that can be connected to networks and interact with the network or other devices. Two main types of edge devices exist:

- **Electronic edge device** comprises those for which the primary function is data storage or use; e.g. entertainment and communication type devices, such as smart TVs
- **Other edge device** comprises those for which the primary function is not data-related; i.e. all appliances and equipment other than electronic devices. These include kitchen and laundry appliances, cooking equipment, heating and cooling equipment, lighting, and all manner of commercial and industrial equipment.
- **Network equipment** provides connectivity to and among all devices attached to networks.
- **Network infrastructure** includes servers, data storage equipment and enterprise storage, load balancers, data centres and data security systems, which collectively manage and manipulate the data within the network as well as service application requests from edge devices. Because of demand for 24/7 service, most of these are networked devices that draw at least some power most of the time.

More devices joining the networked world

TVs are just one example of the consumer electronics that are evolving to become network-enabled devices – a domain previously limited to computers and the network equipment needed to connect them. White goods, lamps and lighting systems, and home entertainment systems are increasingly “connected” all the time. This capacity to respond to messages from the network at any

given time is a major selling feature, even though it means many devices spend most of their time fully powered on. An underlying challenge is that if a device does not respond to messages, it can be excluded from the network and potentially affect other devices or limit the provision of services or functions.

How devices interact with networks and each other

In the context of network standby, functions are pre-determined operations undertaken by a network-enabled device: a connection to the network equipment is required to facilitate the function. Common functions include file sharing, content upload/download, etc.

To deliver desired functions or services, network-enabled devices themselves need to perform a set of key operations:

- establish a network link
- maintain a network link
- establish a network connection
- maintain network presence
- perform ordinary data transmission

The issue of standby comes into play in a new way with network-enabled devices. Once a device is connected to a network, it can be controlled not only by the user (either directly or remotely, e.g. via a smart phone) but also by other devices on the network and by network service providers.

Who's responsible? What can we do?

40%–80% percentage of standby power energy waste attributable to poor design or inappropriate use of devices

65% percentage by which application of best available technologies and solutions could reduce energy consumption of network-enabled devices

Negligible estimated cost of some technology options for achieving higher energy efficiencies

Low priority given to energy efficiency by device manufacturers since buyers and users are more interested in exciting new features than in energy efficiency

What keeps people from making the obvious choices?

No technical barriers exist to making network-enabled devices substantially more energy efficient.

Rather, the challenge is that people all across the value chain – from network designers and device manufacturers to operations managers and individual consumers – are either unaware of the energy issues or have little incentive to engage actively in resolving them. An additional non-technical barrier is that

many stakeholders are not required or motivated to look further than one component of this chain; they do not have a systems approach.

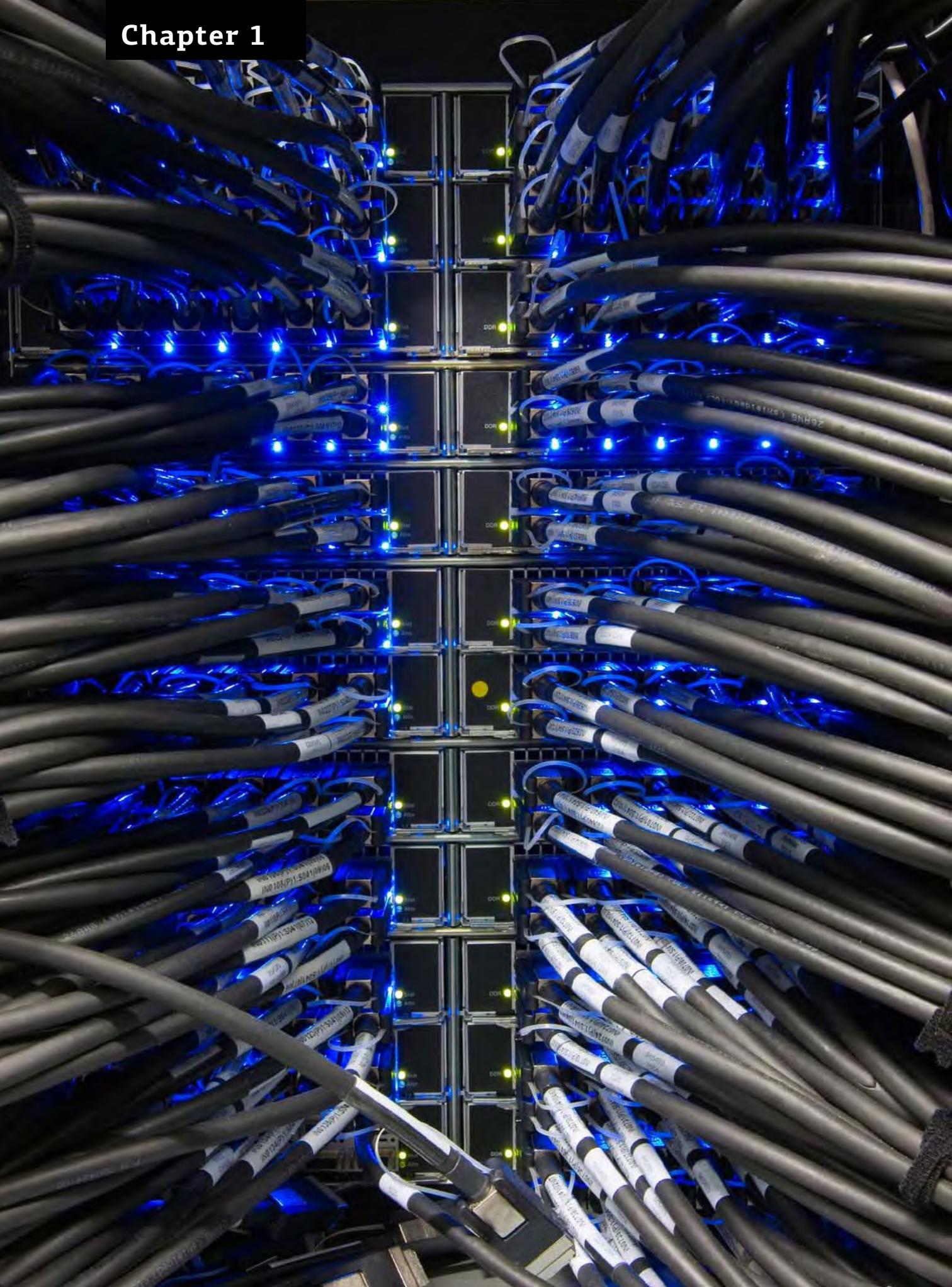
In highlighting initiatives already underway in both industry and policy spheres, in parallel with outstanding issues across the value chain, this publication aims to stimulate collective, strategic effort such that network-enabled devices provide useful functions and services in the most energy efficient manner possible.

Who can do what to address the issue?

Actors	Roles
Policy makers	Implement policy instruments that create incentive for other players to increase individual and collective activity towards addressing standby energy consumption of network-enabled devices, including R&D, implementation of standards, uptake of solutions and deployment of efficient devices.
Standardisation organisations	Mainstream energy efficiency considerations into standards that specify how devices, components or communications protocols operate; provide definitions, energy efficiency metrics and test procedures.
Intellectual property providers	Pursue energy efficiency innovation through R&D across all ICT-related areas.
Software and hardware developers	Develop components that enable more efficient devices with higher levels of compatibility and interoperability, ensuring devices can power down as quickly and for as long as possible.
Device manufacturers	Select efficient, compatible software and hardware and implement power management features as the default across entire device lines; raise consumer awareness of energy demand and power management.
Network designers	Incorporate energy efficiency as a core criterion when aiming to increase the speed, quality and quantity of information transmitted.
Service providers	Select efficient, compatible devices and promote energy efficiency among both suppliers and end users.
Telecommunications industry	Optimise network architectures, develop intelligent energy management solutions and improve control algorithms to enable energy savings across networked systems; drive the development of communication protocols that support energy efficiency.
Consumers	Select efficient devices to create market drive for greater efficiency; apply power management; be conscientious about turning off devices that do not need to be connected 24/7.

For sources and notes relevant to this material, see Annex E.

Chapter 1



Everything is becoming “smart” and network-enabled

Network-enabled devices, such as smart phones, tablet and set-top boxes, currently outnumber people on the planet by a ratio of 2:1. They underpin many aspects of daily life and are quickly transforming societies. As network connectivity spreads to more types of devices and appliances, new services are emerging and usage patterns are changing. Data traffic is expected to grow at an exponential rate.

Key points

- *The capability of being “network-enabled” is fundamentally changing markets for information and communications technologies (ICTs) and for more traditional appliances and equipment. Consumer demand drives manufacturers to embed network connectivity in a wider range of devices, thereby making them “smart”.*
- *The enhanced functionality of network-enabled devices offers multiple benefits to individuals and businesses – which explains why demand is rising rapidly in all regions of the world. Projected demand growth is sharp in OECD regions, where devices are increasingly commonplace. In the Middle East and Africa, demand growth will be exponential.*
- *Drivers of demand include the increasing global online population, increasing network traffic, greater consumer and business demand for online services, and rapid deployment of a wider array of network-enabled devices.*
- *Smart devices increasingly participate in smart networks or smart systems (such as smart grids and smart homes); this adds another layer of functionality and benefits.*

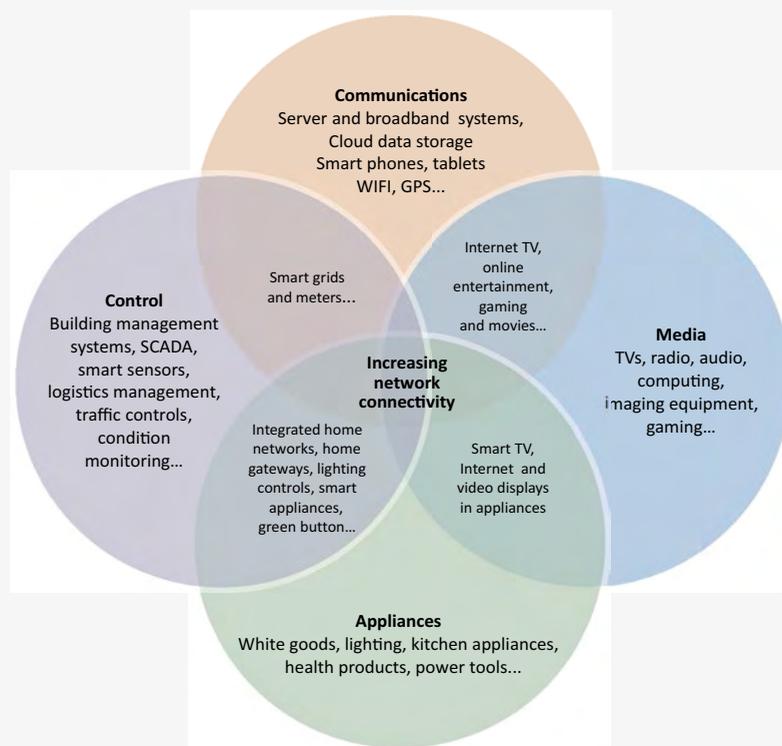
Before delving into the energy implications of increased network connectivity, this chapter examines key trends and developments in information and communication technology (ICT), with a particular focus on network-enabled devices. Central to these developments is the spread of ICT functions to a broader range of devices, which warrants analysis of the drivers that are shaping market development. This chapter thus provides a background for the following chapter, which quantifies some of the energy implications arising from devices being connected to networks – and continuously drawing power in order to maintain this connectivity.

Network connectivity is becoming ubiquitous

Online technologies, such as broadband connectivity, wireless mobility, cloud computing, e-commerce, social media and sensors are quickly transforming the world. Network connectivity already touches many aspects of daily life and is set to play an increasingly important role in the future. Several trends point towards increasing uptake of network-enabled devices, broader deployment of smart devices and creation of smart systems. An important phenomenon within these trends is that advanced technologies are creating new services and benefits; in some cases, this leads to overlap among previously distinct areas of activity (Figure 1.1).

Figure 1.1

The new age of information and communication technology



Notes: GPS = global positioning system; SCADA = supervisory control and data acquisition system. Data will be online.
Source: IEA (2013b), *Energy Efficiency Market Report 2013*, OECD/IEA, Paris, www.iea.org/w/bookshop/add.aspx?id=460.

Key point

In the digital age, the number of devices that interact with networks — and with each other — is increasing rapidly.

Today, network connectivity is rapidly expanding to a range of new device groups that offer both wired and wireless network functionality. All types of appliances, consumer electronics and equipment, and lighting and heating systems that can potentially connect to networks (i.e. network-enabled devices) are viewed as desirable in many markets. In 2012, 74% of Internet Protocol (IP) traffic and 94% of consumer Internet traffic originated from personal

computers (PCs). By 2017, analysts predict that 49% of IP traffic and 39% of consumer Internet traffic will originate from non-PC networked-enabled devices.

Most of the services outlined in Figure 1.1 are not new; what is novel is the way in which they are now provided by networked systems, and the additional functionality and controllability this enables. Smart appliances and devices transcend existing functions and capabilities, and offer new ways of providing services simply by receiving and transmitting information that was previously not available. In doing so, quantum leaps are being achieved from established technologies in service quantity, quality and controllability of normal activities.

Box 1.1**When is a device “smart”?**

In this publication, the term “smart” is used in the broadest sense – to cover all types of devices that have the ability to send and receive data.

Terminology describing devices that are connected to networks varies, at times overlapping, at times contradictory. In some circles, “smart appliance” may denote any device with integrated information and communication functions, i.e. anything that can go on line to transmit and receive information. Others narrow the focus to include only mobile devices, such as smart phones and tablets. But as technologies continue to evolve, some are broadening the definition to include

appliances that are part of emerging smart grid systems, in which the appliance can be configured to communicate information directly to the utility or energy provider to support more efficient and more productive use of electricity.

Common to most definitions is that smart appliances can operate autonomously to some extent, i.e. they can control and change their behaviour or operation in response to a communication signal. Depending on the functionality of the device, synonyms used include ICT device, Internet appliance, network-enabled, smart grid-ready and demand response-ready.

Drivers for increased network connectivity

Network connectivity is expected to continue growing at exponential rates for decades to come, driven by four interrelated trends:

- increasing global online population
- increasing network traffic
- increasing demand for online services, from both consumers and business
- increasing number of devices online.

Box 1.2

The "Internet of Things" and machine-to-machine communication

The term the "Internet of Things" (IoT), first coined in 1999 by the technology pioneer Kevin Ashton, generated much discussion and controversy. Not one unique technology, the IoT is a concept that covers a range of technologies.

On the most basic level, the IoT is about connecting everyday objects to networks to provide a range of services or applications in areas of personal healthcare, smart grids, surveillance, home automation and intelligent transportation. Possibilities are virtually unlimited. Sensors and network-enabled devices, for example, can be set up to help identify potential problems in the home by monitoring critical information about temperature, vibration, motion and moisture.

IoT encompasses both machine-to-machine (M2M) communication (where devices interact and share data without the direct involvement of people) and connecting "things" to networks to enable people to remotely control processes or manage their devices.

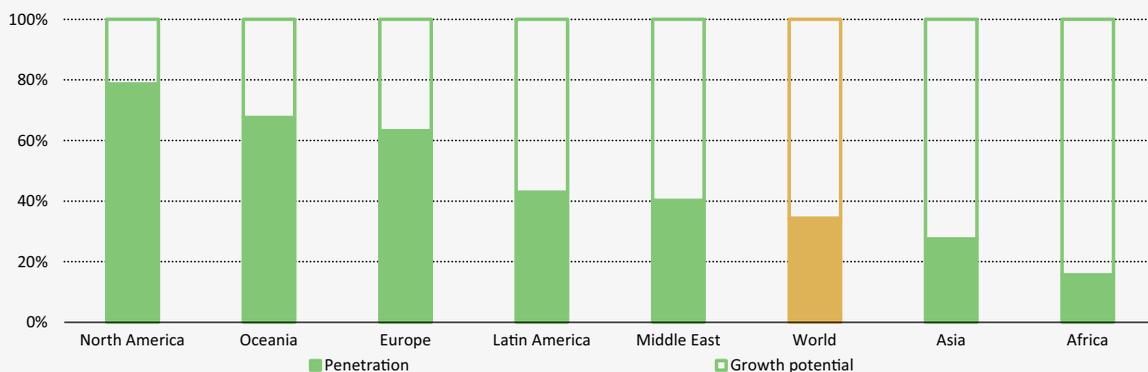
New services and applications based on M2M are being developed at a rapid rate and becoming commonplace. By 2017, some analysts project 1.7 billion M2M connections globally in devices such as global positioning system (GPS) tracking systems in cars and asset-tracking systems in shipping and manufacturing sectors (Cisco, 2012). Networked sensors account for an increasing share of Internet traffic; in 2012, 20% of non-video Internet traffic originated from physical sensors (Hammersmith Group, 2010).

Increasing global online population

From 1990 to 2010, the number of Internet users increased from 3 million to 2 billion (WEC and INSEAD, 2011); by mid-2012, the number had already increased to 2.73 billion (ITU, 2013). Regional growth rates between 2000 and 2012 have been astonishing, exceeding 3 600% in Africa and 2 600% in the Middle East (ITU, 2013). Yet most regions still show substantial growth potential and worldwide access is still less than 40% (Figure 1.2).

Figure 1.2

World Internet usage in 2012



Sources: Adapted from ITU (International Telecommunication Union) (2013), ITU statistics 2013, ITU, Geneva, www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx; Miniwatts Marketing Group (2001-2013); www.internetworldstats.com.

Key point

Worldwide access to the Internet remains below 40%, suggesting continued expectation for rapid growth in the future.

The value of Internet access for social and economic development is well recognised; governments around the world have established policies and plans to expand access rapidly. While penetration has reached almost 80% of homes in North America, significant scope for further growth exists in developing and emerging economies.

Increasing network traffic

The growing number of people using online devices is only part of the equation. The volume of data and information available, and the rates at which it is transferred among multiple points around the globe, are equally important to projected trends for growth in network activity and associated energy demand. In recent years, the volume of data collected, transmitted and stored globally has doubled every 18 months (Table 1.1).

Table 1.1 Growth of global Internet traffic

Year	Global Internet traffic
1992	100 GB/day
1997	100 GB/hour
2002	100 GB/sec
2007	2 000 GB/sec
2012	16 809 GB/sec
2017	46 544 GB/sec

Note: GB = gigabyte.

Source: Cisco (2013a), *Cisco Visual Networking Index: Forecast and Methodology, 2012–2017*, Cisco White Paper, Cisco Systems, Inc., San Jose, www.cisco.com/c/en/us/solutions/collateral/service-provider/ip-ngn-ip-next-generation-network/white_paper_c11-481360.pdf.

Key point

The rate at which data is transmitted around the globe via networks continues to grow exponentially.

Between 2000 and 2010, global Internet traffic grew more than 100-fold (GreenTouch, 2013b), partly reflecting a radical change in the nature of data being transmitted with audio and video data taking up an increasing share. One second of high definition video, for example, generates more than 2 000 times as many bytes as required to store a single page of text (McKinsey, 2011).

By 2017, analysts predict that:

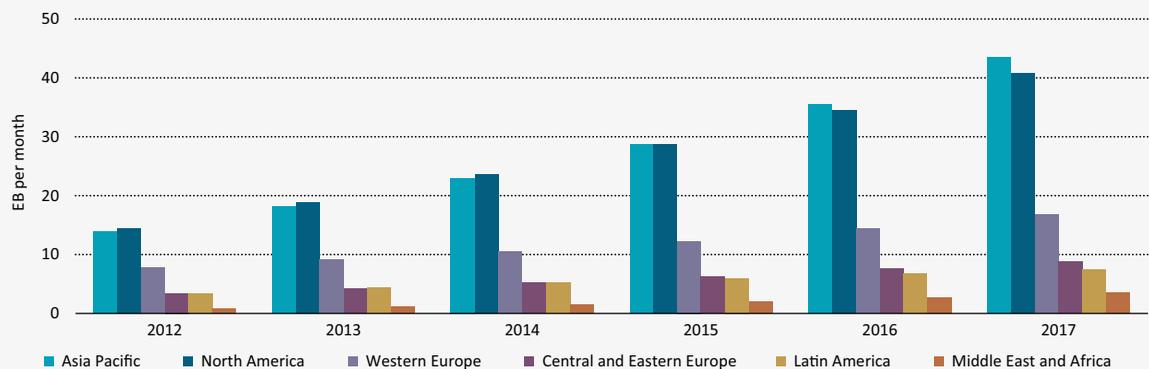
- Global Internet networks will deliver 13.8 petabyte (PB) every five minutes; the equivalent of all movies ever made will cross the global Internet every three minutes (Cisco, 2013b).
- Internet Protocol (IP) traffic per capita will reach 16 GB annually, up from 6 GB in 2012 (Cisco, 2013b).
- Video-on-demand (VoD) traffic will nearly triple, reaching the equivalent of 6 billion DVDs per month (Cisco, 2012).
- Video traffic will constitute nearly 70% of all consumer Internet traffic, up from 57% in 2012 (Cisco, 2012).

- The sum of all forms of video (television, VoD, Internet and peer-to-peer [P2P]) will account for 80% to 90% of global consumer Internet traffic (Cisco, 2012).

Others project that global wireline Internet traffic from 2010 to 2020 will increase 16 times, to approach 250 exabytes (EB) per month, and the global mobile Internet traffic will increase 150 times to approach 40 EB per month (GreenTouch, 2013a). Global mobile data traffic is currently increasing at 78% per year, while mobile cloud traffic is skyrocketing at a rate of 95% per year (CEET, 2013).

Figure 1.3

Projected growth of global Internet Protocol traffic by region



Source: Adapted from Cisco (2013a), *Cisco Visual Networking Index: Forecast and Methodology, 2012–2017*, Cisco White Paper, Cisco Systems, Inc., San Jose, www.cisco.com/c/en/us/solutions/collateral/service-provider/ip-ngn-ip-next-generation-network/white_paper_c11-481360.pdf.

Key point

Internet traffic volume in emerging markets is rapidly catching up with mature markets — and is expected to pull ahead by 2017. Traffic in the Middle East and Africa grew at a compound annual growth rate (CAGR) of 38% between 2012 and 2017.

Increasing demand for online services

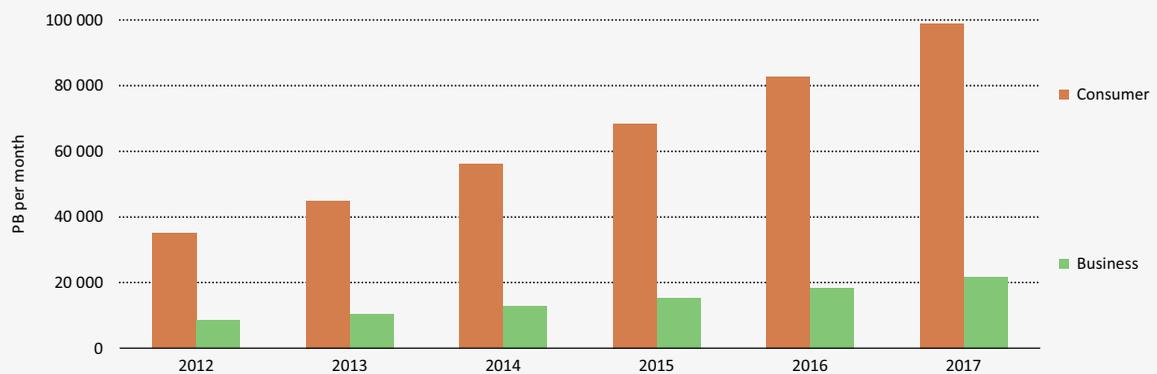
For decades, traditional ICT equipment such as computers, modems and routers drove Internet demand by business and residential consumers, with uptake of these devices increasing as broadband and Internet access spread. Network connectivity provides consumers with new functions including diverse ways to communicate at any time of day or night, the possibility to schedule computing or other functions at a later date/time, and enhanced and remote control, comfort and entertainment. Internet access has underpinned globalisation. Increases in functionality and networking capabilities, coupled with the development of new services, are boosting demand for ICT devices in all sectors.

Business demand

Business Internet Protocol traffic is expected to increase at a CAGR of 21% from 2012 to 2017, with increased adoption of advanced video communications projected to lead the growth by a factor of three over other services or functions (Cisco, 2013b). With a CAGR of 29%, business Internet Protocol traffic will grow fastest in the Middle East and Africa. Asia Pacific is projected to have the largest volume (8.3 EB per month) of business IP traffic in 2017, followed by North America (5.4 EB per month) (Cisco, 2013b).

Figure 1.4

Projected growth of global Internet Protocol traffic, consumer vs. business



Note: Consumer includes fixed IP traffic generated by households, university populations and Internet cafés; business includes fixed IP WAN or Internet traffic generated by businesses and governments.

Source: Adapted from Cisco (2013a), *Cisco Visual Networking Index: Forecast and Methodology, 2012–2017*, Cisco White Paper, Cisco Systems, Inc., San Jose, www.cisco.com/c/en/us/solutions/collateral/service-provider/ip-ngn-ip-next-generation-network/white_paper_c11-481360.pdf.

Key point

Business Internet traffic is expected to grow by a CAGR of 21% between 2012 and 2017; growth of consumer traffic will be even faster, at a rate of 23%.

Most businesses, in addition to equipping their employees with ICT equipment and network tools and access, now provide online services to a wide range of users, including consumers, business customers and partners. Businesses that provide online services need to adapt to the demands of the always-on, 24 hours/7 days a week expectations of their users.

E-commerce is growing much faster than sales in general. The second quarter of 2013 (Q2 2013) marked the 15th consecutive quarter of positive year-over-year growth in US retail e-commerce sales, and the 11th consecutive quarter of double-digit growth. E-commerce sales in 2012 accounted for 5.2% of total US sales. Mobile commerce sales in the United States reached USD 4.7 billion in the Q2 2013, up 24% year over year. Mobile commerce transactions are expected to reach USD 3.2 trillion in 2017, up from USD 1.5 trillion in 2013. In the US Q1 2013, in-store sales grew only 3.2%, while e-commerce sales experienced a 20% growth. The boost of mobile e-commerce is even bigger – it grew 31% in Q1 2013, reaching USD 8.75 billion.

Worldwide figures are even more impressive: in 2013, people were expected to spend USD 1.2 trillion online. In People's Republic of China, e-sales reached USD 181 billion in 2013. There are approximately 250 million e-shoppers in Europe (population 820 million). In 2012, online retail in Europe reached 5% of total retail. Digital sales were expected to reach USD 141 billion in 2013 in the United Kingdom (eMarketer, 2013).

Residential demand

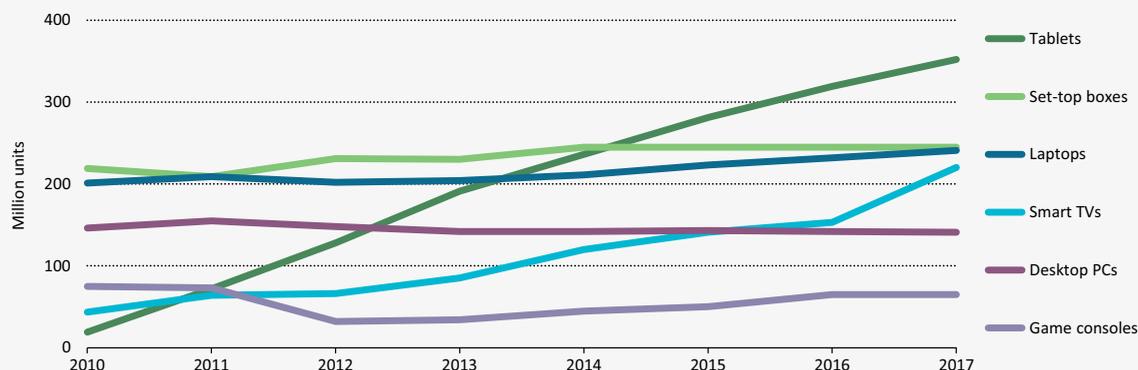
In 2011, a UK Energy Saving Trust study titled *The Elephant in the Living Room* alerted readers of the risks inherent in the extraordinary growth in appliances (EST, 2011). The area of home entertainment has shown particularly rapid growth, which is expected to continue as content is becoming increasingly digital and on-demand. Many home audio and video devices now include networking functions to enable digital media streaming from the Internet, and manufacturers continue to add network features to other devices ranging from refrigerators, microwaves and coffee machines to pillows and eyeglasses.

Increasing number of devices online

Globally, there were already two network-enabled devices per capita in 2012; projections indicate that the ratio will rise to nearly 3:1 by 2017 (Cisco, 2013a). In a longer term perspective, network-enabled devices are forecasted to increase fivefold by 2020 (World Economic Forum and INSEAD, 2012) and industry experts project an uptake of 50 billion network-enabled devices by 2020, reaching towards 500 billion over the coming decades (OECD, 2012).

Figure 1.5

Historic and projected annual global sales of network-enabled devices



Note: Unless otherwise indicated, all tables and figures derive from IEA data and analysis.

Key point

Network-enabled device sales are increasing; smart TV sales are expected to increase by a factor of five in 2017 compared to 2010.

Network-enabled or smart TVs have, in very few years, taken a prominent position on the market (Box 1.3). In-home and device-to-device streaming of audio and video content is also on the increase. More than 20 000 device models now feature Digital Living Network Alliance (DLNA) certified technology, and approximately 1 billion devices deployed can share data via in-home networking based on DLNA standards. DLNA certified technology is based on Universal Plug and Play (UPnP) standards for media management, discovery and control that allow content sharing among in-home devices. Similar technologies, such as the Wi-Fi Alliance's Wi-Fi Direct and Miracast™, allow mirroring of content from smaller screens to larger screens (CEA, 2013).

Such devices will dramatically change the volume of Internet traffic. A smart high-definition (HD) TV drawing 30 minutes of content from the Internet will generate as much Internet traffic as an entire household does today (Cisco, 2013a).

The case of TVs brings up another important challenge: the fact that market forces can undermine energy efficiency gains. Policy requirements in the past decade effectively prompted industry to find technology solutions to reduce standby energy for regular TVs to 1 watt (W) or less per hour. Over the same period, however, manufacturers either created or responded to consumer demand for smart, network-enabled TVs. And standby energy consumption of TVs is once again on the rise.

Box 1.3

How TVs went from simple to smart

In 1956, commercialisation of the remote control began to change the course of consumer electronics. Suddenly, people could turn their televisions "on" or "off" – or indeed change the channel – without getting up from their chairs. But this meant that some component in the remote control had to trigger another component in the TV itself, which implies that both were somehow "awake" and ready to communicate. Remote controls relied on battery power; the plugged-in TV set continuously drew electrical current – and ultrasound waves allowed them to communicate.

Until the 1970s, TVs had one primary function: to provide audio/visual content as it was broadcast. Then the video-cassette recorder (VCR) came along, essentially adding a secondary function – i.e. the capacity to record content that the user could view later. In fact, the VCR could be programmed to record at any desired time, as long as both the TV and the VCR could pick up the appropriate signals. The connection between the two devices was an early example of network connectivity that required both devices to be ready to provide a limited set of functions at any time. Both devices continuously drew electrical current.

Smart or network-enabled TVs developed in recent years give users the possibility to connect to the

Internet or with other electronic devices and thus access a range of services and applications, such as social networking, gaming, communication platforms (e.g. Skype), downloadable videos, and other applications (or "apps").

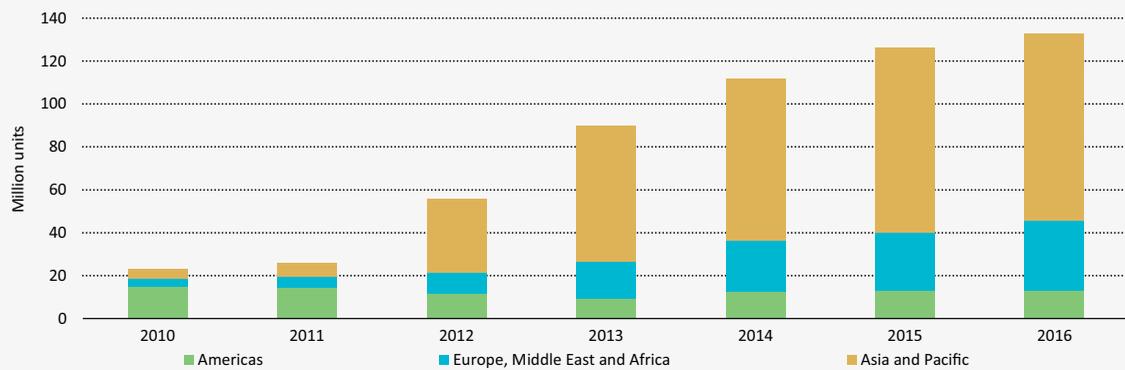
The rapidly expanding market for smart TVs is a good example of how quickly consumer demand and industry supply can evolve. Some 15% of the population in the United Kingdom and France reported owning and using a smart TV; in 2010, 21% of all TVs shipped globally were Internet-enabled (DisplaySearch, 2011). Already today, 80% of all TVs sold in the United States are Internet-enabled (Radulovics, 2013); in 2013, 44% of the TVs shipped globally offered smart features. By 2015, it is expected that smart TVs will make up 55% of the global market and over 80% of the TVs sold globally will be enabled for network connectivity (DisplaySearch, 2011).

Current growth is fuelled by high uptake rates in Japan, but emerging markets are expected to take over as lead drivers. Demand in Eastern Europe, for example, is projected to quadruple from 2.5 million units in 2010 to more than 10 million in 2014 (DisplaySearch, 2011). Smart TV ownership is expected to increase by more than a factor of six between 2012 and 2017 (IEA, 2013b).

Smart meters and demand response

Large-scale deployment of smart grids is a key aspect of future energy systems, but transforming infrastructure will take some time. As a first step, governments and energy companies are rolling out smart meters at a high rate. By mid-2011, nearly 90 million smart meters had been installed globally; forecasts indicate as many as 490 million could be in place by 2015 (International Data Corporation [IDC] in GSMA, 2011).

Smart meter deployment opens up possibilities for enhanced management of energy and for demand response measures. It also creates a market for network-enabled devices that can participate in demand response – that is, which have the capability to interpret and act upon signals from power utility networks. Demand response-enabled appliances are already available and make it possible for consumers to manage electricity costs by letting their appliances alter functions in response to signals from smart meters. Grid operators or electricity utilities can then manage electricity system load by altering time-of-use prices in response to supply and demand perturbations. Demand response functionality can, for instance, enable the power utility to turn off remotely the air-conditioning units in customer homes to avoid peak load issues.

Figure 1.6 Forecast uptake of smart meters


Note: APJ (Asia-Pacific, Japan), EMEA (Europe, Middle East, Africa), Americas (North America and Latin America).

Source: IDC (2012a), "Worldwide smart meter shipments grow 28.8% year over year in the first quarter of 2012", press release based on *IDC Energy Insights: Worldwide Quarterly Smart Meter Tracker*, IDC, Framingham, www.idc.com/getdoc.jsp?containerId=prUS23992413 (accessed 7 March 2014).

Key point

Roll-out of smart meters is progressing at a rapid rate and is expected to contribute to increased deployment of other network-enabled devices.

While the roll-out of smart meters and demand response-enabled devices holds potential for substantial energy efficiency gains, it also means that even more devices will be "on" and drawing power continuously.

Smart homes and home automation

As applications have improved and the cost of sensors, controllers and home automation networks has declined, deployment of smart home technologies is on the rise. Homes, much like offices, are becoming an increasingly electronic and networked place, equipped with a system or combination of systems to allow remote control or programming of home electronics and also enable real-time monitoring of energy use. A homeowner can, for example, use a smart phone to activate the home security system, regulate temperature gauges, switch appliances on or off, control lighting, programme the TV or entertainment system, and perform other tasks. Smart home networks span security, convenience, entertainment, communications and information systems. Smart homes can also include an option to programme appliances to respond to external stimulus, such as changes in temperature or signals from the power supplier.

Three main factors underpin the recent upswing in systems such as smart homes:

- increased availability of small and inexpensive network-aware sensors and devices
- growing availability of networking technologies in homes, which allows these devices to communicate
- availability of small computing devices in homes, such as smart phones and tablets, which have a greater role – often via custom apps – as controllers and interfaces for other appliances.

This combination of processors and network communication equipment makes it easy to deploy the infrastructure needed for smart environments (Torunski et al., 2012). Many homes already have multiple wired and wireless network devices that allow end users to move digital content from one virtual location to another. Increasingly, end users can also remotely manage the devices in their homes.

Smart or networked homes already exist, with strong projections for growth. The Republic of Korea is a world leader in the area of deploying smart home systems in which appliances are connected to "home gateways". In effect, a gateway connects all the home's local area networks (LANs) to the Internet or to other wide area networks (WANs), thereby making it possible to remotely control any device, via a smart phone, for example. Korea has ambitious plans to ensure that 61% of households (10 million) will have home networks in the near future (MOCIE and KEMCO, 2010).

Box 1.4**Network-enabled devices are changing life at home and work**

In the 1960s, the popular cartoon *The Jetsons* presented a vision of smart homes with robot maids, video phones and meals at the push of a button. Many devices to make homes and offices smart – coffee makers that have a cup ready when you get home or systems that turn on lights and computers when you enter a room – are already starting to become part of daily life.

Network connectivity is changing how we interact with our devices and enabling devices to interact with each other to provide additional services to users. Network-enabled televisions make it possible to watch favourite shows at any time and even fast-forward over commercials. We can adjust thermostats via our smart phones. Refrigerators with Wi-Fi enabled screens on the door are entering the market, from which a person can check the weather, leave notes, load a calendar and display photographs. Going even further, some refrigerator systems take stock of all items and their expiry dates, and send shopping lists either to the owner or directly to supermarkets for home delivery. Some can even respond to queries such as: "Is there any milk?"

Tea kettles can be made to boil at exactly the right time by sending text messages or location alerts; washing machines can be prompted to start up so that the cycle is done when you arrive home. Microwaves connected to networks can go online to check for appropriate cooking times. Network-enabled smart ovens will put at ease those who worry about forgetting to turn them off when going for a trip: network connectivity makes it easy to check what appliances or devices are turned on via smart phones, tablets or other devices.

Network-enabled devices and sensors can provide additional services for specific user groups. Some solutions are targeted at making it possible for the elderly or disabled to remain at home, surrounded with devices that enhance their safety. Devices can be enhanced with automatic reminder systems or made able to send alerts to care givers in case something occurs – if, for instance, the resident has fallen down or spilled something on the floor.

Further developments are underway for new solutions that harness information from appliances, computers, smart phones and other devices to intuitively meet the needs of the people who live or work within a given space. Aided by computer software and network connectivity, sensors will perceive the state of the physical environment and its residents; software will then interpret this information and automatically adjust heating, cooling, lighting or other services.

Offices are already filled with network-enabled devices such as desktop and laptop computers, printers, scanners, phones and lighting systems that can be turned off remotely. Further solutions are on the way: for instance, when a person enters the building, a signal sent via a network could turn on the computer, lights and air-conditioning so that everything is fully ready in the short time it takes to reach the individual's work space. Conference rooms can be equipped with sensors to ensure the ventilation is adjusted to carbon dioxide levels. Walls and tables can be equipped with touchpads and used to show presentations retrieved through the network from computer in the building or located in a different country.

By 2011, 1.8 million home automation systems were supplied globally; forecasts suggest a dramatic increase to 12 million systems by 2016 (ABI and Pike Research in GSMA, 2011). One million home energy management systems (which, like gateways and automation systems, serve to connect several home electronic devices) were deployed by 2011; total deployment is expected to reach 13 million in 2015 (ABI and Pike Research in GSMA, 2011). The growth of the smart homes market is expected to develop rapidly with revenue growth estimated to reach USD 51.77 billion by 2020, at an estimated compound annual growth rate (CAGR) of 17.74% from 2013 to 2020 (Markets and Markets, 2013).

Box 1.5**Opportunities for ICT to unlock sector-specific energy savings**

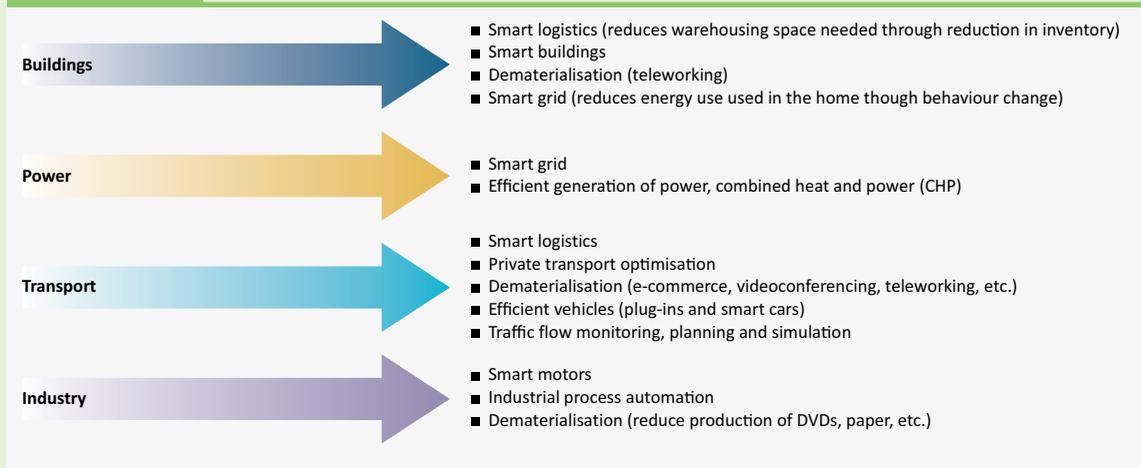
Significant energy efficiency potential can be unlocked by ensuring that network-enabled devices are more efficient. Information and communication technology (ICT) can also unlock further energy savings in other sectors.

Industry has heralded ICT as a vital element of more sustainable energy supply and use. ICT is integral to the development and deployment of "smart" devices that can drop to lower power modes, thereby reducing overall consumption and staggering power use to reduce peak demand. The potential for making everything smart is revolutionary; as devices, homes, cities, transportation, industrial processes and even power grids all become equipped with enhanced energy management systems the cumulative effect is exponential. Network connectivity can also enable users to control any smart device remotely or smart devices can be programmed to recognise when they are not in use and automatically turn themselves off. Additional savings are anticipated through "dematerialisation", as digital alternatives replace more and more physical devices and less efficient activities.

- Switching from retail to digital music distribution can slash energy demand by a factor of seven (Weber et al., 2009).
- Applications for building energy management systems can reduce energy consumption in any type of building, while ensuring supply is adequate for demand. Controls that provide

real-time data can improve processes across the sector.

- Smart grids are an example of applications for system optimisation. Such grids use advanced software applications and communication network infrastructure, together with sophisticated sensing and monitoring technologies, to manage – in a smart and much more dynamic manner – energy supplies, energy demand and energy transmission.
- Integration of high-tech supply chain logistics and warehousing technologies are increasingly important to governments and business; some have the ability to also integrate e-commerce and web shopping applications. Providing traffic information services to logistics companies and transport operators carrying people and goods facilitates better traffic control and avoids traffic jams. An intelligent and networked traffic control system can rapidly react to an unbalanced traffic situation.
- Estimates of the potential global energy savings resulting from implementing ICT solutions vary significantly. Given the diverse nature of the technologies, it is difficult to assess their individual or aggregate impacts on efficiency. Many offer small savings in terms of activity, but are used widely so can represent important efficiency potential. Projections indicate that ICT could enable a reduction of energy demand in the region of 15% by 2020 (IEA, 2013a).

Figure 1.7 Role of ICT in enabling energy savings across different sectors


Key point *ICTs have strong potential to delivery energy savings across all eletrical end-uses.*

Realising the energy savings described above without risking that the electricity demand of deployed solutions outweighs enabled savings requires co-ordinated actions on two fronts: a) technical

improvements of the devices, and of software and hardware components; and b) implementation of effective energy management.

Chapter 2



Energy implications of being connected

Network connectivity comes at an energy cost: recent trends indicate that electricity demand from information and communication technology (ICT) is growing at a much faster rate than overall demand. Around 40% of this electricity is used by billions of network-enabled devices in offices and homes around the world; the total consumption is expected to double over the next decade. This growth in demand can be effectively counteracted: IEA estimates indicate savings potentials in the region of 65%.

Key points

- *To participate in networks, devices and equipment must remain “on” all the time; thus, their increased functionality comes at an energy cost.*
- *Globally, electricity demand for network-enabled devices is growing more rapidly than overall electricity demand; ICTs now account for 8% of total final electricity consumption.*
- *Between 2005 and 2020, total energy demand in the European Union is expected to increase by 15.5%, while ICT energy consumption will grow by 84.3%.*
- *Without comprehensive efforts by policy makers and industry to improve efficiency, the IEA projects that the electricity consumed by network-enabled devices worldwide will double by 2022 and increase threefold by 2030.*
- *Widespread deployment of technologies and technical solutions currently available could reduce energy consumption of network-enabled devices by as much as 65%. The major barrier to achieving this substantial energy savings potential is lack of market drivers for energy efficiency.*

ICT energy demand: Big and getting bigger

Information and communication technology (ICT) is evolving rapidly. New types of devices and solutions that provide information and communication services are continuously developed and deployed. This creates a situation where it is challenging to establish firm boundaries for calculating electricity demand. This publication defines ICTs broadly to

encompass network-enabled devices (including edge devices and network equipment) and data centres and other network infrastructure. According to the IEA, in 2013, the global electricity demand of ICT comprising network-enabled devices, network infrastructure and networks exceeded 1 560 terrawatt hours (TWh), corresponding to approximately 8% of total current final global electricity use. This is a conservative assessment; recent market developments, infrastructure developments; expansion of services, growing online population and growth in traffic volumes indicate that the current ICT energy demand could be in the region of 30% higher. All trends indicate that this demand will continue to grow at a rapid rate.

In terms of sub-sets of ICT energy demand, network and data centre electricity demand surpassed 640 TWh in 2013. Meanwhile, global electricity consumption of network-enabled devices, including edge devices and user-premise network equipment (i.e. devices used in homes and offices) reached 615 TWh in 2013, overtaking the current electricity consumption of Germany.

Box 2.1**How much energy is needed to transfer data on the Internet?**

Studies seeking to determine the electricity intensity of Internet data vary widely due to differences in boundaries, data uncertainties and methodologies (Coroama et al., 2013). In fact, the energy intensity of data transfer depends very much on the technologies used. Consider, for example, the energy required to transfer 1 gigabyte (GB) of information using the following devices:

One recent study indicated that the energy intensity of data transmission (not including energy use in edge devices and data centres) could be around

0.2 kWh/GB, with routers and switches accounting for 76% and transmission lines for 24% (Coroama et al., 2013).

Analyses that include data centres and edge devices show much higher energy demand – in the region of 5 kWh/GB with edge device accounting for 38%, data centres for 48% and network transmission for 14% (Costenaro and Duer, 2012). Other methodologies put the share of data centre energy use in the region of 10% with edge devices accounting for a larger share (Nordman, 2013).

Table 2.1**Energy required to transfer 1 GB of information**

Device	Energy consumption (/GB)
Dial-up and wireline connection	3.56 kWh
Fibre optics and power lines	0.77 kWh
Cable	0.72 kWh
DSL	0.17 kWh

Note: These figures do not include energy used in edge devices or in data centres. kWh = kilowatt hour.

Source: Coroama, V.C. et al (2013), "Journal of Industrial Ecology", Journal of Industrial Ecology, Vol. 17, Issue 5, pp. 680–688.

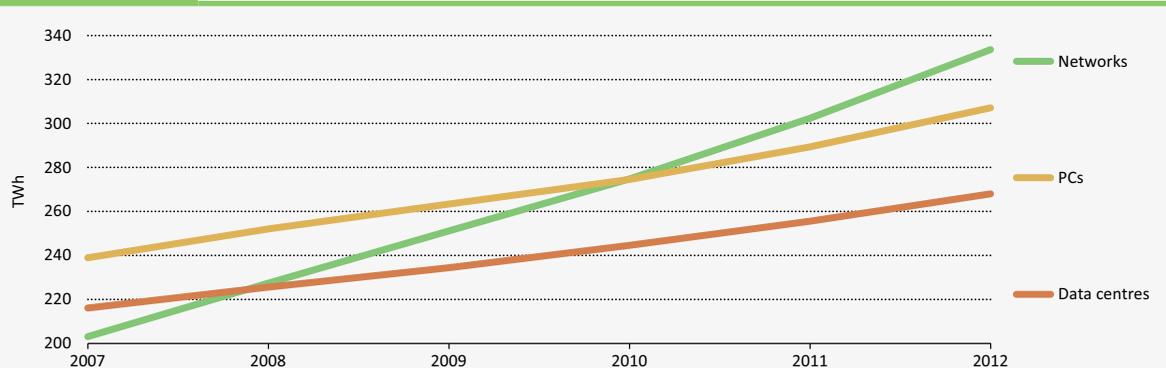
The electricity demand of network-enabled devices is forecasted to continue to grow at a rapid rate to almost 1 140 TWh by 2025 – exceeding the current electricity consumption of Russia and corresponding to 6% of current total final global electricity consumption.

Recent trends in growth of energy demand

Between 2007 and 2012 global electricity use grew by a compound annual growth rate (CAGR) of 2.9%; meanwhile, the electricity demand of communication networks grew by a CAGR of 10.4%, personal computer electricity demand by a CAGR of 5.1% and data centre demand by a CAGR of 4.4% (Van Heddeghem et al., 2014).

Figure 2.1

Growth in global electricity consumption of communication networks, PCs and data centres



Source: Van Heddeghem, W., S. Lambert, B. Lannoo, D. Colle, M. Pickavet and P. Demeester (2014), "Trends in worldwide ICT electricity consumption from 2007 to 2012", *Computer Communications* (2014), doi: 10.1016/j.comcom.2014.02.008 <http://dx.doi.org/10.1016/j.comcom.2014.02.008>.

Key point

Electricity demand of networks, PCs and data centres is growing at a much faster rate than overall electricity demand – with networks showing the sharpest increase.

Growth in some regions has been particularly rapid. For example, already in 2005, ICT accounted for 8% of electricity use in the European Union, with devices such as computers, imaging equipment, televisions, audio system and set-top boxes constituting more than half of this share. Broadband equipment alone in the European Union is expected to consume up to 50 TWh/yr by 2015 (European Commission, 2011). Between 2005 and 2020, EU total energy demand is expected to increase by 15.5%, while ICT energy consumption will grow by 84.3% (BIO Intelligence Service, 2008). In the European Union, it is estimated that between 2005 and 2020 data centre energy consumption could increase by 396% (Coroama and Hilty, 2009).

In light of the projected rapid growth of Internet access (see Chapter 1) – and reflecting massive demand for edge devices, network equipment, data centres and other network infrastructure – ICT energy demand is expected to grow at a particularly rapid pace in developing and emerging economies.

Which devices are most energy-hungry?

Whether speaking of data centres where banks of computers carry out complex operations or the billions of small devices found in homes and small businesses, most of global ICT electricity use is highly dispersed.

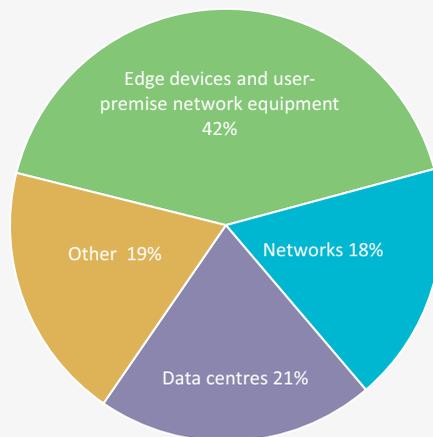
With an increase of 63% in just one year (2011 to 2012), global data centre energy demand has understandably received most attention to date (Datacenter Dynamics, 2012). As energy

costs are a key business consideration in approximately half a million data centres deployed globally, most data centre operators are actively working on improving energy efficiency.

Of greater cause for concern is the growing energy demand of billions of edge devices and user-premise¹ network equipment, scattered in offices and homes around the world. While the individual energy consumption of each device may not seem high, cumulatively these devices currently constitute more than 40% of ICT energy demand.

Figure 2.2

The global energy footprint of information and communication technologies in 2013



Note: Unless otherwise indicated, all tables and figures derive from IEA data and analysis.

Key point

Edge devices and user-premise network equipment constitute the bulk of current ICT electricity demand.

For example, in the United Kingdom, non-domestic ICT equipment (excluding large servers and data centres) was responsible for over 7% (16.5 TWh) of non-domestic energy consumption in 2004, with the share having increased by over 70% between 2000 and 2006. If current trends continue, non-domestic ICT consumption in the United Kingdom is expected to grow by a further 40% between 2006 and 2020 (National Energy Foundation and IEA, nd). Worldwide, the energy demand of office network equipment (switches, routers, firewalls, modems, network security appliances, and wireless access points) and their cooling needs was estimated at 42 TWh in 2012, equivalent to New Zealand's annual power demand (Lambert et al., 2012).

Global electricity consumption of network-enabled devices (edge devices and user-premise network equipment) exceeded 570 TWh in 2012, surpassing the electricity consumption of France. By 2013, this had already grown to 615 TWh, overtaking the electricity consumption of Germany. This electricity demand is forecasted to continue to grow at a rapid rate to almost 1 140 TWh by 2025 – exceeding the current electricity consumption of Russia and corresponding to 6% of current total final global electricity consumption.

¹ Equipment that is located in buildings and offices as opposed to equipment that is located in telecommunication or Internet service provider sites.

Figure 2.3

Current and projected global network-enabled device electricity consumption



Notes: Domestically and professionally used network-enabled devices, connected to external or internal networks. Projections start with 2012.
Source: Bio Intelligence Service, 2013, Inputs provided.

Key point

By 2025, the energy demand of network-enabled devices could reach 1 140 TWh, corresponding to 6% of current total final global electricity consumption.

ICT energy demand: Thinking beyond electricity

Most ICT energy demand is consumed in the form of electricity. Thus, standby power also has implications for the range of primary fuels used to generate electricity, as well as on electricity infrastructure. The electricity mix varies significantly from country to country, and changes over time. To illustrate the relationship between electricity generation and fuel use, current ICT energy consumption corresponds to 520 Rosenfelds² – i.e. the annual electricity generated by 520 mid-size coal-fired power plants (500 MW), which together would require 728 MT of coal per year. A 500 MW conventional coal-fired power plant may cost over USD 1 billion to construct and will incur fuel, operating, maintenance and other costs for about 50 years.

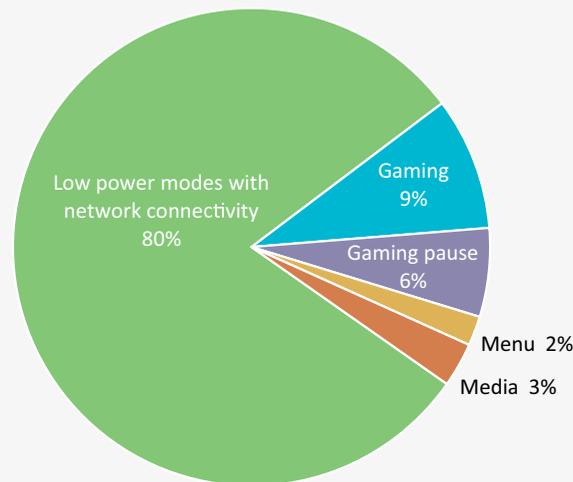
The energy efficiency opportunity

In their current state, network-enabled devices carry an inherent paradox. They have enormous potential to deliver diverse efficiencies across many sectors and services, yet they fall far short of their own potential to be energy efficient. A massive opportunity to harness ICT advances to enhance access to data and manage the energy demand of a networked world is being missed. And consumers are paying the price, in electricity bills and environmental impacts associated with rising energy consumption. A few straightforward examples illustrate the scope and scale of the missed opportunity.

² A Rosenfeld is a unit used to depict a standard avoided power plant that has physical meaning and intuitive plausibility. It is based on a 500 MW existing coal plant operating at a 70% capacity factor with 7% transmission and distribution losses. Displacing such a plant for one year would save 3 TWh/year at the meter and reduce emissions by 3 million metric tonnes of CO₂ per year.

Figure 2.4

Annual energy consumption using a typical duty cycle of a 2010 games console model



Notes: A 2010 games console model with a low power active mode in which the console appears to be in standby but remains connected. In that mode, the 2010 model used 10 watts of power per hour. This accounts for 80% of the annual energy consumption of the console using a typical duty cycle. Source: NRDC (2013), Inputs provided based on preliminary research.

Key point

Some network-enabled devices currently use only 20% of their electricity demand to provide main functions – the rest is used just to maintain network connectivity.

To be part of a network, devices such as set-top boxes and smart TVs typically remain on 24 hours a day, 7 days a week. Estimates suggest that two-thirds of the electricity they consume is while sitting idle (2011). More than 160 million network-enabled set-top boxes were consuming electricity constantly in the United States alone in 2010, most of them operating at near full power even when no one was watching TV or recording a broadcast. Collectively, when in standby, these boxes consumed an estimated 18 TWh in one year,³ at a cost of USD 2 billion to consumers (NRDC, 2011).

Other examples point to even larger energy implications. In 2010, games consoles in the United States accounted for 16 TWh, corresponding to 1% of residential electricity consumption (Figure 2.4). Globally, games console electricity demand is projected to reach 45 TWh by 2015 and more than 70 TWh by 2020 (Bronk et al., 2010). A significant proportion – up to 80% – of this electricity is used just to maintain network connectivity (Hittinger et al., 2012; NDRC, 2013).

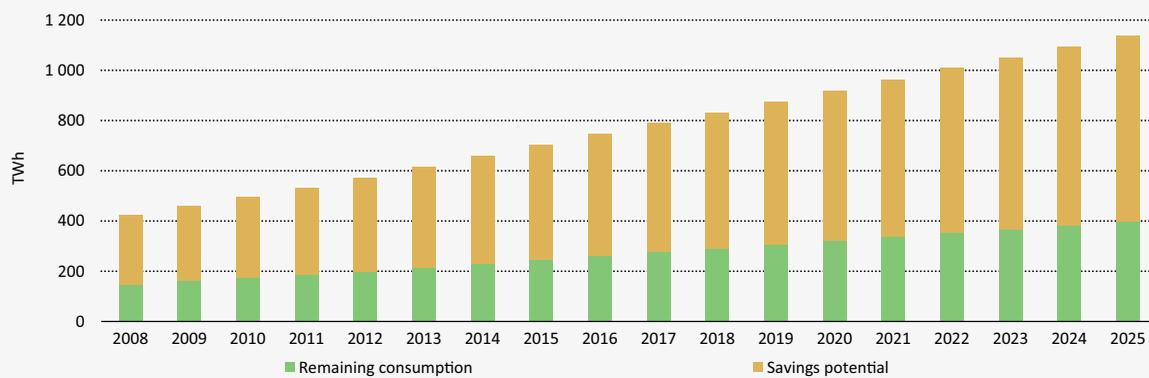
The potential for energy savings

Solutions exist to dramatically increase the energy efficiency of such devices by optimising power management and enabling network equipment to scale energy use to data throughput. In fact, analysts predict that efficiency measures have the potential to save more than half of the projected energy waste; some go so far as to suggest that, considering currently available technologies and solutions, the upper limit of current technical potential for energy savings is closer to 65% (Figure 2.5).

³ Equivalent to the annual output of six 500 MW coal-fired power plants.

Figure 2.5

Current and projected global network-enabled device electricity consumption and savings potential



Notes: Domestically and professionally used network-enabled devices, connected to external or internal networks. Savings potential estimated on the difference between the best available technology and the average device on the market. Projections start with 2012.
Source: Bio Intelligence Service, 2013, Inputs provided.

Key point

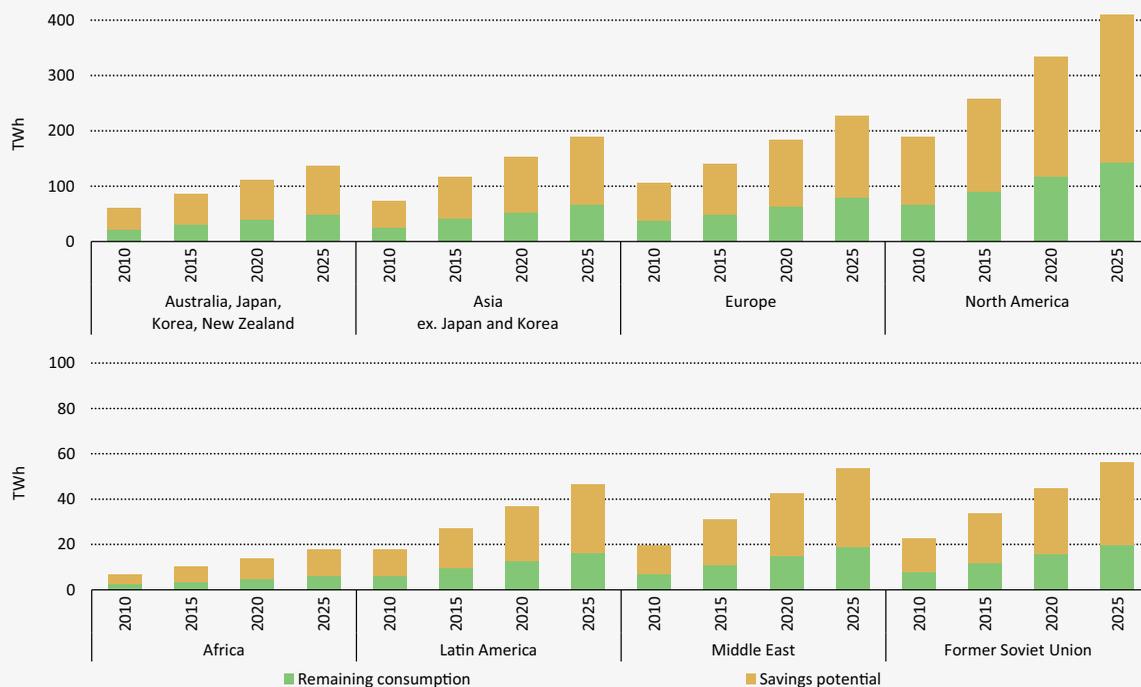
Implementing best available technologies and solutions for energy efficiency could unlock savings of 739 TWh/yr by 2025 – more than the current total final electricity consumption of Canada, Denmark, Finland and Norway combined.

The savings potentials from mainstreaming energy efficiency considerations into the ICT ecosystem are considerable and growing at a rapid rate as these systems expand and connectivity spreads. Looking just at network-enabled devices, implementation of best available technologies and solutions can result in global electricity savings of almost 740 TWh/yr by 2025.

Estimates of energy reduction potentials from improving the efficiency of network-enabled devices are assessed on a regional basis, reflecting the different drivers for growth in networked system power demand. From a regional perspective, North America has the largest projected growth in energy consumption of network-enabled devices, exceeding 400 TWh/yr by 2025. The savings potential of 266 TWh equals one-third of the net power generation from all US nuclear power plants (Figure 2.6). While European projections also indicate rapid growth in consumption, the rate of growth will be contained substantially by a new policy targeting energy consumption of network-enabled devices, which will enter into force in 2015 (European policy approaches are discussed in Chapter 5: Network standby policy options). The Republic of Korea is also implementing policies in this area and has recently launched a large-scale research project on developing solutions to improve the efficiency of network-enabled devices.

Figure 2.6

Current and projected global network-enabled device electricity consumption and savings potential by region



Notes: Domestically and professionally used network-enabled devices, connected to external or internal networks. Savings potential estimated on the difference between the best available technology and the average device on the market. Projections start with 2012.
Source: Bio Intelligence Service, 2013, Inputs provided.

Key point

By implementing best available technologies and solutions to improve the energy efficiency of network-enabled devices, North America could save 266 TWh/yr by 2025 – more than the current total final electricity consumption of Mexico.

Energy consumption of network-enabled devices is still low in Africa, Latin America, the Middle East, and Eastern and Central Europe – primarily because such devices are not yet widely deployed. Still, their electricity consumption is forecasted to double by 2020, pushing these regions to reach or surpass the 2012 electricity consumption of network-enabled devices in Europe. Again, substantial energy savings are possible.

Already a few steps towards energy savings

While the projections of increased energy demand from network-enabled devices are daunting, the challenge of addressing them should not be considered overwhelming. It is not a question of starting from zero to develop energy efficiency solutions for network standby. Many technical solutions are already available, some of which have no additional cost for implementation.

IEA experience shows that policies in this area can stimulate the development and implementation of energy efficient solutions – with the 1-watt plan being the most relevant case in point. This initiative set a precedent for how concerted effort by government

and industry can dramatically shift device design and efficiency in a relatively short time frame (see: IEA 1-watt Standby Plan – A Groundbreaking Approach). A similar approach to network standby will be needed to deal with the reality that energy management in both devices and networks will require changes across the entire spectrum of elements, including the various layers of network communication protocols, data links, network, transport and/or application layers (Energy Efficient Strategies, 2010).

Addressing network standby is the logical next step to continue addressing standby energy consumption in a digital age. As with traditional standby, several areas within network standby would greatly benefit from international co-operation, and from alignment and pooling of efforts and resources. The topic of network standby serves as a good “point of entry” for dialogue among policy makers, industry and other stakeholders on how to move towards more efficient network-enabled devices and systems.

IEA 1-watt standby plan: A groundbreaking approach

1-watt standby: What was the problem and what was the solution?

Standby power, also called “vampire power” or “phantom power”, refers to the amount of electricity consumed by consumer electronics and appliances when they are switched off or are not being used for their primary function. Concern about the energy implications of standby were raised in the late 1980s when it was found that standby power accounted for around 10% of residential electricity demand – in some countries, even up to 22%.

To address the growing problem of energy wasted by consumer electronic devices in Stand-alone standby mode, in 1999, the IEA proposed that all member countries harmonise energy policies to set a limit. Such devices had to be manufactured so they would consume no more than 1 watt (W) per hour when not providing primary functions (IEA, 2007).

The IEA 1-watt plan grabbed global attention

Since its launch, the issue of standby power and the IEA 1-watt plan have gained international attention. Follow up processes to the G8, the Asia-Pacific Partnership (APP), Asia-Pacific Economic Cooperation (APEC) and the Commission on Sustainable Development (CSD) Marrakech Accord subsequently called on other governments to make a commitment to the IEA 1-watt plan and other programmes to tackle standby power. The plan was endorsed by G8 leaders at Gleneagles in 2005.

The 1-watt plan was groundbreaking in two ways. First, it identified more than 40 devices with substantive standby energy consumption. Second, and perhaps more importantly, it established a horizontal solutions approach, setting a limit that could be applied across all types of devices, whereas traditional energy efficiency requirements used a device-by-device approach. As standby was quickly spreading to additional devices, a traditional or vertical approach would have been costly and time consuming.

The IEA proposal contained three elements:

- Participating countries would seek to lower standby power to below 1 W in all devices by 2010.
- All countries would adopt the same international definition and test procedures.
- Each country would use measures and policies appropriate to its own circumstances.

This approach ensures that all devices – including those yet to be developed and placed on the market – are covered by default. The horizontal approach was easier to implement, and sent the signal that there were no technical reasons to adopt a device-by-device approach. Administratively, it was easier to define exceptions than to try to specify all devices included. This framework provided certainty for manufacturers and prepared the market for technical solutions to transform faster and at lower cost.

The IEA Implementing Agreement for Energy Efficient End-use Equipment (4E) continues to promote the 1-watt plan and conduct further research on horizontal policy approaches to support energy efficiency.

Standby policy timeline

1986	Standby recognised as significant area of energy waste
1992	ENERGY STAR programme commences in the United States
1999	IEA announces its 1-watt plan
2001	European Union establishes voluntary code for consumer electronics
2001	Australia releases standby plan
2001	European manufacturers establish voluntary code for televisions
2003	California sets the 3 W television requirement
2005	G8 leaders endorse the IEA's 1-watt initiative in the Gleneagles communiqué
2005	Korea publishes its 1-watt plan (e-Standby Program)
2005	Asia-Pacific Partnership initiates its Standby Project
2005	IEC 62301 Household electrical appliances: measurement of standby power standard is published
2007	Korea adds standby requirements to the Korea Energy Efficiency Labels and Standards Program
2008	1-watt standby policy included in the IEA 25 Energy Efficiency Policy Recommendations
2008	IEA establishes the Implementing Agreement 4E Standby Power Annex
2009	Brazil and Japan establish standby labels
2010	European Union sets horizontal requirements at 1 W (2 W for some devices)
2011	IEC 62301 Edition 2 Household electrical appliances: measurement of standby power standard is published
2012	Canada introduces minimum energy performance standards (MEPs) for audio, video and televisions
2013	European Union sets horizontal requirements at 0.5 W (1 W for some devices)

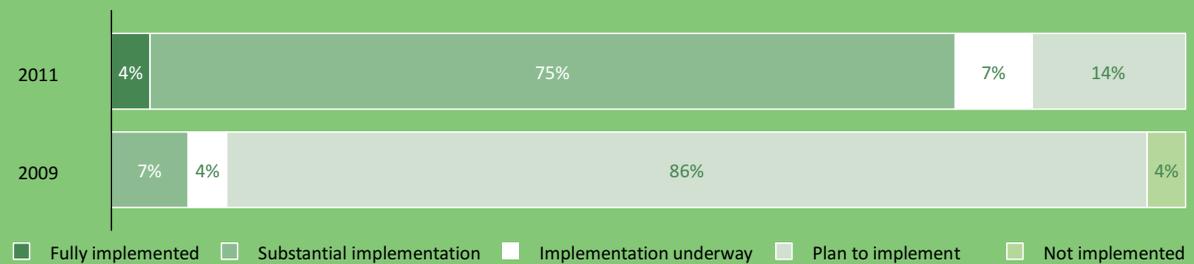
For sources and notes relevant to this material, see Annex E.

Current levels of 1-watt implementation

Introduction of the IEA 1-watt plan prompted many governments to take action against the standby power issue. Following a slow start, the initiative has ramped up considerably in recent years. In 2009, only 7% of IEA countries had achieved

substantial implementation of power limits or equivalent policy measures, 4% reported that implementation was underway, and 86% were planning to implement policies. By 2011, 4% had fully implemented policies and 75% had reached substantial implementation.

1-watt standby policy implementation in IEA member countries



Key point Over a two-year period, countries achieving substantial implementation of stand-alone standby policies surged from 7% to 75%.

Countries have chosen a variety of approaches to address the issue of standby energy consumption, often transitioning from the original plan into a phase of voluntary schemes that allow industry to prepare for mandatory regulation. Australia, Korea, the European Union and the United States provide useful illustrations of the variety of approaches to addressing this challenge.

Australia adopted the 1-watt plan in 2000 and implemented a voluntary scheme in 2002. In 2006, dishwashers and clothes washers became subject to standby energy consumption into the total energy consumption calculation; in 2009, a mandatory television efficiency programme included low power mode requirements. Standby electricity consumption was

introduced into energy labelling and minimum energy performance standards (MEPS) for air conditioners in 2010. Horizontal MEPS launched in 2013 set a limit that is applicable across a range of device groups.

Korea published a comprehensive plan to tackle standby in 2005, starting out with a voluntary framework. By 2010, numerous programmes had set the stage to introduce a mandatory 1-watt limit for a wide range of devices. Korea now attaches warning labels to devices that do not meet standby power requirements as part of its voluntary e-Standby Programme.

European Union regulation came into force in 2010 with requirements for standby and off mode energy consumption of electrical and electronic household and office equipment.

The first tier requirements, depending on the functionality of the device, sets maximum allowed power limits for standby of either 1 W or 2 W. From 2013, when appropriate for the intended use of the device, requirements were made more stringent, with standby limits being 0.5 W to 1 W. Devices are also required to include a power management function that ensures they power down automatically into off or standby mode after an appropriate period of time.

United States energy efficiency standards for appliances and equipment typically do not include discrete limits for different power modes but rather set a minimum energy performance limit for total energy consumption, with standby energy consumption included in the total. Specific standby power requirements exist for some devices such as microwave ovens.

Creating markets for 1-watt devices

Diverse policy interventions have had clear impacts on reducing standby energy consumption. One of the most successful is complementary measures to create markets for efficient devices.

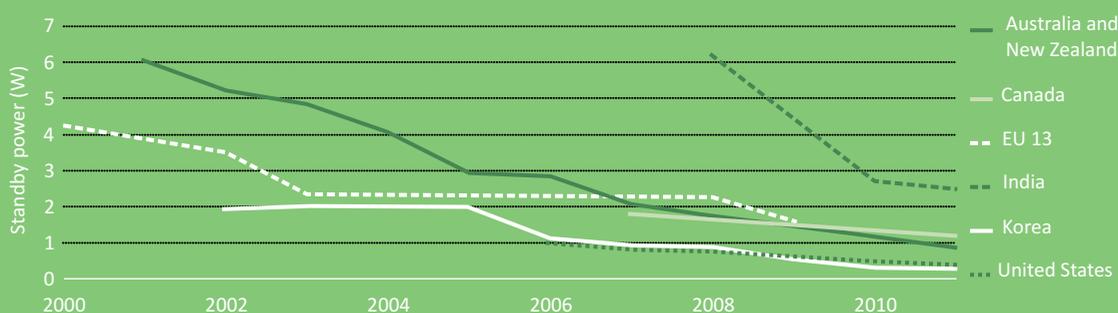
Some jurisdictions have integrated standby power requirements in public procurement schemes. The US Presidential Executive Order of 2001 required government agencies to purchase devices that use no more than 1-watt in standby mode. In 2007, China made it mandatory to select energy efficient equipment in procurement processes; requirements for standby power consumption are included for some device categories (e.g. networked televisions, computers, printers and monitors).

Standby power for TVs

The IEA Implementing Agreement 4E used retail surveys from six countries or regions representing 45% of 2011 global TV sales to analyse progress on the implementation

of low power standby modes. On the basis of nearly 9 600 measurements, these data show a consistent and significant reduction of average standby power from over 4 W in 2000 to well under 1 W by 2011.

Average standby power of TVs (CRT, LCD and plasma)



Key point Across different countries and regions, policy intervention has spurred the decrease in standby power for TVs.

For sources and notes relevant to this material, see Annex E.

In 2001, standby power levels in TVs in Australia varied considerably for different models: some televisions were drawing as little as 0.5 W while others sucked up 18 W. By 2011, in almost all regions, television standby energy consumption was reduced to meet the 1-watt IEA goal.

By 2008, nearly 80% of televisions on the US market met ENERGY STAR requirements, reducing overall standby energy consumption by more than 7 billion kWh per year – double the annual energy consumption of Washington, DC.

Korea pushes the envelope on standby policies

Using mandatory policies, Korea has led the world in successful standby policy interventions. Some devices consistently show average standby power levels 20% to 50% lower than for similar devices in other countries (IEA 4E, 2012).

Two measures make the Korean strategy particularly effective: delivery of a comprehensive policy plan and early signalling of policy intent. The government announced

in 2005 the performance targets that would be set for some devices in 2010. This dual approach has pushed the market for efficient devices further and faster than conventional commercial device development alone is likely to have achieved (IEA 4E, 2012).

A 2011 evaluation of standby policy impacts in Korea shows that residential standby energy consumption was cut by 45%, despite a 19% increase in the average number of standby-equipped appliances per home. Korea is now moving towards 0.5 W requirements.

Summary of the Korean 2011 standby power survey compared to 2003

Indicator	2003	2011	Result
Average standby power per home	3.66 W	2.01 W	-45%
Average number of standby appliances per home	15.6	18.5	+19%
Average annual standby energy (% of total electricity)	306 kWh (10.6%)	209 kWh (6.1%)	-32% decrease (-43% decrease)
Percentage of appliances < 1 W per home	30%	53%	+23%
Nationwide annual standby energy consumption	4 600 GWh	3 470 GWh	-25%
Nationwide standby electricity bill per year	USD 460 million	USD 347 million	USD 133 million savings
Residential standby (% of nationwide electricity use)	1.67%	0.80%	-50%

Now is the time for an action plan for network standby

The need to raise awareness of the paradox associated with network-enabled devices is clear – and increasingly urgent. The potential to save energy is enormous; the risk that massive amounts of energy will instead be wasted is costly from financial, environmental and energy security perspectives.

The success of the IEA 1-watt plan demonstrates what can be achieved, rapidly and cost-effectively, when all stakeholders engage in a crucial objective. A clear, simple and realistic message – that it is feasible and necessary to limit standby power levels to 1 W or less – served as an effective rallying

call and created a shared understanding around the issue of stand-alone standby.

The IEA proposes a plan of action to promote energy efficiency for network-enabled devices and systems. This requires ongoing and collaborative actions to undertake the necessary research, initiate stakeholder dialogue and stimulate information sharing to ensure that energy efficiency considerations are central to the advance towards increasingly digitalised societies.

While it may be tempting to use an equally simple and marketable approach – e.g. a “3 W network standby plan” – this time the challenge is much more complex.

Ten IEA guiding principles for energy efficient networks and network-enabled devices

In 2007, the IEA developed a set of principles to promote efficient energy management in networks and network-enabled devices. The principles underscore that no single power management solution ensures energy efficiency and that efficiency must be addressed in an integrated manner over the entire network-enabled value chain. The principles are as follows:

- All digital network technologies should include and actively support power management and should follow standard (international) energy management principles and designs.
- Connection to a network should not impede a device from implementing its own power management activities.
- Devices should not impede power management activities in other devices connected to the network.
- Networks should be designed such that legacy or incompatible devices do not prevent other equipment on the network from effective power management activities.
- Network connections should have the ability to modulate their own energy use in response to the amount of the service (level of function) required by the system.

For sources and notes relevant to this material, see Annex E.

- Electronic devices should enter low power modes automatically after a reasonable period when not being used (power management).
- Total energy consumption should be minimised in network-enabled electronic devices, with a priority placed on the establishment of industry-wide protocols for power management.
- Governments should consider limits on energy consumption in low power modes for network-enabled

devices and require technically feasible energy-saving options where these are warranted.

- Energy efficiency specifications should not require a particular hardware or software technology.
- Requirements for network-enabled devices need to be generic and performance based.

Seven specific aims to save energy in networked systems

Energy efficiency and energy savings in networked environments is not only about reducing watts; it is about working towards an end-state that enables and delivers continuous network-enabled services while using the least possible energy. The following chapters will explore in detail the mechanisms by which this can be achieved, including:

- encourage appropriate use of power management, power scaling and application of low power modes
- establish communication protocols or other solutions that enable devices to go to sleep when not in use but wake up quickly to deliver services as needed
- scale the energy requirements of network equipment to actual work load
- ensure that service providers actively promote energy efficiency
- engage consumers to take an active role in promoting energy management in their network-enabled homes and businesses
- apply smart solutions, such as energy harvesting, to ensure that small energy loads due to network connectivity do not cumulatively add up to a large growth in electricity demand
- design smart systems to be energy efficient in terms of their own use and also in regard to maximising energy savings across all sectors

Step by step, starting right now

Achieving the vision of energy efficient digital societies requires a step-by-step or staged process to establish technology standards and policy mechanisms that can keep pace with the rapidly changing technology. Stakeholders must also be ready to accept some exceptions; it may not be feasible or justifiable from an energy efficiency perspective to require some types of equipment to power down.

Rather than viewing network connectivity and interdependence as a barrier to energy efficiency, stakeholders must work together to harness the inherent opportunity.

System-wide approaches and the intelligent use of all technologies and solutions can decrease the energy requirements of networked systems as a whole.

Given the wide range of devices expected to have network connectivity in the near future, the issue will have to be addressed through combinations of different policy options, as well as voluntary industry initiatives. Moving forward, energy efficiency of entire networks, including edge devices, network equipment and network infrastructure, is a key consideration.

Three actions to up efficiency in a digital age

To initiate this plan, the IEA calls for governments, together with industry and other stakeholders, to adopt three measures:

- **develop policies with clear and measurable energy efficiency objectives to:**

- promote power management in network-enabled devices
- stimulate reduced energy consumption in low power modes with network connectivity
- help consumers reduce the energy consumption of their networked devices

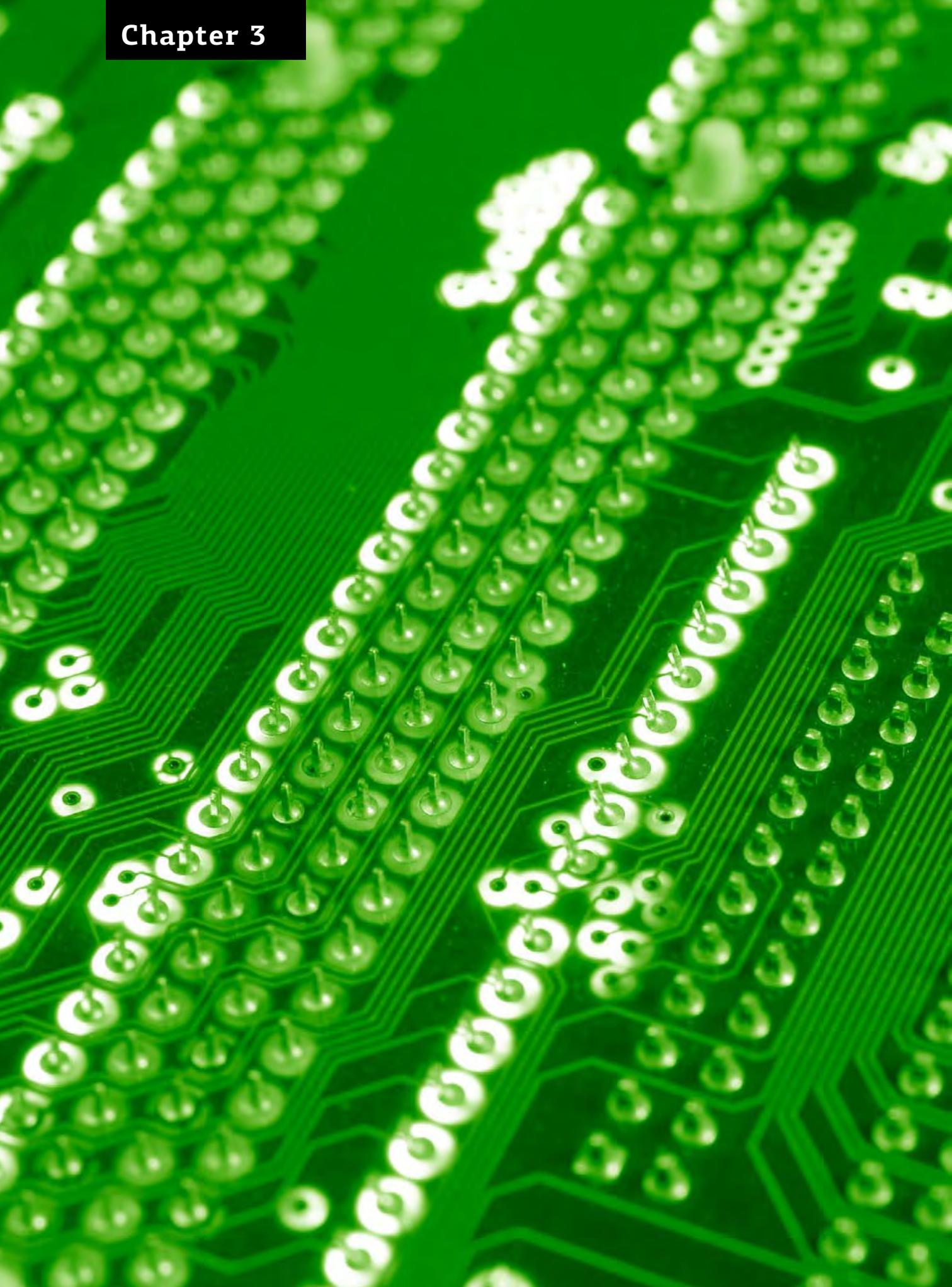
- stimulate the development and uptake of solutions that promote energy efficiency in network-enabled devices and systems.

- **intensify international co-operation to develop technical foundations for policy making, including:**

- data collection and data sharing
- international metrics, definitions and test procedures.

- **work towards establishing or supporting international initiatives to promote energy efficiency in the broader context of digital economies.**

For sources and notes relevant to this material, see Annex E.



Technologies and technical solutions for network standby

Solutions exist to improve the energy efficiency of network-enabled devices; which are most appropriate depends on the type of device and sometimes even on the type of network. While industry has begun to implement some solutions in some products, further efforts are needed to address the issue of energy waste across all network-enabled device categories.

Key points

- Solutions are available and are already implemented in some devices; many solutions are low-cost and could quite easily be incorporated into network-enabled devices and network equipment and infrastructure.
- Design and operation of communication protocols, networks and software are the main routes for improving energy efficiency.
- Energy management solutions focus on prompting devices and equipment to power down to low power mode when not performing primary functions – as quickly as possible and for the longest time possible.
- Power scaling solutions seek to match, minute-by-minute, the power draw in relation to the work being performed by the device or equipment, turning off unneeded functions and adjusting processing power.
- Energy efficiency should be tackled at multiple levels. Optimising individual devices is important, but a holistic “systems” approach is needed to capture the highest level of energy savings while ensuring the performance of functions and interactions is not compromised.

This chapter covers three main areas:

Section 1 explains some of the challenges in developing and implementing technical solutions to network standby and provides insights regarding features of network connectivity that have an impact on achieving energy efficiency.

Section 2 outlines two of the main categories of solutions: a) **energy management** – making sure that devices power down when appropriate; and b) **power scaling** – ensuring

that device energy consumption matches the work being performed. It describes a range of options to achieve these two objectives and discusses when different types of solutions are appropriate and when they can be counteractive.

Section 3 explores some of the benefits and challenges of systemic approaches in greater depth, taking further the allusions in Sections 1 and 2 regarding the need for integrated solutions. This more aggressive approach looks, for example, at the need to partner improvements in devices themselves with changes in communication protocol that would enable energy efficiency.

Section 1: Why is it a challenge to make network-enabled devices more efficient?

Communication networks (such as the Internet) and network-enabled devices have, for the most part, been developed with little regard to energy efficiency. The key considerations were to ensure reliability and capacity among a relatively small number of devices that were dedicated to transmitting and processing data. The situation has changed. Networks and the devices on networks have evolved dramatically in a very short period of time. In just 30 years, the Internet has grown from just a few computers to spanning the globe and connecting billions of devices. Increasingly, homes and offices have local networks that are then connected to wider networks.

Communication networks and information and communication technology (ICT) evolve in response to technological developments and innovations spurred by market demand. This explains why ICT has come to encompass the spectrum from modems and computers to, more recently, traditional devices with ICT capabilities (such as network-enabled coffee makers). Considering the growing range of devices that are now network-enabled – and their sheer numbers on the global scale – an urgent need has arisen to curb their growing energy demand.

Partly a question of what type of network-enabled device

Network-enabled devices are very heterogeneous and different solutions will be needed for different types of devices. The functions that devices provide when connected to networks are a crucial aspect in determining, developing and implementing appropriate solutions. In terms of low power modes, for example, a significant distinction exists between edge devices and network equipment. Many edge devices are used intermittently to perform their primary functions; they spend a substantial amount of time in “non-active” modes, and should be encouraged to power down as quickly as possible and stay in low power mode as long as possible. Conversely, as the primary function of network equipment is to maintain or support communication, the scope for powering down is far more limited. Much of existing network equipment consumes almost constant power, with some variation in demand reflecting the volume of data throughput.

For network-enabled devices, the challenge is to enable them to power down while maintaining a sufficient level of operation to either sustain a network connection or enable the device to power up and resume network connection in a timeframe that does not negatively affect delivery of primary function(s) or service(s).

Some solutions will be specific to certain device types; others target common features and will apply to several device types. In fact, some solutions will not be appropriate for some devices, as they would have a detrimental impact on functionality and could, in certain cases, have a negative effect on the energy efficiency of other devices in the network.

Regardless of the type of device and the purpose for which it will be used, users of network-enabled devices typically need one main feature: rapid action. Resume time is the main characteristic that determines how quickly a device can start up and establish a network connection – essentially, it is the time a device requires to resume a main function after detecting a remotely initiated trigger. Definitions and interpretations of resume time vary: some are primarily focussed on “time-to-application” (i.e. how quickly a device can, from a low power mode, re-start operations); others emphasise “time-to-response” (i.e. how quickly a device can respond to a remotely initiated trigger). Ultimately, the resume time determines a device’s “network availability” (i.e. both how quickly it is available and the total time).

Different resume times – and hence different network availabilities – require different levels of energy to maintain components in an (re)active state. Typically, the faster the reactivation has to be, the more functional components need to be active, and the higher the resulting energy level. The main challenge of reducing the energy demand of network-enabled devices is not about getting them to sleep; it is about making sure that they can respond to valid network requests – i.e. that they wake up quickly when needed.

Partly a question of protocol

As more and more devices enter the digital domain and begin to interact, the potential for chaos and cacophony is high. To make sure the right devices connect – whether through a single link or across an entire network – and can also understand each other, computer programmers establish certain ground rules, known as protocols.

In the same way that common rules for grammar allow many people to “speak the same language”, a network communication protocol sets the standard procedures by which network-enabled devices will connect and interact, including the formatting rules that specify how data are packaged into messages that can be sent and received. Protocols can be implemented in hardware or software, or in both. To participate in a given network, a device must understand, accept and use this pre-determined protocol.

As the digital world became increasingly crowded, programmers began looking for ways to optimise communication protocols, and devised the solution of “layering” network protocols. This technique divides the protocol into several smaller parts, each of which accomplishes a particular sub-task and interacts with the other parts of the protocol in specific and well-defined ways. By keeping the design of each layer relatively simple, layering controls the overall complexity. It also allows protocols to be adapted to specific needs or circumstances. Most protocols are now based on the Open Systems Interconnection (OSI) model, which comprises seven layers, each having specific functions (Figure 3.1).

Network communication is an evolving process and thousands of network protocols have been established – many of which are interrelated. Currently, most protocols require devices to remain awake and ready to respond to signals (messages from other devices) within a short time frame. This makes it difficult or, in some cases, impossible for the devices to power down to low power modes. Poor interoperability continues to hinder energy savings from power management. Router protocols, for example, can impede a network-enabled television from powering down as designed.

Figure 3.1 Open Systems Interconnection (OSI) model


Source: Adapted from ISO (International Organization for Standardization)/IEC (International Electrotechnical Commission) (1996), ISO/IEC Standard 7498-1, Second Edition, ISO/IEC, Geneva, www.ecma-international.org/activities/Communications/TG11/s020269e.pdf.

Key point

Targeted action within the structure of communication protocols can improve the energy efficiency of network-enabled devices.

Aside from ensuring that communication protocols to support energy efficiency are developed and used, other ways exist to circumvent this challenge. Independent energy management is now built in to some PCs and imaging equipment, enabling them to self-manage energy use, unimpeded by network protocols. There are no technical barriers to implementing this independent energy management into other device categories.

Partly a question of networks

Wired networks may use existing electrical or coaxial cabling (effectively riding along on electrical or telephone wires) or Ethernet cables, which are designed specifically for data transmission and serve only this function. Ethernet is becoming increasingly commonplace, particularly in newer buildings and homes, and has clear advantages for energy efficiency. Essentially made up of point-to-point links connected to a switch, Ethernet allows each component to become “non-active” when the device relying on connectivity becomes non-active. When other cables are used to transmit data, they function as a “shared medium” technology with no switches; instead a central controller receives all transmissions and redistributes each to all network-enabled devices. As long as one device is active, the controller must remain active, and it activates all devices on all transmissions.

Wireless networks use radio waves; many different types of wireless networks exist with a common example being Wi-Fi. Energy efficiency in wireless networks can be promoted by enhancing network control – where Internet service providers add or remove resources based on traffic load. Other options include use of service control, where the Internet service provider identifies the types of services that are running in the network and, if appropriate, marginally decreases the quality of service (which can be done by reducing bandwidth, for example). In wireless networks, saving energy may require a reduction in network performance or redundancy.

Partly a question of software

Software components are often the culprits that prevent hardware from performing in an energy efficient way, but software can also be the enabler of energy efficiency. Software solutions used in networked mobile applications can provide a starting point for improving standby power efficiency in plugged-in devices. While a large share of software that enables energy management is proprietary, open source software is expected to play an increasing role in supporting effective energy management, especially when enabling interoperable energy-saving practices across the network.

Software can contribute to energy efficiency in several ways:

- using high-performance algorithms and data structures that complete tasks more quickly, and thereafter allow processors to power down
- using less complex (and more energy efficient) algorithms
- scheduling optimisations that can make application run more efficiently
- using lower-level system programming languages when appropriate, as some high-level languages may cause more frequent wake-ups
- optimising applications to use the longest timer rate possible while still fulfilling the requirements, which enables the device to power down more frequently and for longer periods
- reducing data movement, for example through better use of buffering or memory storage
- matching the application to the core that provides the best performance for the least amount of energy.

Section 2: Main types of technical solutions for network standby

Network devices are diverse and will require a range of technical solutions to improve energy efficiency. Broadly, these solutions fit into two approaches:

- implementing **energy management** by designing devices to automatically reduce the time they spend in high-power modes and increase the time they spend in low power modes
- implementing **power scaling** by turning off unneeded functions and adjusting processing power to the actual tasks that need to be performed.

Energy management for network-enabled devices

Energy management (also called power management) in devices is typically integrated as a feature that prompts the device to enter low power mode following a set period of time after it has stopped performing its primary function. Powering down is relatively straightforward for stand-alone devices, but much more complicated for network-enabled devices.¹

Network communication channels need to be available at any time: this means that devices on network continuously send requests to other devices to check whether they are still present and operational. These devices need to respond in a timely manner (in network terms, timely typically means in milliseconds), otherwise they risk being excluded from further network communication. This means that equipment and devices are either fully “on” (and present on the network) or are powered “off” (and off the network). This constant messaging and need to respond to messages means that network-enabled devices need to stay “on” even when all they are doing is waiting and responding to messages.

Getting devices to power down or go to sleep is relatively easy; the bigger challenges lie in maintaining network connectivity and waking devices up quickly enough to maintain service quality. Successful implementation of energy management depends upon ensuring the ability to resume operations without negatively affecting the net output or services. From the technical side, the question is how much circuitry can be turned off so that, upon resuming operations, the overall network function is not compromised. The rate and quality at which operations can be resumed depends on the amount of resources and operations it takes to return the system to the operational state it was in before suspending operations.

Two main approaches enable energy management in devices connected to networks:

- **powering down without the co-operation of the network**, i.e. implementing solutions that make the network “think” that the device is fully operational when it has actually powered down
- **powering down with the co-operation of the network**, i.e. implementing solutions within networks that allow the networks to understand when devices have powered down and deal with them appropriately (e.g. not waking them up unnecessarily by sending non-essential messages).

¹ The term “powering down” here is used to refer to going from active mode to low power mode(s) not to be confused with turning devices completely off. For network connected devices powering down necessitates maintaining a sufficient level of operation to either maintain network connection or enable the device to power up and resume network connection in a timeframe that does not affect delivery of its primary function nor has a negative impact on delivery of service.

Options to power down devices without network co-operation

To maintain network connectivity, a device must at regular intervals prove its presence to the network and other connected devices. If a device fails to respond to queries from the network, it may lose its place. Currently, networks understand only “present” or “not present”; there is no concept of “sleep”. So, if a device is “asleep” and does not respond when the network sends a signal, it is thrown off the network with the possible impact that it will stop receiving the information required to perform its functions – negatively affecting quality of service (Eckerman, 2013). Sleeping can also prevent running tasks scheduled during times of low utilisation, such as network backups (Nedevshi et al., 2011).

Proxying is a work-around solution that allows a device to “trick” the network into thinking it is awake when it is really asleep. This makes it possible for the device to enter into low power, energy-saving modes when not performing its primary functions without the risk of losing its place in the network. The proxy function is achieved by transferring the task of responding to network messages to a separate entity either embedded in or external to the device itself. The proxy takes over the task of responding to routine network interactions, while most of the edge device goes to sleep. The proxy is programmed to recognise when it needs to wake up the device to respond to essential messages.

Techniques recently introduced into network standards have added an intelligent proxy to the network interface to maintain network connectivity. The ECMA-393 standard (ISO/IEC 16317) of June 2012 establishes the standard for the implementation of proxying relevant to a range of devices including PCs, printers, game consoles and set-top boxes (Ecma International, 2012). The standard sets out how a low power proxy can handle key network tasks for a high power device, allowing the high power device to sleep when not in active use (Ecma International, 2012).

Ecma International identifies other power management options that could enhance energy efficiency, such as having devices detect when the user changes the power source for the device (e.g. unplugs the device or switches from AC to battery) and having it automatically turn off, enter Wake-on-LAN mode (described in the following section) or start proxying. For laptops, a similar option could detect when the device lid is closed, and turn it off automatically (Ecma International, 2012). Hardware improvements would be needed to implement these options.

Proxying is an attractive option for the short term as it does not require changes in communication protocols; it can be implemented as an add-on to current networks. In the long term, it is desirable to optimise network communication for energy efficiency and make sure that devices on the network do not need to respond to unnecessary communication, thereby eliminating the need for options such as proxying. However, this is a much larger and more complex undertaking that requires the concerted effort of a wide range of stakeholders.

Options to power down devices with network co-operation

Several options exist to co-operate with networks to transfer devices from active to low power energy-saving modes. These approaches openly announce device behaviour to the network and to other connected devices, so they can take it into consideration and adjust their own behaviour so as not to wake the device up unnecessarily. Instead of hiding the low power mode of the device, as in proxying, these options are more like hanging a “do not disturb sign” on the door of a hotel room.

Adjusting peripherals to leading device: in systems where one leading device has associated or peripheral devices, one option is to have all associated devices adjust their power modes in relation to that of the leading device. For instance, if a television is asleep, the networked sound system would also power down, as is already routinely done in the

case of PCs and monitors. Implementing this approach requires carefully considering how it should be included in relevant technology standards.

Reducing or filtering network traffic: networks in the home and office typically have traffic 24 hours a day, even when no one is present (Eckerman, 2013). Analysis shows that a significant proportion of network traffic is not essential information but rather a by-product of how communication protocols have been designed. Many of the communication packets sent on the network are distributed to all devices, not just the intended device. Adding a filter could allow most devices to ignore packets not targeted to them. Other methods exist to reduce useless network chatter or limit its impact. Lossless packet operation targets specific devices, waking them up to receive and respond to the packet; this approach ensures that essential packets of information get to the dedicated device and that no important packets are lost (Eckerman, 2013).

Wake-on-LAN (WoL): this Ethernet computer networking standard lets devices go to sleep while still maintaining their network link by using a “Magical Packet” (a special network message) to turn on or awaken a device when an essential message is arriving. In this mode, the edge device is unresponsive to network traffic except for the Magic Packet, and resumes network activity only upon its receipt. This approach is primarily applicable for edge devices when another network-enabled device initiates the wake-up call. For network equipment and networked infrastructure devices, the WoL mechanism is used less frequently and only in co-ordination with other devices under a centralised control. WoL has been developed for wired (Ethernet) and wireless networks (Wake-on-Wireless).

Box 3.1

Solutions also depend on the type of network that devices are connected to

Considering the wide array of networks and of communication protocols that define their functions and operations, it is not surprising that interoperability issues sometimes arise – i.e. that only devices with a certain set of communication protocols can fully interact with other devices on a given network. These factors may also affect the implementation of solutions that promote energy efficiency. Fortunately, efforts are underway to improve interoperability and standardisation, and to design custom solutions for specific network environments.

ECMA-393, for example, does not include a proxy solution that works in Universal Plug and Play (UPnP) or Direct Local Area Networks (DLAN) environments.

Networking protocols for UPnP permit network-enabled devices (such as PCs, gateways, Wi-Fi access points and mobile devices) to discover each other's presence and establish network services for data sharing, communications and entertainment. UPnP is intended primarily for residential networks.

DLAN is a home and office networking solution that uses the electric wiring already installed in buildings. The Digital Living Network Allowance (DLNA) has developed a Low Power functionality solution that works in these network environments, based on two fundamental premises:

- a physical device is the only entity capable of knowing all of its internal resources and considerations for energy management
- a modern physical device typically has multiple functions.

If a physical device decides to place one or more of its network interfaces in a reduced power state, there are two implications to normal operations:

- discovery of the physical device could be impaired or unusable
- the physical device could be unaware of the intentions of the edge devices.

DLNA Low Power functionality enables network power save by allowing modules within a device to be in non-active states, yet provide a means for timely response for consumers using edge devices.

The DLNA Low Power functionality consists of three primary aspects:

- **Service subscription:** allows edge devices to indicate which resources are needed so the network equipment can make informed choices on how to reduce power consumption while limiting disruption to edge devices.
- **“Wake On” patterns:** uses various physical network interface technologies to allow a network interface to be non-active other than to recognise a specific bit pattern – commonly referred to as “Wake On”. DLNA Low Power functionality allows a device to advertise “Wake On” patterns on the network so that they can change its network interface state.
- **Proxied network interface information:** allows a server device to be immediately discoverable by client devices, even if the server device network interfaces are currently non-active.

Progress and remaining challenges

Manufacturers in some categories (e.g. PCs and imaging equipment) are starting to implement solutions that allow devices to maintain network connectivity while “sleeping”, a necessary and welcome step in energy management leadership. Powering down to low power modes when not in use has advanced to microseconds for some devices. Faster resume times are also underway, taking into account that “a reasonable period of time” depends on device function and user expectations. Yet simple power management functionality may not be sufficient to expedite or optimise energy savings in this area; work is needed to ensure resume times are tolerable for different device categories. Recent advances for computers, imaging equipment and other high-end devices need to be mainstreamed in other device categories.

Technologies that actively support efficient energy management in devices are entering the market. Yet widespread technological development, and the establishment of and adherence to standards, are lacking. Further and faster progress requires more concerted action on the part of all stakeholders, from standardisation organisations to industry.

Making solutions even better

Solutions such as Wake-on-LAN require continuous AC power, as much as 0.5 watts, to monitor wake-up signals. This energy requirement is to a large extent due to power loss in AC-DC conversion. Research is ongoing on solutions that would address these losses and enable devices to power down to virtually zero energy consumption. To avoid conversion losses, it could be possible to eliminate the need for AC power supply by, for instance, use of a pre-charged capacitor (an electrical component that stores energy electro-statically in an electric field) when the device needs to monitor wake-up signals. Implementing such a solution also requires a special communication protocol that would be used only for powering down and powering up. Initial demonstrations indicate that such solutions can be implemented and that it is possible to maintain network functionalities while letting devices power down to zero watts – further slashing power requirements for low power modes with network connectivity by a factor 17 (Tanizawa et al., 2013).

When is energy management counterproductive?

In some cases, energy management is not an appropriate solution; it may be irresponsible or short-sighted to autonomously power down, manage or change the connection state

of devices that rely on the network to conduct a major function. Security cameras and monitoring devices, for example, should not autonomously power down or suspend operations, just because no security issue has been identified. In such instances, security cameras may suspend video capture but need other functions (e.g. network drivers enabled) to respond in a timely manner to a security event. Energy savings in such systems can be achieved as a co-ordinated function across the network and among multiple devices. In many cases, the network state is maintained while other parts of the system may be suspended to reduce the overall energy consumption (ITI, 2013).

Energy management is also inappropriate for large data transmission hubs, even under periods of moderate inactivity. If some devices along the path are in low power mode, large context-contiguous data content can easily run into bottlenecks. Resetting the task and the devices along the path could expend more energy for the process of recovering operations than what was saved by lowering the power level. Inappropriate use of power management could, for example, entail the need to reset a two-hour modelling application because equipment that was essential to relaying information had powered down and was unable to respond in the required timeframe (ITI, 2013).

For network equipment – i.e. devices whose primary function is to ensure the functioning of network communication – completely powering down is not an appropriate solution. However, it may be possible to power down parts of the equipment without having an impact on functionality (examples of how this can be done are provided in the next section on power scaling).

Proxying facilitates powering down, but is less than ideal on several counts. Some technical options entail longer resume times for the device to wake up from low power modes, which can negatively affect the device's ability to stay on the network. Some applications require very short resume times; if the proxying solution cannot respond quickly enough, the device can cease to be a viable component of the network. Aggressive energy management that results in disconnecting devices from the network can drive increased energy consumption in other parts of the network.

Longer resume times may also be perceived by the user as an unacceptable level of service quality; as technology has evolved, so have user expectations for instant "on" and instant gratification. For some devices (e.g. televisions and personal computers), users expect a very short resume time; they are willing to wait longer for other types of devices (e.g. printers).

Devices that are primarily machine-to-machine (M2M), with no direct human user demand but involving multiple machine requests, have almost no tolerance to resume times. Similarly, tasks that require large computing and storage resources, such as model convergence, would not tolerate resume time.

Power scaling for network-enabled devices

While energy management might not be an appropriate solution in all circumstances, other options can be used to improve energy efficiency of network-enabled devices. Power scaling enables a device to dynamically and proportionally change its energy consumption as its workload varies. Options to achieve this include, for instance, light sleep, optimised scheduling, selectively operating sub-systems, dynamic power savings, power islands and Energy Efficiency Ethernet (EEE).

Light sleep: refers to a condition of low energy consumption that allows devices to perform essential internal activities while shutting down other tasks. Application of light sleep in set-top boxes, for example, supports tasks such as video displays and channel tuning. Lab tests indicate that transitioning set-top boxes, when possible, from active to light sleep provides 20% or greater energy reductions (Fitzgerald, 2013).

Optimised scheduling: improved scheduling of tasks also creates opportunities to reduce energy consumption in low power modes. Smart TVs and set-top boxes need to regularly update electronic programme guides and the conditional access keys that determine which channels the viewer can watch. Rather than keeping these devices in active mode or high energy consuming idle mode for the purpose of continuous updating, it is possible to make the device stay in low power mode and wake up just in time for the signal for updates.

Multi-core processors: cores or central processing units (CPUs) lose a portion of the energy used as heat due to impedance (the opposition that a circuit presents to a current when a voltage is applied) of electronic circuits. Although much progress has already been made in improving the energy efficiency of cores, the energy demand of high-performance cores is still considerable and varies significantly among different cores in the same performance bracket. This indicates clear opportunities for improved energy efficiency; in some cases, the use of multiple cores can improve energy efficiency.

Dynamic power savings: for network equipment, either a single chip or integrated circuits are responsible for the operation of many ports. Typically, less than 50% of ports are in use at any given time, but the circuit cannot cut the power on any individual port. Redesign of chips to create individual power islands for each port would enable powering down of idle ports. Further savings could be unlocked through redesign that would adjust capacity based on throughput or port utilisation.

Power islands: the concept of power islands is to group various segments of the circuitry with a single power supply. Neighbouring groups have their own supplies. This division enables islands containing unused circuits to power down to low power states without impacting the device's ability to operate. This means that each island could be supplied with the minimal amount of power and frequency to meet its performance and response needs, which may change over time. This approach is still under development and not without challenges, a main one being that the process of powering up or down can affect neighbouring islands. Work is underway to address this challenge; as power islands are already used in some mobile phones and in computer processing units, solutions may be forthcoming.

Energy Efficient Ethernet (EEE): this technology standard for Ethernet Local Area Networks (ELANs) includes mechanisms to scale the energy required by a network link in proportion to data utilisation. It works by running the high rate link in low power idle (LPI) mode when throughput is below maximum, while allowing transmission to be resumed in microseconds (Christensen et al., 2010). By reducing energy consumption during low data activity cycles, EEE can reduce by more than half the amount of energy required by the edge device, without interfering with or disrupting operations. This energy-saving function is enabled only when the two devices communicating (e.g. a computer and a modem) both support EEE. When network equipment (e.g. the modem) uses its EEE functions on transmission paths, the edge device (e.g. the computer) can save power on its receiving paths. The standard defines compatibility protocols that allow the communication link and the edge device to go into a lower power state. As EEE is a technology standard for communication protocols, its implementation does not involve any additional cost for device manufacturers.

Section 3: Optimising networks for energy efficiency

Tackling network standby – getting devices to power down and to use as little energy as possible to deliver primary and secondary functions – is an essential step towards ensuring that increasingly digitalised economies are energy efficient. It is, however, only one part of a much larger issue. Leading experts concur that the largest energy savings opportunities are found in optimising whole systems rather than just the individual components. Electricity is consumed along all parts of networked systems: by edge devices, by network equipment, and by network infrastructure. While significant energy efficiency improvements can be achieved in one of these individual devices, or even in a particular part of the chain, it is now clear that unlocking potential savings in some of these elements (e.g. the end-use device) requires introducing solutions in others (e.g. networking devices).

A piecemeal approach that focusses on different parts of the system, one by one, may not deliver the full savings potential. In fact, it could be counterproductive: fixing one part of the system without considering system implications could result in shifting of electricity consumption to other components. More holistic approaches that seek to optimise efficiency across entire systems can unlock even bigger savings.

For more integrated and sustained policy and technology development efforts towards ICT energy efficiency, a process is needed to assess how each part of the system contributes to overall energy consumption, and to introduce appropriate solutions that improve system-wide energy efficiency. A systemic approach to ICT energy efficiency calls for a comprehensive examination of all the elements within the network infrastructure, from the end-use device to the server or data centre, with two requirements:

- understanding the complexity and interdependency of multiple devices and equipment on a network
- mapping the relationships between network-enabled devices and any real needs those devices have in terms of availability to receive and transmit information to each other (Energy Efficient Strategies, 2010).

To increase the energy efficiency of whole networks, it is also necessary to know how much power each element in the network uses over the full range of traffic loads and profiles.

While considerable energy savings opportunities exist in improving edge devices and network equipment, integrating energy efficiency considerations in the earliest stages of network design will encourage the development of approaches to enable energy management and waste reduction across the whole network (Energy Efficient Strategies, 2010).

The case for more integrated approaches to digital energy efficiency

As soon as a device is able to connect to a network, it is fundamentally different from a stand-alone device that provides the same or similar primary function(s). Its energy consumption is affected by the network itself and other devices on the network.

While efficiency can be improved in a given end-use device, another device on the network or the network itself may not let the end-use device behave in an efficient way. In some instances, energy savings can be unlocked if improvements (e.g. in communication protocols) are made simultaneously in the edge device (e.g. the computer) and the network device (e.g. the router) with which it interacts.

In other instances – from a wider energy efficiency perspective – it can make sense to use more electricity in some parts of the system to enable larger savings in other parts. For example, a centralised system (i.e. home gateway or security system) that provides power management functions, such as enabling users to power down network-enabled devices, may need to be in active mode continuously or power down only to a limited extent but in return can contribute to decreasing the overall electricity consumption of the system (Ecos, 2011). Conversely, if reducing the power levels of network equipment, such as modems or routers, causes a reduction of functionality, this can create bottlenecks that ultimately drive up energy consumption for end-use devices, which are forced to remain active for longer periods to compensate for networking delays.

Optimising network operation

Optimally, data should be transmitted upon demand via networks among various devices and equipment – quickly and without errors. As speed and density of data traffic increases, however, so do the chances for errors. Network stalls and requests to resend packets increase energy consumption. The need to resend data packets can slow down the effective throughput, having increased activity at both ends of the communication link. Take, for example, a situation in which two servers are on either end of the network. The server sending data may be busy re-training the link, queuing the information and sending packets – activities that require high levels of energy consumption – while the other server is simply waiting for data transmission before processing the information (i.e. a low energy activity).

Such bottlenecks can be a major roadblock to energy efficiency across the network, which explains why devices that manage the network and network infrastructure resources are typically controlled in a centralised manner and rarely left to power down. Progress is underway to develop technologies that better automate management processes and fulfil the negotiation function among machines to determine when it is appropriate to enter low power modes (ITI, 2013).

Signal integrity, data volume, speed, compatibility and flexibility are key characteristics to ensure well-functioning, efficient networks. High-speed communication is feasible only if it can ensure error-free transfer of data to the end points, i.e. to the devices and equipment connected to the network. Sophisticated error correction mechanisms help to improve effective throughput and reduce data resend requests. While these mechanisms may increase the power profile of some of the devices on the network, they improve overall network efficiency by reducing bottlenecks (ITI, 2013).

Next steps

The priority for energy efficiency needs to be raised throughout the value chain of network-enabled devices – in software, network design, network architecture, communication protocol development, technical standardisation processes, service providers, and device and component manufacturing. In addition, users will need to be open to changes in how their devices function and perhaps modify their behaviours. In the wider context of ICT and increasing digitalisation of global economies, a strong case must be made for co-operation in tracking trends, assessing energy implications and energy savings opportunities, and identifying areas that warrant energy efficiency technology and policy attention.



Everyone has a role to play

Due to the interdependencies created by network connectivity, improving energy efficiency requires efforts by a range of stakeholders. Policy makers, standards development organisations, intellectual property providers, software and hardware developers, device manufacturers, network designers, service providers, telecommunication industry and consumers all have roles to play in addressing the issue of network standby.

Key points

- *Realising the potential energy savings associated with efficient network standby requires a highly integrated international effort, involving a multitude of players in the development and application of both technical and non-technical solutions.*
- *Policy makers have a unique leadership role – not only to draw countries together into an integrated international effort, but also to ensure standards organisations and industry are enabled to play their roles.*
- *Each player in the network system value chain has a role to play; international co-ordination is vital to ensure that efforts to establish effective policy keep pace with international progress on the technology side.*
- *Addressing network standby energy consumption effectively requires strategic action at all points of the value chain – in device design, hardware and software development, end-use device manufacturing, etc.*
- *Because the aim is to ensure that network-enabled devices can perform individual functions and interact efficiently, solutions must be developed in parallel.*
- *The device value chain comprises diverse players, many with highly specialised areas of expertise. Co-operation among all parties will be necessary to develop a comprehensive and strategic plan.*

ICT and network-enabled devices are produced in greater numbers and with greater variation than any other traded device. To allow these increasingly innovative devices to reach their potential, reliable and transparent processes must underpin the development of policies, standards and related initiatives. Many market players, including consumers, need to participate in these processes. This section looks at the different roles that will contribute to developing and implementing solutions to promote energy efficiency. In this very early stage, the role of policy makers in establishing a framework for action is examined first; following a summary of the points along the value chain at which action is needed, the text aims to identify who is best positioned to act at different points.

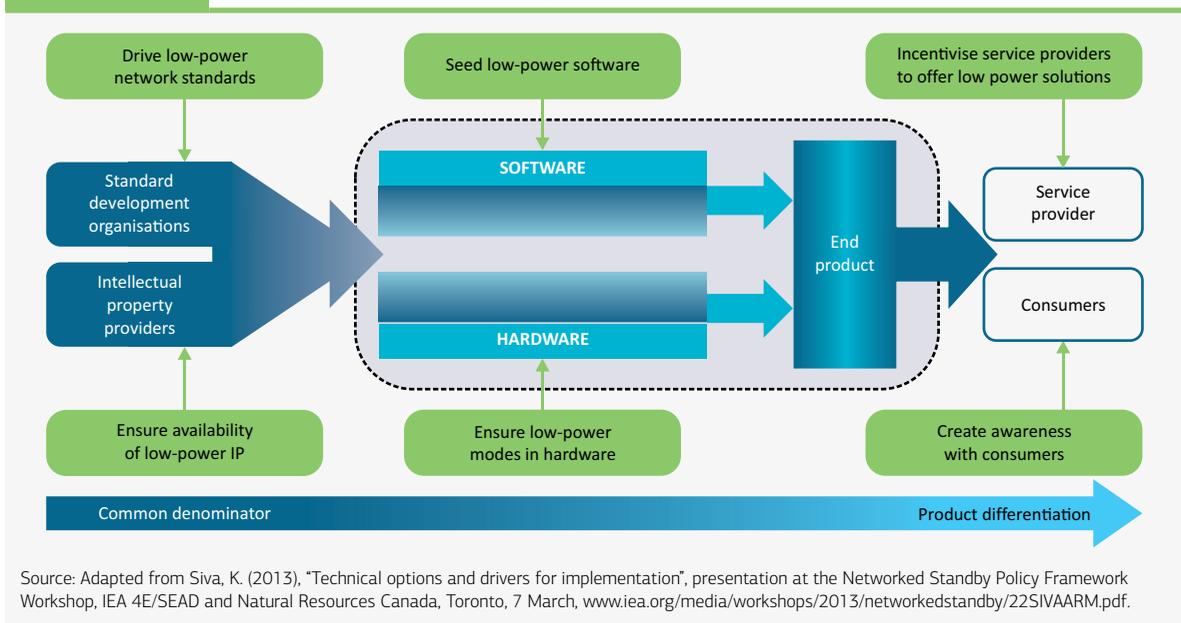
Integrating energy efficiency considerations across the value chain: A collective effort

Improving energy efficiency across the value chain requires the involvement of multiple stakeholders. The value chain of network-enabled devices spans multiple sectors – computing and electronics, appliance and equipment, and media and telecommunications, for example – each of which are complex in unique ways. In fact, as network-enabled devices are a very heterogeneous group, the value chains for specific device categories are dramatically different. The various elements of the computing, electronics, media and telecommunication sectors have evolved complex ecosystems in which supply chains are split among multiple specialised players.

Policy makers, standards development organisations, intellectual property providers, software and hardware developers, device manufacturers, network designers, service providers, telecommunication industry and consumers each have roles to play in addressing the issue of network standby. Yet all must also work together. None of the stakeholder groups have clear-cut roles; instead, opportunities depend very much on actions taken by other stakeholders along the value chain (Figure 4.1). The value chain is not a linear construct but an interdependent and integrated process with multiple points of interaction and feedback loops.

The following sub-sections explore the roles of different stakeholders including:

- **Policy makers**, in developing policies and measures for different parts of the value chain to engage in energy efficiency and ensuring that the pre-conditions are in place to develop and implement energy efficient devices and systems, can provide incentives and establish market drivers.
- **Standard development organisations and intellectual property providers** create the foundations and technical standards to enable development of energy efficient software and hardware solutions.
- **Software and hardware developers** design solutions that can be used by manufacturers of devices.
- **Device manufacturers** bring together software and hardware solutions, thereby determining the energy performance and energy efficiency features of devices.
- **Network designers** establish the terms on which devices can connect to networks and how they need to operate to be part of a network; they also ensure that network communication supports energy efficiency in all connected devices.

Figure 4.1 Energy efficiency along the ICT value chain

Key point

Opportunity for energy efficiency exists throughout the ICT value chain; optimal efficiency requires concerted efforts.

- **Service providers** that provide Internet or other digital services to end users manage bulk purchases and deploy large quantities of devices; they can be instrumental in creating a market for more energy efficient devices.
- **Telecommunications industry** ensures the development and implementation of network design that supports energy efficiency.
- **Consumers** can, with proper guidance, make energy efficient purchasing decisions and adjust the settings of their devices to reduce energy consumption.

The chapter concludes with an example illustrating how stakeholder co-operation can unlock bigger savings than if stakeholder groups were to work on energy efficiency independently.

Role of policy makers

Overall, market drivers for improving the energy efficiency of network-enabled devices are weak. Policy makers thus play an important role, notably in creating alternative drivers and in stimulating R&D. They can also promote progress by encouraging international co-operation and supporting international standardisation processes.

Policy makers can be instrumental in bringing together key stakeholders through voluntary agreements or cross-sectoral forums. Widely deployed policies, such as minimum energy performance standards (MEPS) or requirements, could improve energy efficiency across many categories of devices. MEPS that target device manufacturers can be a critical instrument to capture energy savings opportunities, particularly given the difficulty of

communicating network standby information in a clear and concise way to consumers and the relatively low per-unit savings potential. But the importance of increasing public understanding of the benefits of MEPS and gaining their support for this policy approach should not be underestimated. Creating consumer awareness and stimulating consumer demand for more energy efficient devices would facilitate the setting of energy efficiency regulations and incentivising low power solutions.

While technologies already available could substantially cut energy consumption of network-enabled devices, further R&D is needed. Policies and targeted funding can stimulate the development of new technologies and solutions. Policy makers therefore need to ensure political commitment and effective resourcing of the integration effort. Chapter 5: Network standby policy options describes various mechanisms policy makers can apply.

Role of standards development organisations

A number of standardisation organisations within each domain are actively working on issues related to network standby and energy efficiency through their role in the development of technology standards and as platforms for the exchange of information among different stakeholders. Technology standards are consensus-based documents that specify how devices, components or communication protocols operate. They outline requirements, specifications, guidelines or characteristics that can be used consistently to ensure that materials, devices, processes and services are fit for their purpose. Beyond their main role of ensuring interoperability and device quality, technology standards also play an important role in supporting policy making. Such standards can also directly support energy efficiency, for example through energy management standards or energy efficient communication protocols. International technology standards provide a means for industry-wide technical review and feasibility assessments, independent of regional conditions or preferences.

Technology standards can be developed on industry, national, regional or international levels, and may be initiated by international bodies or by industry itself. Indeed, increasingly, these organisations are establishing joint committees to co-ordinate their work, yet scope exists to increase collaboration to avoid overlaps and to utilise resources effectively.

As network-enabled devices are globally traded goods, a strong case exists for the development and use of international standards. International standardisation organisations are non-partisan bodies where transparent and defensible process can promote development of effective standards and practices. They play an important role in levelling the playing field for market participants in a given sector.

International standardisation supports policy-making efforts by providing harmonised practices in relation to terminology, test procedures and data collection, and policy implementation. International device standards play an important and growing role in support of energy efficiency policies. Standards can provide valuable support for policy making including through the provision of:

- test methods that can provide repeatable and reproducible determinations of energy performance in specified energy-using appliances and equipment (covered in Annex A)
- efficiency metrics that determine how energy efficiency will be defined
- energy performance thresholds, requirements or targets for defined equipment, measured according to a specified test method and efficiency metric (Waide, 2011).

From a policy-making perspective, accelerating standardisation is vital to the urgent need to address network standby concerns. Clear benefit would be gained even more quickly if standardisation organisations would ensure the active participation of a wider range of stakeholders, including non-governmental organisations and policy makers, in the process of identifying and developing necessary standards.

In terms of energy efficiency for network-enabled devices and systems, a further priority areas for ICT standards is the development of network communication protocols that promote energy efficiency and interoperability.

Industry standards are generally accepted requirements followed by the members of a particular industry. The process of developing industry standards is more flexible than the development of technology standards. It is driven by groups of industrial players who work together to find solutions that can be taken up by part or the entire industrial sector or sub-sector. Often the concepts and ideas elaborated by industry standards are later adopted by national or international standardisation organisations and developed further in a more formalised process.

Role of intellectual property developers

Research and development (R&D) are fundamental to energy efficient solutions and technologies in any field. The role of researchers and innovators is particularly strong in rapidly developing sectors, such as ICT. While research, development and innovation are needed across all ICT-related areas, the most pressing need is for solutions that promote energy efficiency. Governments, funding organisations, venture capitalists and industry all have important roles in enabling, supporting and stimulating the development of such solutions by these researchers and innovators. For instance, as part of their efforts to reduce the energy demand of network-enabled devices, the Korean Ministry of Trade, Industry and Energy is funding (at KRW 4 billion or USD 3.7 million)¹ the three-year project *Development of Chip Power Supply Unit & HiNA (High Network Availability) Scheme for Smart Appliances Power Saving*. The project, which involves research institutes, standardisation organisations, integrated circuit and other component manufacturers, and the manufacturers of devices, aims to reduce the power consumption of network-enabled devices to 2 W (when they are not delivering their primary function) (Jung, 2014).

Role of software and hardware developers

Software and hardware developers develop the products and components that are integrated into network-enabled devices. Their work is supported by intellectual property developed within their companies or sourced from companies or organisations conducting R&D. Energy performance of network-enabled devices and systems depends on both software and hardware components, as well as on the interactions between the two. Thus, software and hardware developers play a key role in enabling the development of more efficient devices.

In fact, the scope for increased collaboration is considerable. Many of the solutions for power management and reducing energy consumption in low power modes when devices are connected to networks will require installation of compliant hardware and software at both ends of the relevant link. Component, software and system manufacturers can

¹ 2013 average exchange rate of KRW 1 073 per USD.

incorporate power awareness into design, thereby enabling budgeting and conservation of energy. Such power awareness includes impact on interoperability and energy consumption across the network. Progress to develop solutions in this area is ongoing (ITI, 2013).

Role of device manufacturers

Manufacturers decide what software and hardware solutions to use, and if and how to implement power-saving features in their devices. While policies and requirements play an important role in prompting manufacturers to improve the energy efficiency of their devices, manufacturers can take the lead. Manufacturers can develop high-efficiency devices with performance levels well ahead of set requirements, or improve the efficiency of their devices even in the absence of requirements. In many cases, improving energy efficiency is simply a good business decision: it can reduce heat generated when devices are running and thereby extend performance and lifetime, which could ultimately reduce costs of service and warranty agreements. More energy efficient and greener devices can also be a marketing point.

Manufacturers can also help consumers to be more efficient by providing power management options on easy-to-access menus, making the choice of saving energy readily available to the user, or through manual power-saving options that allow users to implement their own energy-saving routines. Manufacturers have a role in ensuring that power management is implemented in a way that ensures or enhances the device's functionality and usability from both the end-user and network perspectives. Clear user instructions on how to ensure optimal power management of devices could also be provided. If appropriate, manufacturers could use selective deactivation of power management functionalities to prevent users from disabling features that reduce the energy consumption of devices.

Role of network designers

The key focus area of network designers has generally been to increase the speed, quality and quantity of data and information that can be transferred over the network. Energy efficiency has not been incorporated into design processes as it is not identified among typical marketplace goals. Stressing the importance of energy efficiency in the context of network design is a crucial step that should include exploring the co-benefits of energy efficiency, such as increased lifetime of equipment due to lowered heat and reduced costs for key stakeholders. These and other types of benefits should motivate network designers to work more actively on energy efficient protocols, configurations and solutions.

Role of service providers

Service providers make bulk purchases and then deliver vast numbers of network-enabled devices, such as set-top boxes – and could take a lead role in bringing together the stakeholders that can influence energy consumption. When choosing devices and suppliers, service providers can require a certain level of energy efficiency, specific energy management features and appropriate use of energy-saving protocols. Service providers can also fulfil the role of delivering software updates that could enhance the efficiency of existing devices or carry out device replacement schemes.

The current business model for service providers and customers creates a clear example of split incentives: the end-user benefits from lower operating costs for a more efficient device, but there is no incentive for service providers to deliver a device with optimised energy consumption to the end-user premises. To tackle this, measures or mechanisms are needed to redistribute the costs and benefits. One option could be to make the service provider responsible for the cost of electricity consumed by devices delivered, but large differences in electricity prices within regions or countries would complicate implementation. Also, in many jurisdictions households can change their energy supplier, which affects electricity costs. Part of the solution could be to get the set-top box to record usage so that hours watched could be billed to the end-user while the cost of electricity consumed in standby mode would be covered by the service provider.

Service providers in several countries are taking a pro-active role to promote energy efficiency; this is an area that warrants a concerted effort in regard to technology development and policy measures.

Role of telecommunications industry

The telecommunications industry and telecommunication service providers are increasingly working to develop more optimised and scalable networks. They play a crucial role in paving the way towards improving end-to-end network efficiency, and in providing solutions and services for more sustainable communication and networked computing. The development of optimised network architectures, intelligent management and control algorithms can enable energy savings across entire networked systems from data centres to end-use devices. These actors can also support research, development and innovation through collaboration with universities and research centres.

Role of consumers

While one might be tempted to see substantial savings potential if consumers simply made a point of switching off or unplugging devices they are not actively using, in the case of network standby, this is not very realistic or even desirable. On an individual device basis, the cost benefit of consumer action is small. Some devices can be switched off and disconnected from the network with no effect on their functionality or ability to deliver services; others must be continuously connected to deliver their primary functions; to perform the services that users expect with no loss of reliability, staying on line is critical.

Unplugging an Internet phone, for instance, is not an option if the user wants to receive calls. Turning off a set-top box or smart TV could lead to programmes not being recorded or require resetting of user selectable features. Unplugging the modem is not an option if the user wants to access the Internet. In the future, disconnecting home network components in environments implementing smart grid functionality would eliminate the capability for demand response management and negate the energy savings potential of smart grid implementations. As networked systems become more complex, it is increasingly unfeasible for users to switch off devices or to understand how turning off one device will impact on other connected devices.

Automated power-down from active to low power modes is one of the largest energy savings opportunities. Increasingly, devices are being shipped with power management

features; but most users do not use devices as shipped and do not optimise settings. Even when devices are sold with automated power-down enabled by default, many consumers disable this feature at some point in the life of the device for a number of reasons ranging from convenience issues to exceptional needs, and often forget to re-enable them.

Even in regards to devices that have been on the market for a long time, awareness about power management options and features is still limited, as is the interest of users to engage in optimising power management. A 2010 Australian standby survey found that, compared to the 2005 survey, the number of residential computers left on all day, every day, had doubled (Energy Efficient Strategies, 2011). In an office context, surveys have found that computers are on average left unattended and switched on 28% of the time, corresponding to an average wasted energy of 110 kWh/yr per computer (iMinds, 2013). A UK study found that 18% of office computers are never switched off at night or on weekends; a further 13% are not switched off on some days each week. The resulting energy wastage is estimated to amount to 1.5 TWh/yr, costing about GBP 115 million (USD 190 million). Other surveys indicate that 38% of UK employees and 32% of US employees who use PCs either do not know what their power settings are or how to change them (Alliance to Save Energy and IEA, 2009).

Achieving significant consumer awareness and understanding of the complexity of network standby would be exceptionally difficult. By embedding network standby considerations in existing efficiency labels such as ENERGY STAR, and continuing to develop consumer awareness and demand for these labels, consumer organisations and policy makers can leverage consumer purchasing behaviour to increase the deployment of devices that are efficient by design.

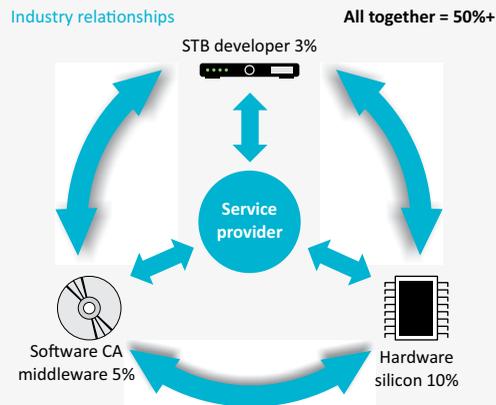
Consumer organisations can play an important role in raising awareness of energy wasted and creating demand for more efficient solutions. Other players, such as manufacturers, retailers and service providers, can raise awareness and inform consumers on how to use their devices more efficiently. As part of their demand-side management programmes, energy utilities and energy provider companies could provide education and support in the form of incentives to enhance consumer awareness and interest in managing the energy of their networked devices. Public education campaigns on powering down devices and energy management could help generate consumer awareness and action.

Working together unlocks larger savings potentials

Getting multiple stakeholders working together has the potential to deliver larger energy savings than efforts that target only devices or components. As seen in the case of set-top boxes, measures aimed only at end-use device manufacturers can deliver savings in the range of 2% to 3% (Figure 4.2). Measures adopted through software and middleware can deliver 5% savings, while hardware can deliver 10%. If these groups and the service providers were to work together, savings of more than 50% are possible (Turner, 2013). Creating opportunities for multiple players to work together to promote energy efficiency is expected to deliver higher energy savings in shorter periods of time also for other device groups and even across device groups.

Figure 4.2

Stakeholder influence on energy efficiency in the set-top box value chain



Source: Adapted from Turner, R. (2013), "Network standby", presentation at the Networked Standby Policy Framework Workshop, at the IEA 4E/SEAD and Natural Resources Canada, Toronto, 7 March, www.iea.org/media/workshops/2013/networkedstandby/8RobertTurnerNEWSlides_040313.pdf.

Key point

As shown in the example of set-top boxes, collaboration among network standby stakeholders can enable cumulative energy savings that far exceed the sum of individual energy efficiency improvements.

Network standby trends confirm the need for rapid policy action

65% the potential to reduce electricity consumption of network-enabled devices by ensuring they power down and remain in low power modes for as long as possible

Determining what would happen in the absence of policy action is relevant to the discussion of network standby initiatives. While largely hypothetical, an exercise in

trends analysis helps to identify trajectories and possible impacts, as well as the effects of policies on both.

Rising demand for network-enabled devices

55% projected percent of “smart” televisions on the global market by 2015

x 4 projected growth in average number of network-enabled devices per US household: from 4 to 16 in just a few years

Current growth in the deployment and uptake of network-enabled devices is more exponential than linear, and the global market is far from saturated. Recent trends show:

- high growth rate for most device categories
- expanding categories of network-enabled devices

- rapid development of associated technologies.

Unexpected and disruptive innovation is a core feature of the ICT sector; the likely ongoing and growing effect is that many current devices will be displaced by new technologies and solutions.

Being connected 24/7 drives up power consumption

1 140 TWh/yr projected global standby electricity consumption of network-enabled devices by 2025

739 TWh/yr projected global energy waste/savings potential from inefficient network standby by 2025 – more than the current yearly electricity consumption of Canada, Denmark, Finland and Norway combined

Power consumption by ICT is rising as a whole, with particularly strong increases seen for network-enabled devices:

- 40% of ICT energy consumption will power network-enabled devices
- 65% of this will be used just to maintain network connection.

Increased ICT traffic flow due to uptake of network-enabled devices will require greater capacity in terms of network equipment, network cables and data centres, further increasing energy demand in the ICT sector.

Although the rush to market tends to take top priority, industry characteristics create opportunities to realise energy savings:

- Mobile technologies are front-runners in energy efficient solutions and technologies.
- Edge devices, with a high rate of development and replacement, evolve quickly.
- Incremental progress towards higher efficiencies is evident in mains-connected devices.

Motivation for energy efficiency is lacking, particularly in initial generations of devices: first generation aims for first-

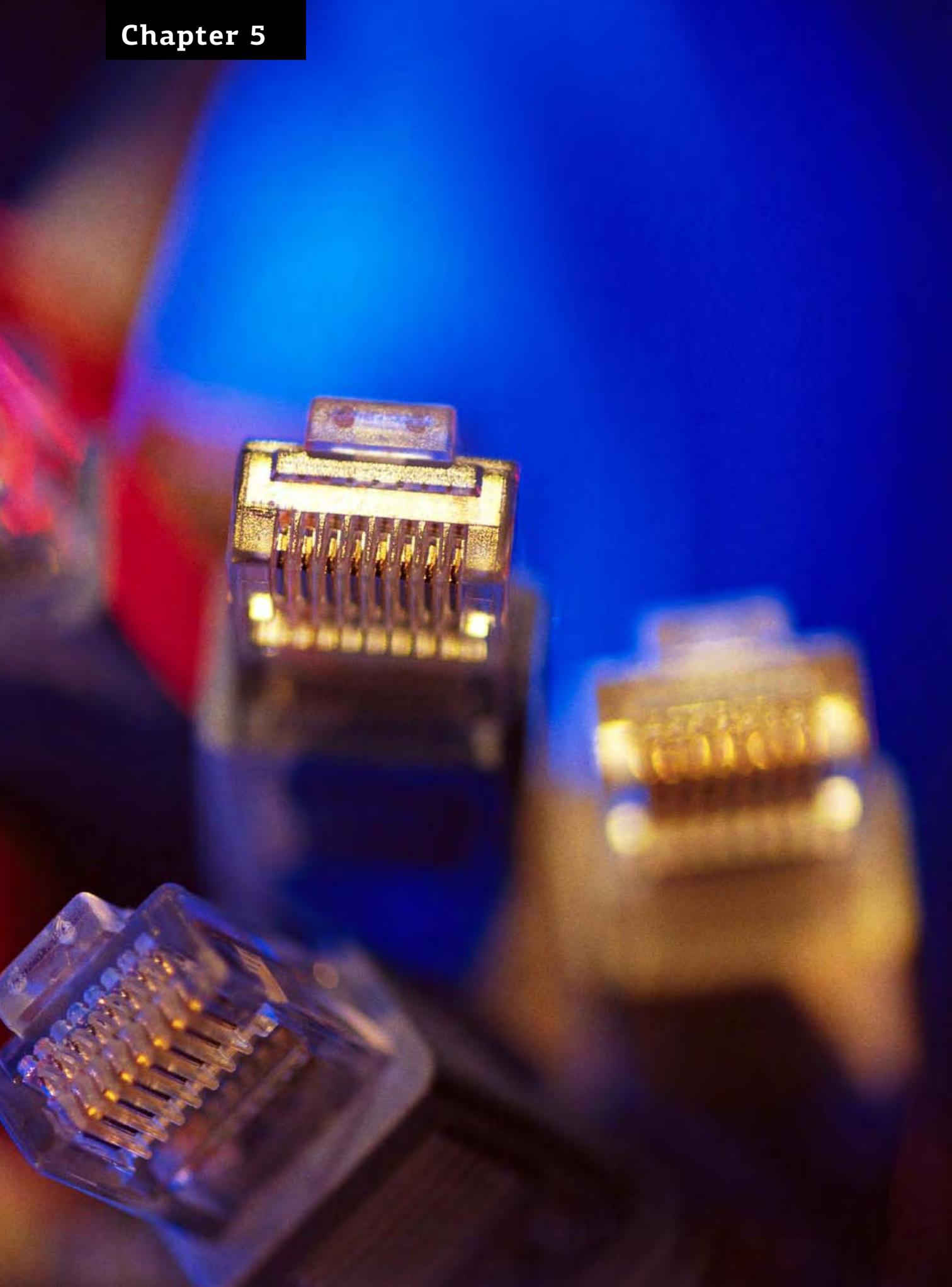
mover advantage; second generation fixes glitches and adds attractive features; energy efficiency is relegated, at best, to being a third-generation feature. Energy savings potentials could be achieved much sooner.

Policy as a positive driving force

Policy intervention is a proven mechanism for stimulating efficiency improvements that keep pace with increasing energy consumption by network-enabled devices. A suite of policy instruments can encourage industry to:

- make energy efficiency a priority in device design
- embed incentives to develop energy-saving solutions across the value chain
- accelerate the pace of energy efficiency improvements.

Standardisation across international markets is vital to achieve the greatest savings and to avoid the risk that inefficient devices will be sold in countries with no legislation or weaker requirements.



Network standby policy options

Network standby poses a challenge for policy makers as network-enabled devices are very different from stand-alone devices. There are, however, policy efforts underway and it is possible to adjust existing policy instruments to start addressing network standby. In a more long-term perspective, a more effective approach may be to develop new policy instruments that better suit this diverse and growing group of devices.

Key points

- *Recognising that clear policy goals inform the choice of appropriate instruments, network standby policies should aim to ensure or encourage five key goals:*
- *Energy consumption across all devices when in low power modes is as low as possible.*
- *When not performing a primary function, network-enabled devices enter the lowest power mode that satisfies standby function(s) as quickly as possible and for as long as possible.*
- *Devices wake to required connectivity and functionality levels promptly and automatically to maintain user satisfaction and avoid disabling power management.*
- *Network equipment automatically scales power consumption to data transfer and processing requirements.*
- *Optimising energy consumption across the expected range of typical use is rewarded.*

After reiterating the need for policy intervention, this chapter highlights progress to date. It then describes some key policy considerations before outlining a set of six policy options that could be used individually or in combination to start addressing the issue of network standby. Insights into the advantages and disadvantages of each option are coupled with illustrative examples of how the policy instrument is being designed and used in different countries and regions. A final section recaps the main advantages and disadvantages, and assigns a rating of how easy or difficult it is likely to be to implement each option.

The case for policy intervention

Governments worldwide are starting to address network standby consumption through multiple policy instruments. Harmonisation and further development of policies is critical as more jurisdictions seek to implement network standby policies. Yet a number of policy considerations unique to network standby must be taken into account, such as finding a solution that fits across a diverse set of technologies with individual but interdependent functions and requirements. Because network-enabled devices are changing rapidly, policies need to be adaptable to remain effective.

Six main policy options are available, including:

- minimum energy performance standards (MEPS)
- energy labels
- voluntary agreements
- incentives and awards
- consumer awareness campaigns
- certification schemes
- energy reporting through networks.

Each option has inherent advantages and challenges. Some are difficult to plan, develop and implement while others can be put in place quickly to begin capturing at least a portion of the substantial energy savings potential. Collectively, the policy instruments can be complementary and highly effective.

While this chapter focusses on policy initiatives, it is important to acknowledge also that industry and research groups are tackling network standby concomitantly through voluntary approaches and initiatives. Several of these efforts are highlighted in Annex B. These, too, would benefit from greater collaboration.

The evolution of standby energy efficiency policy

As demonstrated throughout this publication, device innovation and technological change have dramatically increased the complexity of standby. It has evolved from a relatively simple state available on a handful of devices to a feature that enables billions of devices to operate and/or interact all the time.

In this context, curbing energy consumption of consumer electronic devices has become a complex policy challenge. Since 2001, several countries and industry initiatives have taken a lead in developing responses, often building on each others' strong points. Yet most existing policies are somewhat behind the technology innovation stream: they deal mainly with low power modes and cover network-enabled devices only to a limited extent.

Table 5.1 Network standby initiative timeline

Year	Action
2001	Network standby highlighted as an issue in the IEA publication <i>Things that go Blip in the Night</i> .
2007	IEA Workshop on Set-top Boxes and Digital Networks. IEA develops <i>Guiding Principles for Energy Efficient Networks and Network-enabled Devices</i> . IEA Implementing Agreement 4E Standby Power Annex starts working on network standby.
2009	Network standby highlighted as an issue in IEA <i>Gadgets and Gigawatts</i> . European Union Lot 26 study initiated to explore the need, implications and possible approaches to limit standby power in network-enabled devices.
2010	4E and APP commission the report <i>Standby Power and Low Energy Networks – Issues and Directions</i> . Switzerland introduces minimum energy performance requirements for set-top boxes. IEC 62301 publishes <i>Household Electrical Appliances – Measurement of Standby Power 2nd ed.</i>
2011	IEA initiates project on network standby. SEAD Network Standby working group established.
2012	United States set-top box industry voluntary agreement established (entered into force in 2013.) Leading industry associations adopt guiding principles for network-enabled consumer electronics based largely on the IEA <i>Guiding Principles for Energy Efficient Networks and Efficient Network-enabled Devices</i> .
2013	European Union amendment setting semi-horizontal requirements for network standby. Canada undertakes research to characterise network standby energy losses, and consults with industry, regulators and other stakeholders on how to accelerate energy efficiency for complex set-top boxes.

Note: Unless otherwise indicated, all tables and figures derive from IEA data and analysis.

Key point *Since 2001, both industry and governments around the world have taken steps to address the issue of rising standby energy consumption.*

Policy considerations

Given the rapid evolution of network technology, any policy approach needs to be fluid, flexible and forward-thinking: policy needs to be driving energy efficiency decisions in early phases of device development. Moreover, network standby policies will need to accommodate continual changes in device definitions, the splitting and merging of traditional device categories, and the emergence of new device categories.

Timeframe

Developing effective policy for the rapidly evolving area of network standby is a daunting challenge. Policies to improve appliance and equipment efficiency have been effective but demand considerable time and resources. Currently, it takes two to three years (or more) to advance through the stages of preparatory studies, consultation processes, and the development of requirements, testing procedures, labelling systems and compliance monitoring systems. Where policy makers aim to get the worst performers off the market, this long timeframe may result in large-scale uptake of worst performers (particularly if they are relatively low cost) and/or wasted effort, if new technologies replace those under consideration.

More rapid results could be achieved by identifying priority areas where it is possible to reduce excess consumption while simultaneously building the knowledge base around network-enabled devices and stimulating the development and deployment of efficient solutions. Ultimately, work on network standby should be expanded or co-ordinated to

integrate broader energy efficiency considerations such as network-enabled buildings or value-chain efficiency in the delivery of network services.

Alignment with technology development

Network standby policy considerations imply a need to modify policy-making processes for greater alignment with technology development. This may include increasing the stringency of targets or expanding policy scope with continuous performance reviews while still providing clear long-term vision and directional cues to industry to invest in energy efficiency R&D.

Improving alignment of regulations with the device development process may have considerable benefits. Manufacturers work with strict timelines: adjusting the timing of regulations may promote the integration of energy efficiency considerations into the design process, enabling companies to deliver savings more quickly. Such an approach is currently being considered in EU regulations for televisions.

Ideally, such considerations include both long-term approaches and exit strategies, which require defining an end state and identifying points of diminishing returns for any incremental collaborative policy efforts.

International collaboration

Understanding rapidly developing technologies and collecting data comes at a cost for policy makers and administrations. Increased international collaboration can serve to mitigate these costs while providing the added value of increasing the potential for harmonised approaches that contribute to decreasing costs for manufacturers. Collaboration and knowledge-sharing will reduce the time needed to build up viable data sets and workable approaches. A disaggregated approach is likely to have higher costs in terms of reduced innovation, lower trade and loss of reliability for industry and consumers.

What if we wait and then regulate?

Many factors have stalled the development of network standby policy: methodologies for data collection and technology testing are under development, available data sets are limited, and national and international end-user surveys are insufficiently comprehensive to inform policy making and prioritisation.

None of these barriers will diminish without collaborative effort and the development of the technical and information tools described in this report. Neither will any government be in a position where it could effectively regulate without first undertaking the actions outlined here. Effective power management and power-level reduction policies could deliver energy savings of up to 65%, but will not be achieved without the prioritised efforts highlighted.

But waiting until all the pieces are in place may mean missing significant energy savings.

- From 2008 to 2012, the cumulative energy savings potentials that were missed amounted to more than 2 000 TWh – more than four times the current annual electricity consumption of the Republic of Korea.
- From 2014 to 2025, the cumulative energy savings potentials are more than 7 000 TWh – more than 13 times the current electricity consumption of Canada.

Developing informed network standby policies in light of increasing complexity and insufficient data is a challenge, but consider that it took almost two decades to develop policy to reduce regular standby waste. The additional technical complexity, scale of potential waste and number of avenues to address network standby waste make it prudent to move towards policies that can be updated by taking action in three key areas:

- use existing and planned policies to inform policy-making decisions and international collaboration
- promote the development of international technical standards that support energy efficiency policy making
- establish data-sharing mechanisms to streamline resources invested in data collection.

Annex A provides additional information on the technical foundations needed for network standby policy.

Policy options

To maximise network standby savings, an adaptable ongoing strategy that optimises the benefits of several policy instruments and approaches will work best. Solutions that can be implemented quickly within existing policy frameworks can help pave the way for options requiring more long-term changes. In exploring the options, policy makers would do well to consider two underlying questions:

- *To what extent can the rapidly changing area of network standby be added and adequately addressed within existing policy frameworks?*
- *To what extent can existing frameworks be adjusted to accommodate rapid technological developments?*

Existing approaches to network standby provide an excellent basis for policy options that fit different national needs and contexts. For the most part, network standby is currently addressed through amendments to existing policy – e.g. EU amendments to the Ecodesign Directive regulations, the inclusion of network-enabled devices in labelling and minimum energy performance requirement programmes in Korea, and the ENERGY STAR programme of the United States.

The ease and speed with which amendments can be introduced prevent some energy waste in the short term while longer-term solutions are developed, and may spur further energy efficiency measures throughout the value chain. Further advantages include that amendments do not require significant changes in the regulatory framework and that they build on existing processes, which saves resources and provides industry with familiar procedures. There are some disadvantages though. By taking the amendment route, it may not be possible to take into account all issues of relevance to network standby. Also, trying to fit complex, rapidly evolving technologies into an existing framework developed for stand-alone devices may produce sub-optimal outcomes. But amending existing policies to encompass network-enabled devices is a first and immediate step to reduce some network standby issues and stimulate developments in others.

The proposed policy solutions range from pragmatic, rapidly implementable actions to complex solutions that will maximise savings over the long term. Some approaches, such as making amendments to current policy and consumer awareness programmes, could deliver energy savings almost immediately; others, including energy reporting through networks

and certification schemes – are policy options that require larger efforts but could form the basis for innovative policy approaches.

Minimum energy performance standards

Minimum energy performance standards (MEPS) or requirements are legislated regulations that specify the maximum allowable energy demand of energy-using devices; MEPS are applied primarily to home and office appliances and equipment. Requirements often include an implementation timeline, typically phased, starting with partial adherence and gradually moving to total enforcement. Testing procedures and protocols are required to measure and report reliably the efficiency of devices on the market. Energy labels are typically used in conjunction to incentivise manufacturers to produce more efficient units, certify compliance and provide information to consumers.

Two general approaches are used to regulate minimum energy performance:

- **Minimum energy performance standards (MEPS)** set minimum efficiencies that manufacturers must ensure in all models of a regulated category of device. Generally, only the performance level is set by regulators; manufacturers are free to choose the technologies by which they achieve the standard.
- **Prescriptive energy efficiency requirements or standards** require that a specific feature or technology be installed in all models of devices covered.

The second way to regulate MEPS, prescribing energy efficiency requirements or standards, can be seen as promoting specific technology. However, several neutral prescriptive requirement options exist in the area of network standby:

- **Powering down** to low power modes requires consideration of primary function, resume time, load (level of network interaction required) and level of service required from related devices (if any).
- **Power scaling** is applicable in the development and implementation of energy efficiency measures, and could be used to specify standby, sleep and idle modes as well as performance considerations, such as resume times.
- **Requiring non-proprietary technology solutions and standards** supports policy without endorsing a particular product or solution. For example, the Energy Efficient Ethernet (EEE) enables an Ethernet link to sleep and wake in quick response to data transfer requirements. Including EEE carries no additional cost but does depend on involved devices having this standard. Policy options include requiring EEE, providing incentives to include EEE and applying warning labels to devices that are not EEE-compliant.
- **Default power management settings** can lead to automatic savings. Most consumers use the settings and functions enabled when the device is taken out of the box. Manufacturers could be required to sell devices with energy-saving features and settings enabled, remove the ability for users to disable them, and/or include clear information to consumers on how to improve energy management in their devices (and the benefits of doing so).

Regardless of which overriding approach is chosen, three options exist for setting the actual requirements: **vertical, horizontal and semi-horizontal or clustered**.

Vertical requirements are set on a device-by-device basis. They can set more appropriate requirements for specific devices, but require substantial time and resources to develop, implement and update. Horizontal requirements cover a range of different device categories. They are relatively fast and easy to implement, saving time and resources, and are easy to communicate; however, they risk setting sub-optimal requirements for some covered devices.

Box 5.1

When should devices power down?

Horizontal requirements for automated power-down times – irrespective of function and load (level of network interaction required) – may impact resume time, functionality and user service perceptions. They risk being inadequate for some devices and insufficiently ambitious for others.

In general, the simpler the function and load, the more expedient the power down and resume

times. A very short time to automated power down could be required for devices with low load and short resume time without negative impacts on service or functionality. Requirements for more complex devices would be higher.

Many devices already power down to low power modes within milliseconds and co-ordinated power-down in linked devices is being developed.

Semi-horizontal or clustered requirements combine elements of both, typically clustering devices according to a variety of parameters. Ideally, the clusters developed closely correspond to categories of devices on the market and reflect similarities in main functions such as:

- appliances and devices with minimal network functionality
- lighting
- communications equipment
- audio/video equipment (e.g. televisions, home audio, home video)
- ICT devices or office equipment (e.g. desktop and mobile computers, printers and multi-function devices)
- network equipment.

A clustering approach is based on the premise that smart appliances (refrigerators, washing machines) with similar network functions and energy demands could have the same network standby targets, while a computer's network interaction is completely different, requiring different targets. Elements of a clustered approach could also apply in setting device-by-device specifications. For example, the ENERGY STAR specification process reviews similar devices or those with similar functionality to establish parameters when developing functional adders or power limits for network-enabled devices (Box 5.2).

MEPS are based on two basic measures. Modal power, expressed in watts (W), specifies measures, and sets requirements for individual low power modes or a collection of modes.¹ Total energy consumption (TEC), expressed in kWh/yr, provides the sum of energy consumption across all modes (including active), based on an expected operating pattern or use profile.

From an innovation perspective, overly prescriptive modal approaches may force the prioritisation of sub-optimal solutions. They may also prevent the implementation of technologies such as proxying that can reduce overall energy consumption.

¹ The modal approach can (but does not have to) include active modes.

Box 5.2

Making allowance for special functions

Functional adders are supplemental energy consumption allowances for extra functions such as network connectivity. Adders can be used for both power and total energy requirements, and can be expressed in watts or as a percentage of base requirements.

Both vertical and horizontal approaches can be tailored through functional adders. For example, 2013 EC standby regulations allow an additional 0.5 W for a meaningful display. A horizontal approach to set base requirements, coupled with functional adders, would encompass the diversity in device design and function, and optimise allowable consumption; however, it requires the establishment and constant review of consumption levels – a challenge, given the breadth of features and number of device categories.

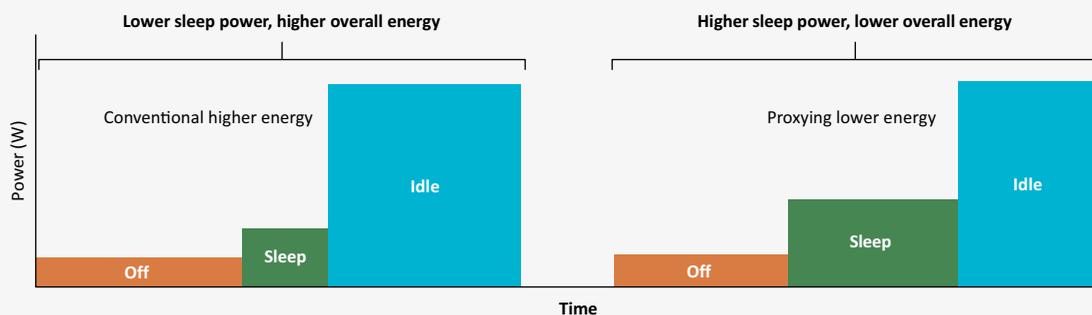
Implementation would also require time and global co-operation.

Adder values that are overly generous can have the adverse effect of prompting manufacturers to add functions to gain greater power allowance rather than improve efficiency to comply with the programme. Appropriately calculated adder values give no such advantage, thereby ensuring that additional functions cost manufacturers to develop and incorporate into design and manufacturing. Most approaches using adders have a cap for total allowance beyond which no additional allowance is possible, irrespective of features. In order to meet the overall consumption cap, high adder allowances for additional features or specific states will drive down the consumption allowance for base functionality, thereby incentivising efficiency measures in those functions.

From a total energy savings perspective, it is important to consider networked standby in the context of the entire duty cycle of the device, i.e. how these devices are used and how much time they spend in different modes. Similarly, it is relevant to explore constellations of devices and their interactions to identify where policy interventions could have the greatest impact. For example, a centralised system (e.g. home gateway or security system) that provides power management functions (such as enabling users to power down network-enabled devices) may need to be in active mode continuously. But in return, it contributes to decreasing the system's overall standby energy consumption (Ecos, 2011).

Figure 5.1

Higher power in low power mode to enable more time asleep



Source: Intel Corporation (2013), Inputs provided.

Key point

In some cases, higher energy allowances can lead to higher overall energy savings.

In areas of rapid technological change, TEC requirements are seen as more flexible and as such may more strongly stimulate innovation and the development of system-wide solutions. The downside of total energy limits is their dependence on usage patterns or use profiles, which are established by assessing typical consumption based on a combination of duty cycle attributes and a given use case or “majority profile” (the most common use of a given device, based on surveys). Requirements are set on the total consumption, not the constituent consumption (Nordman et al., 2009).

Majority profile surveys exclude low and high use, instead basing the usage pattern on the average use. Still, several factors may undermine the accuracy such survey results:

- social desirability bias, in which respondents report falsely based on a desire to conceal unfavourable behaviour or to present a more positive image (e.g. underreporting television time)
- multi-tasking, which may or may not include television time if it is “on in the background”
- unclear or lack of definitions, which invites incongruous interpretations and responses (e.g. what constitutes a large-screen or small-screen television).

Wider factors may also affect usage patterns and the requirement limits they inform. Usage patterns may differ in different regions, or may change over time and quickly become outdated. Actual use is subject to increasing variability as devices become more multifunctional and as new, unanticipated uses arise (e.g. games consoles are now used to access the Internet and to watch DVDs). It should be noted that it is costly to conduct the necessary surveys to update usage patterns. Inaccurate usage patterns may result in total energy limits that are not sufficiently ambitious or do not drive innovation towards increased energy efficiency.

Current policy examples

European Union Ecodesign Regulation

The European Commission is the first jurisdiction in the world to develop a policy specifically targeting network standby. In 2009, it commissioned a broad, in-depth Ecodesign Directive preparatory study in consultation with industry organisations and other stakeholders. This work covered market analysis, consumer behaviour, best available technologies and improvement potential. The study concluded in 2011 and recommended a horizontal approach to network standby policy. Ecodesign Regulation 1275/2008/EC includes both power management and minimum energy efficiency requirements. While acknowledged as problematic in its attempt to be a “one-size-fits-all” solution, this dual approach best ensures the broadest implementation of measures to minimise network energy waste.

Based on the study recommendations, the Dutch NL Agency proposed an amendment, which the Commission subsequently incorporated into energy performance requirements for network-enabled devices (called devices in the Regulation and Amendment). Performance requirements are now based on three categories of “network availability” (how quickly devices need to respond to network signals):²

- devices with high network availability (HiNA): router, switch, hub, modem, wireless access point, voice over Internet protocol (VoIP) phone or video phone
- devices with HiNA functionality: router, switch or wireless access point as side function
- devices with low network availability (LoNA) or “other network-enabled devices”: all other network-enabled devices.

² In the Regulation, “network availability” is defined as the capability of the equipment to resume functions after a remotely initiated trigger has been detected by a network port.

Since the amendment does not change the scope of the Regulation, it applies to all devices listed in Annex A of Regulation 1275/2008/EC. The Regulation stipulates two additional EU performance requirements:

- All devices are required to power down within 20 minutes of stopping their primary function. This must be the default when devices are placed in the market.
- All devices must be able to deactivate wireless network ports. When all network ports are deactivated i.e. the device is no longer network-enabled, then standby power consumption (if it exists), must be less than 0.5 W.

As is typical of EU regulations, the policy is phased in over several years with multiple tiers to reflect that implementation for some devices/devices will be more complex and require additional time. In each case, the regulation becomes increasingly stringent.

Table 5.2

Energy performance requirements and timeline for Ecodesign Regulation 1275/2008/EC amendment

Device category	Tier 1 (1 January 2015)	Tier 2 (1 January 2017)	Tier 3* (1 January 2019)
HiNA	12 W	8 W	8 W
Devices with HiNA	12 W	8 W	8 W
LoNA (other)	6 W	3 W	2 W

* Tier 3 requirements will be subject to detailed review in 2016.

Source: European Commission (2013), Commission Regulation (EU) No 801/2013 of 22 August 2013, amending Regulation (EC) No 1275/2008 with regard to Ecodesign requirements for standby and off mode electric power consumption of electrical and electronic household and office equipment, and amending Regulation (EC) No 642/2009 with regard to Ecodesign requirements for televisions, Official Journal of the European Union L 225/1, <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:225:0001:0012:EN:PDF>.

This amendment route has notable advantages, but is not without shortcomings. On the positive side, network-enabled performance requirements can be introduced as an amendment to the current standby and off mode regulation EC/1275/2008 by including provisions to limit consumption in network-enabled devices. Moreover, because of its horizontal nature, the Regulation will also be applicable to new devices coming on the market. Due to the heterogeneity of network-enabled devices, however, the three categories may still be too broad: there is some risk that the requirements will be too strict for some devices and too weak for others. The 50%+ difference between HiNA and LoNA requirements may also tempt manufacturers to add nonessential functions so their devices qualify for a different category. The functions that classify a device as HiNA are quite specific, hopefully discouraging such practices. In any case, all devices must comply with the normal standby provisions when all network ports are deactivated.

Korea's programmes

Korea's e-Standby Program uses a device-by-device approach to set network standby limits for 11 target electronic edge devices, based on a combination of power limits:

- total energy consumption, including sleep mode, transition time and off mode for computers, printers, fax machines, copiers, multi-function devices
- specified transition times and power limits for modes (or a set of modes).

An additional 11 devices have power limits for passive standby mode and idle mode.

Table 5.3 Korean network standby power limits in e-Standby Program

Target devices	Power limits for network standby modes	Network functionality	Availability of network standby mode(s)
Computers	Total energy consumption including sleep mode, transition time and off mode	Available	Available (Wake-on-LAN mode)
Printers, fax machines, copiers, multi-function devices	Total energy consumption including sleep mode, transition time and off mode	Available	Available
Scanners	≤ 15 min (transition time) ≤ 5-10 W (standby mode) ≤ 0.5 W (off mode)	Available	Available
Building door phones, cord/cordless phones	≤ Various (standby mode)	Available	Available (backlight off control)
Set-top boxes	≤ 1 W (optional, passive standby) ≤ 10-20 W (active standby)	Available	None
Modems	≤ 0.75 W (off mode) ≤ Various (standby mode)	Available	None
Home gateways	≤ 10 min (transition time) ≤ 10-20 W (sleep mode)	Available	None

Source: Adapted from Jung, S. (2013), "Korea's energy efficiency Program in terms of networked standby", presentation at the Networked Standby Policy Framework Workshop, IEA 4E/SEAD and Natural Resources Canada, Toronto, 7 March, www.iea.org/media/workshops/2013/networkedstandby/5SanggukjUNGGKoreaEnergyEfficiencyPrograms_TTA_130305.pdf.

Korea's standards and labelling programme uses a differentiated approach to setting minimum limits.

Korea has strategically linked these standby power limits to a corresponding labelling system. Devices that do not meet the standby power limits cannot be rated above level 2 on the scale of 1 to 5, with 1 being the most efficient (Jung, 2013).

Table 5.4 Network standby power limits in Korea's energy efficiency standards and labelling programme

Target devices	Power limits for network standby modes	Network functionality	Network standby mode
Air conditioners	≤ 1 W (passive standby) ≤ 3 W (active standby)	Available (some)	Available (Ethernet communication)
Gas boilers	≤ 3 W (sleep mode)	Available (majority)	Available (serial communication)
Gas water heaters	≤ 3 W (sleep mode)	Available (majority)	Available (serial communication)
Washing machines	≤ 2 W (active standby)	Not available	-
Drum washing machines	≤ 2 W (active standby)	Available (some)	Available (Ethernet communication)
Dish washers	≤ 3 W (active standby)	Not available	-
Televisions	≤ 0.5 W (passive standby) ≤ 2 W (active standby)	Available	None

Note: W = watt.

Source: Adapted from Jung, S. (2013), "Korea's energy efficiency program in terms of networked standby", presentation at the Networked Standby Policy Framework Workshop, IEA 4E/SEAD and Natural Resources Canada, Toronto, 7 March, www.iea.org/media/workshops/2013/networkedstandby/5SanggukjUNGGKoreaEnergyEfficiencyPrograms_TTA_130305.pdf.

Key point

Korea has used network standby power limits, along with energy efficiency standards and labelling, to aggressively improve efficiency of network-enabled devices.

Minimum energy performance requirements: Impacts to a network standby plan

Stringent requirements have a strong impact on the most poorly performing technologies and could serve as effective mechanisms to push these technologies off the market. Clear long-term performance classes or tiers provide industry with clear signals regarding the need to invest in energy efficiency research and development.

Table 5.5 Minimum energy performance requirements

Advantages	Disadvantages
<ul style="list-style-type: none"> ■ Prevent inefficient devices from entering the marketplace. ■ Encourage manufacturers to increase device efficiency. ■ Raise the average energy efficiency of devices. 	<ul style="list-style-type: none"> ■ MEPS require rigorous standards development, which may be difficult given the heterogeneity of devices and variety of factors that influence the energy consumption of networked devices. ■ MEPS can be ineffective for devices that evolve faster than the MEPS review process.

Energy labels

By providing a description of energy performance, energy labels equip consumers with facts to make informed purchasing decisions. Labelling is proven as an effective instrument for helping consumers identify which electric and electronic appliances incorporate energy-saving standards such as power management or efficient data transmission.

Two main categories of labels are well known; a third option is emerging:

- **Endorsement labels** are given to device models that fulfil specified energy efficiency criteria.
- **Comparative labels** allow consumers to compare energy performance among models.
- **Warning labels** are affixed to devices that do not comply with requirements.

Labels are not entirely appropriate for standby or low power mode policy making. An endorsement or comparative label focussing just on network standby could end up giving the wrong message to consumers – promoting a device that is efficient in powering down but inefficient in on mode. Endorsement or comparative labels could integrate network standby requirements into total consumption and continue to rank appliances on energy use across all relevant modes rather than just network standby (TEC approach). Any labels would be only one component of an effective solution. Incorporating network standby considerations into existing specifications means the load performance requirements can be tailored to that particular device. ENERGY STAR has already incorporated network standby into many specifications, calling it sleep mode. Another option is labels that signify compliance with certain standards that affect network standby consumption, such as Energy Efficient Ethernet (EEE) compatibility or power management features. Warning labels could be a complement to other policies.

Current policy examples

United States ENERGY STAR

Initiated by the United States in 1992, ENERGY STAR is now the leading international voluntary label for high-efficiency devices. It has been adopted by Australia, Canada, the European Union and the European Free Trade Association, Japan, New Zealand, Switzerland and Chinese Tapei, among other regions, countries and organisations.

ENERGY STAR focusses on total energy consumption and takes network standby into account in terms of promoting network connection with the lowest power possible. Consideration is paid to offsetting active modes with standby modes and incentivising lower

power budgets for the device as a whole. Network connectivity specifications are typically based on total energy consumption: i.e. annual consumption, incorporating consumption in on mode (or idle in the case of personal computers), standby mode (for select devices) and off mode. Currently, devices for which ENERGY STAR sets out specifications to address network connectivity include audio/visual equipment, game consoles, televisions, set-top boxes, servers, computers, imaging equipment, digital television and displays. ENERGY STAR has been in dialogue with appliance manufacturers since January 2011 and is developing specifications for demand-response enabled devices (Radulovic, 2013).

The US Environmental Protection Agency (EPA) has rewarded those ENERGY STAR-rated computer devices that maintain network connectivity in low power states, including allowances for Wake-on-LAN for Ethernet connectivity and incentive for proxying (according to the technical standard ECMA 393). This reward system has potential for energy savings by encouraging devices to enter sleep mode for longer periods.

Korea

Korea's labelling and certification schemes are an effective complement to the voluntary minimum energy requirements programme described above, which covers 22 device categories. Collectively, these efforts are effective for promoting energy efficient appliances and equipment (called devices), each with specific aims and strengths:

- The Energy Efficiency Standards & Labelling Program, introduced in 1992, encompasses mandatory minimum energy performance requirements covering 35 device categories.
- The voluntary High-efficiency Appliance Certification Program covers 41 device categories.

Korea's labelling programme recently incorporated power limits for network standby modes in seven target devices, and for off and passive standby mode in an additional 28 devices.

Energy labels: Impacts to a network standby plan

Comparative energy labels specifically for network standby are not suitable since there is a risk that the labels give the wrong message about total energy use. Warning labels could be considered as a complement to other policy instruments. Endorsement labels such as ENERGY STAR and Energy Boy can be effective tools within a structured programme to address network standby.

Table 5.6 Energy labels

Advantages	Disadvantages
<ul style="list-style-type: none"> ■ Stringent network-enabled efficiency requirements to secure top rating encourage manufactures to improve devices. ■ Warning labels may be effective in promoting compliance with network standby regulations and communicating the importance of tackling network standby. 	<ul style="list-style-type: none"> ■ Networked standby is just one part of device energy consumption; typical energy labelling systems are not applicable to network standby alone. ■ Any network standby-specific label risks giving the wrong message about total consumption. ■ While tailored, the vertical, device-by-device approach likely means not all devices will be covered. ■ Device-by-device labelling schemes take considerable time to develop and to incorporate new devices. ■ Effectiveness of warning labels depends on the efficiency programmes they are linked to. ■ Warning labels can be implemented within a country, but are not currently feasible in an international context where requirements differ.

Voluntary agreements and codes of conduct

Voluntary agreements are negotiated covenants between public authorities and individual firms or groups of firms that include targets and timetables for action aimed at improving energy efficiency. Participating manufacturers and industrial stakeholders commit to common goals such as power limits on certain modes and maximum delay before powering down. A code of conduct (CoC) is a voluntary, flexible mechanism to initiate and develop policy to improve energy efficiency. CoCs constitute a forum wherein industry, experts and member states conduct an open and continuous dialogue on market, device and system performance.

Current policy examples

United States voluntary agreement on set-top boxes

The US Department of Energy (US DOE) recently drafted provisions to include set-top boxes and network equipment as devices covered in its Energy Efficiency Program for Consumer Devices, spurring industry to launch a voluntary agreement in 2013. As of June 2013, the US DOE was not yet considering conservation standards for other network-enabled devices (Dommu, 2013).

The US Set-top Box Energy Conservation Agreement is a voluntary agreement between US government, oversight bodies and device providers and manufacturers. It requires 90% of all new set-top boxes purchased and deployed after 2013 to meet ENERGY STAR 3.0 efficiency levels, among other agreement targets. The agreement is flexible and expected to consider new devices in the future. Participants will report measures taken and aggregated results will be presented on an annual basis.

Participants will meet regularly to review and update energy efficiency measures, and to host ongoing discussions with the US DOE, the US EPA and other interested government agencies and stakeholders on new technologies and equipment. To create accountability and support transparency, the agreement's terms include detailed processes for verification of set-top box performance in the field, annual public reporting on energy efficiency improvements, and posting device energy consumption information by each company for its customers.

As part of the agreement, "light sleep" is being implemented in an increasing number of new and existing set-top boxes; it involves powering down hard disks, in-band tuners and video outputs, and automated power down. Enabling light sleep provides energy savings in the region of 20%. "Deep sleep" functionality in the next generation of cable set-top boxes will be field tested and deployed if successful. The agreement is expected to improve set-top box efficiency by 10% to 45% by 2017.

European Union voluntary agreements and codes of conduct

The European Union is addressing the efficiency of network-enabled devices and other complex device categories through voluntary agreements and codes of conduct that specifically cover these device categories.

Table 5.7

European Union voluntary agreements and codes of conduct

Voluntary agreements	Codes of conduct
<ul style="list-style-type: none"> ■ Complex set-top boxes (STB) ■ Imaging equipment ■ Medical imaging equipment 	<ul style="list-style-type: none"> ■ Complex set-top boxes (STB) ■ External power supplies (EPS) ■ Broadband equipment

Voluntary agreements and codes of conduct: Impacts to a network standby plan

The collaboration and innovation aspects of voluntary agreements have made them a policy instrument of choice for complex ICT devices. Their inherent marketplace impetus can stimulate the adoption of common technology standards in industry. The IEA *Guiding Principles for Energy Efficient Networks and Efficient Network-enabled Devices* could constitute a cornerstone of voluntary agreements for network standby.

Table 5.8

Voluntary agreements and codes of conduct

Advantages	Disadvantages
<ul style="list-style-type: none"> ■ Bring together the range of stakeholders needed to develop systemic solutions that promote energy efficiency. ■ Enable wider stakeholder collaboration i.e. create platforms for energy efficiency dialogue between service providers and component and device manufacturers. ■ Enable collaborative solutions, e.g. updating devices to improve their energy efficiency via software downloads. ■ Ensure fair competition; lay the ground for all parties to abide by the same parameters. ■ Flexible and do not stifle innovation. ■ Can be updated in line with technological change and innovation; particularly responsive where devices and their features are constantly improving or changing. ■ Can sometimes be developed and deployed faster than regulated requirements. 	<ul style="list-style-type: none"> ■ Robust and effective agreements require considerable time and resources to develop. ■ Do not cover the whole market. ■ Difficult to quantify resulting energy savings. ■ Focus on just one device category, which can lead to unintended impacts on other network-enabled devices or network equipment.

Incentives and rewards

Policy measures built on systems of incentives and rewards can both “push” innovation and create market “pull”. Financial incentives, procurement programmes, endorsement schemes and other market-support measures aim to draw attention to the most energy efficient devices available, thereby increasing the market demand. Rewards can take the form of competitions and awards or be integrated into other instruments. For instance, ENERGY STAR provides rewards for implementing EEE within some requirements.

Government procurement programmes with strict efficiency requirements for network-enabled devices could create a market demand for more efficient devices. Policies can promote technological development through establishing criteria that incentivise efficiency features, including EEE, proxying and energy reporting. Another option is taking measures to promote the use of highly efficient mobile devices, which have much lower energy consumption in all power modes. Procurement schemes are also relevant when service providers supply equipment, such as set-top boxes or network equipment.

Other stakeholder groups could be involved in or initiate reward programmes. For instance, consumer organisations could develop programmes to reward manufacturers when energy-saving settings are the default and enabled out of the box, or for providing user-friendly information to consumers on how to optimise the energy management features of their devices. Such programmes could be effectively linked to consumer awareness campaigns about more efficient devices.

Incentivising consumers to select energy efficient devices and not disable energy-saving functions requires finding effective ways to communicate the importance of power management. Communication around resume time expectations may also be warranted if there is a trade-off between energy efficiency and instant start-up. Many technical solutions identified in this report may overcome such trade-offs. Awards, competitions or targeted research grants promoting the development and innovation of, for example, efficient resume time technologies would enhance policy efforts.

Motivated by such policy incentives and rewards, along with market forces and corporate social responsibility (CSR) and other ethical and advocacy considerations, many industry, research and consumer stakeholder groups are actively pursuing energy efficiency in networks and network-enabled devices. Leading examples are summarised in Annex B.

Table 5.9 Incentives and rewards

Advantages	Disadvantages
<ul style="list-style-type: none"> ■ Can be linked to other policy instruments. ■ Diverse stakeholders can contribute. ■ Flexibility in requirements and rewards. 	<ul style="list-style-type: none"> ■ May take time to achieve energy savings. ■ May be difficult to assess the results and impacts of measures.

Consumer awareness campaigns

Consumer awareness campaigns can be an effective vehicle in creating market demand for more efficient devices. They can be organised as stand-alone campaigns or as an integral part of energy efficiency requirement and/or labelling schemes. Campaigns can be organised by governments, municipalities, energy providers or other actors.

Current policies

In May 2013, as part of the “Swiss Energy” initiative, the Swiss Federal Office of Energy (SFOE) launched a large consumer awareness campaign on optimising the energy performance of modems, routers and set-top boxes. The three largest service providers – Swisscom, UPC Cablecom and Sunrise – will target advice to consumers on how to reduce energy waste and use energy-saving features. Considering that there are 3 million modems and 2 million set-top boxes in Switzerland, the SFOE estimates that such optimisation would cut the current consumption of 500 gigawatt hours (GWh) to 320 GWh – a savings equivalent to the total electricity of 40 000 households. Pending positive results, the campaign will be developed and continued (Brüniger, 2013).

Table 5.10 Consumer awareness campaigns

Advantages	Disadvantages
<ul style="list-style-type: none"> ■ Complementary to other policies. ■ Can engage a range of stakeholders. ■ Can create market demand for options to improve energy management. ■ Can be started quickly. ■ Comparably low cost. 	<ul style="list-style-type: none"> ■ Precondition is that is possible for consumers to manage energy without impacting on service or functionality. ■ Consumers tend to lose interest in energy management – may require sustained efforts.

Certification schemes

Certification schemes are a form of benchmarking that enables quick assessment of energy efficiency. A certification scheme differs from energy labelling in that it targets industry and provides a basis for policy decision making. Certifications can provide useful input for systems designers, stimulate efficiency competition within industry and ultimately assist consumers in selecting their purchases.

In an international certification scheme, efficiency requirements can be set for a range of performance criteria at each certification level and new levels can be added or existing levels upgraded as technologies evolve. Policy implementation can be varied, using different levels appropriate to different device categories, different markets, etc. Industry could aim to improve their certification in anticipation of regulation in different jurisdictions or for marketing reasons, while regulators could use such a certification scheme to put measures in place to remove the worst performers from the market. Certifications can also be connected to registration fees, which could be scaled to performance. A broader certification scheme enabling consumers to understand the energy consumption of their ICT services, for example, could stimulate focus on efficiency among Internet service providers and other service providers, which would in turn increase the demand for more efficient network infrastructure and network-enabled devices.

Current policy example

External power supplies (EPS)

At present, there are no certification schemes in place for network-enabled devices. However, the approach used for external power supplies (EPS) could serve as a basis for developing such a scheme. Energy efficiency policies targeting EPS began in 2003. Interested parties collectively undertook the groundwork, including ENERGY STAR, the Californian Energy Commission, the People's Republic of China Certification Centre for Energy Conservation Devices (ECP), the China National Institute of Standardisation (CNIS), the European Commission's Joint Research Centre and the Australian Greenhouse Office (Ellis and Rozite, 2013). This joint effort led to the development of a simple efficiency mark indicating to enforcement agencies that a device has been tested according to the unified test method and claims to meet a certain performance level. Roman numeral I to V (least to most efficient), corresponding to agreed performance levels, is placed on the device nameplate alongside safety and other compliance information (Ellis and Rozite, 2013).

ENERGY STAR was the first national programme to adopt the test method, performance requirements and marking system in 2005. Since then Australia, the European Union, China, Korea and Canada have or will introduce policy measures based on technically identical test methods and the tiered requirements. Most programmes require or encourage the use of the marking system (Ellis and Rozite, 2013).

Certification schemes: Impacts to a network standby plan

An international certification scheme, as has been developed for EPS, could be developed as a tool to rate network enabled-devices in terms of energy performance.

Table 5.11

Certification schemes

Advantages	Disadvantages
<ul style="list-style-type: none"> ■ Different types of network standby certifications could stimulate energy efficiency and overall energy savings for network-enabled devices. ■ Could be used by governments in the development of policies. ■ The success of the EPS protocol could provide a model. 	<ul style="list-style-type: none"> ■ Energy service and energy efficiency of a power supply is easy to define but is more complex for network-enabled devices. ■ Would require international co-operation with governments and industries. ■ Would have a lengthy set-up time.

Energy reporting through networks

While not a policy approach *per se*, energy reporting through communication networks is a developing area in which network connectivity could help better inform policy making and facilitate the creation of new types of measures and instruments. Network connectivity opens up possibilities for collecting highly disaggregated data on energy consumption, and could ultimately provide a platform for new approaches to improving the energy efficiency of devices.

Establishing mechanisms by which devices automatically report on their own status, power levels and energy consumption could be used to create more comprehensive baselines, gain knowledge of energy saving opportunities, develop more effective power management tools, and eventually quantify the impacts of policies and measures. To maximise the benefit of these intelligent energy data gathering and management possibilities, protocols need to be developed that apply to every network-enabled device. Ethical issues need to be addressed to ensure that such opportunities can be captured without infringing upon the privacy of users. The Energy Management Working Group (EMAN) of the Internet Engineering Task Force (IETF) is developing a protocol for this kind of energy reporting (Nordman, 2011b).

Table 5.12 Energy reporting through networks

Advantages	Disadvantages
<ul style="list-style-type: none"> ■ Could enable development of targeted policies that maximise energy savings. ■ New way to access information on energy savings potentials and device performance. ■ Might eliminate the need to develop test protocols, specifications and conduct expensive testing of devices. 	<ul style="list-style-type: none"> ■ Complex to design. ■ Requires global co-operation. ■ Requires engagement with protocol designers and Internet experts. ■ Involves information protection and security issues. ■ Involves breaking new ground for energy efficiency policy.

Box 5.3 Apples and oranges: Comparison of international approaches

An overview of key features for different schemes provides insights into the pros and cons of each, while also highlighting the need for a mix of policy instruments.

US ENERGY STAR

- addresses network standby indirectly, as part of an endorsement label recognising/ incentivising the most efficient devices on the market
- no specific power limits
- network standby in low power modes factored into total energy consumption
- network-enabled consumption typically dealt with by adders (i.e. additional allowances)

- adders vary considerably among device categories.

EU approach

- addresses network standby indirectly; as part of agreements with industry to improve overall efficiency of network-enabled devices does not cover the whole market
- regulations aim to get the least efficient devices off the market
- Power limits set for three broad categories.

Korean approach

- energy consumption limits set on a device-by-device basis.

Impacts

The power limits set for devices sold in the European Union and devices sold in Korea will differ. Overall, the Korean requirements are more stringent and the timing is more ambitious. For example, a network-enabled drum washing machine sold in Korea will need to power down to 2 W or less, while a corresponding washing machine sold on the European market will need to power down to 6 W or less (starting in 2015).

The European approach covers more devices than the Korean programme and ENERGY STAR and will also cover devices that are not yet on the market.

In terms of power management, network-enabled devices sold in Europe will need to power down 20 minutes after they stop performing their primary function, while scanners sold in Korea will need to power down after 15 minutes and home gateways after 10 minutes.

Standby policy 2.0

Network standby is complex, technical, fast-moving and fast-growing. Measures to regulate energy efficiency will be various in nature, scope, scale and timeline, and should be adaptable to optimise savings in current and projected network-enabled landscapes. Having assessed the components and savings potentials, the IEA proposes a suite of possible measures that ideally form a staggered solution over time. While short-term options may not resolve the network standby issue, some savings can be realised immediately: a first step to curb energy waste now. The more targeted policy options for larger savings will require co-operation and further research, as well as mechanisms to make implementation practical.

Implementation of network standby policy options

Table 5.13

Network standby policy options: Advantages and disadvantages, level of complexity

Policy option / Difficulty of implementation and time required (1 = low; 7 = high)	
Advantages	Disadvantages
Vertical approach to MEPS (with functional adders) / 4	
<ul style="list-style-type: none"> ■ Requirements can be adjusted to cater for the specific functions that a device provides. ■ Can cater to need for stricter requirements where applicable. 	<ul style="list-style-type: none"> ■ Expensive and time consuming to develop requirements for each individual device. ■ Requires continuous work to cover new devices entering the market.
Horizontal approach to MEPS (with functional adders) / 4	
<ul style="list-style-type: none"> ■ Covers a broad range of devices. ■ Can cater to need for stricter requirements where applicable. ■ Can cover devices that are not yet on the market. 	<ul style="list-style-type: none"> ■ Complex to develop. ■ Requires commitment to develop and update appropriate allowances for functional adders.
Semi-horizontal or clustered approach to MEPS / 4	
<ul style="list-style-type: none"> ■ Broader coverage of devices. ■ Flexibility. ■ Provides more targeted allowances and requirements that could enable greater energy savings. ■ Can cover devices that are not yet on the market. 	<ul style="list-style-type: none"> ■ Requires time to design. ■ Could result in multiple regulations for different device clusters.

Advantages	Disadvantages
Comparative labels / 3	
<ul style="list-style-type: none"> High consumer awareness of labelling schemes. As a device-by-device approach, it can be more targeted. 	<ul style="list-style-type: none"> Network standby-specific labelling risks sending wrong message to consumers about the energy consumption of device – also a risk of having too many labels. Requires regulation for each device. May not be an effective instrument to address network standby if the label is based on the total energy consumption of devices (of which low power modes with network connectivity is one part.) New devices could fall through gaps.
Endorsement labels / 2	
<ul style="list-style-type: none"> High consumer awareness of labelling schemes. As a device-by-device approach, it can be more targeted. Can provide incentives for manufacturers to improve efficiency. 	<ul style="list-style-type: none"> Network standby-specific labelling risks sending wrong message to consumers about the energy consumption of device – also a risk of having too many labels. May not be an effective instrument to address network standby if the label is based on the total energy consumption of devices (of which low power modes with network connectivity is one part.)
Warning labels / 2	
<ul style="list-style-type: none"> High consumer awareness of labelling schemes. A warning label promotes compliance with regulations. 	<ul style="list-style-type: none"> Requires minimum energy performance requirements or some form of standards on which to base warning labels.
Voluntary agreements / 2	
<ul style="list-style-type: none"> Flexible. Stimulates co-operation along the value chain. Stimulates technology development. 	<ul style="list-style-type: none"> Does not cover the whole market. Challenging to measure the impacts. Compliance can be variable; difficult to link to strong compliance enforcement mechanisms.
Incentives and rewards / 2	
<ul style="list-style-type: none"> Stimulates the development of a market for more energy efficient devices. 	<ul style="list-style-type: none"> Requires other policies, such as requirements, to be in place. Considering one mode in procurement requirements may be sub-optimal; may require the development of weighting system.
Consumer awareness campaigns / 1	
<ul style="list-style-type: none"> Complementary to other policies. Can engage a range of stakeholders. Can create market demand for options to improve energy management. Can be started quickly. Comparably low cost. 	<ul style="list-style-type: none"> Precondition is that is possible for consumers to manage energy without impacting on service or functionality. Consumers tend to lose interest in energy management – may require sustained efforts.
Certification schemes / 5	
<ul style="list-style-type: none"> Flexibility. Adaptable: new levels can be added as technology improves. Adaptable to regional needs. 	<ul style="list-style-type: none"> Complex to design. Requires global co-operation. Savings may not be maximised or consistent. No simple efficiency metric.
Energy reporting through networks / 7	
<ul style="list-style-type: none"> Could enable development of targeted policies that maximise energy savings. New way to access information on energy savings potentials and device performance. Might eliminate the need to develop test protocols, specifications and conduct expensive testing of devices. 	<ul style="list-style-type: none"> Complex to design. Requires global co-operation. Requires engagement with protocol designers and Internet experts. Involves information protection and security issues. Involves breaking new ground for energy efficiency policy.

Note: 1 to 7 scale where 1 is the quickest and easiest to implement and 7 is expected to take the most time and effort. The rankings do not take into consideration the expected impact of policies – i.e. a higher ranked option may deliver comparably more energy savings so as to warrant the time and efforts invested.

Source: Adapted from Maia Consulting (2012), *Staying Connected: Unravelling Energy Waste Issues in Network Standby*, prepared for the Australian Government, Department of Climate Change and Energy Efficiency, Maia Consulting, Melbourne, <http://standby.iea-4e.org/documents-results/chronological-list-of-documents> (accessed 27 February 2014).

Towards more integrated policy approaches

Network standby may be the next frontier but it is not the only energy efficiency issue of the digital age. The urgent need for network standby policies is clear: but these must be part of a broader energy efficiency policy approach that, in a co-ordinated and integrated manner, targets other elements on the network and network-enabled systems as a whole. Further efforts are needed in exploring constellations of devices and their interaction to identify where the greatest impact could be made by policy interventions, as well as in developing innovative policy approaches that suit a dynamic, rapidly evolving and multifaceted technological environment. Ultimately, to develop and implement effective policy, further effort is needed to understand the precise functions and energy requirements of network-enabled devices and systems, and subsequently to develop comprehensive, complementary programmes, international standards and test procedures.



Digital energy efficiency action plan

Global challenges call for global solutions. International co-operation is needed to ensure that energy efficiency becomes a core characteristic of increasingly digitalised economies. Policy dialogue, coupled with dialogue among policy makers and other stakeholders, is a prerequisite to effectively stemming the growing electricity demand of billions of network-enabled devices. The IEA outlines how this co-operation could be organised and identifies key actions towards tackling network standby and furthering the development of energy efficient network-enabled devices and systems.

Key points

- *Governments, industry and standards development organisations need to jointly commit to the IEA Guiding Principles for Energy Efficient Networks and Efficient Network-enabled Devices.*
- *International co-operation is essential to launch and carry out a digital energy efficiency action plan that promotes harmonisation of current and future efforts.*
- *Endorsement by high-level international processes would set the stage for establishing a governance entity and international standardisation platforms.*
- *Multiple stakeholders will need to engage in developing technical standards and test procedures, as well as criteria and processes for data collection.*
- *Actions towards developing solutions for network standby are the immediate and urgent goal; ongoing effort should expand to operational development of digital energy efficiency solutions.*
- *While all stakeholders have a role to play in developing and implementing a digital energy efficiency action plan, governments must lead by committing resources for the concerted international standardisation effort.*

To help governments and other stakeholders address network standby and other energy efficiency challenges that arise in increasingly digitalised societies, the IEA is working in close co-operation with the IEA Implementing Agreement for Energy Efficient End-use Equipment (4E) and the Clean Energy Ministerial Super-efficient Equipment and Appliance Deployment (SEAD) initiative to develop a plan of action.

A digital energy efficiency action plan

This action plan identifies key roles and actions that should be undertaken by different stakeholders to promote energy efficiency of network-enabled devices. It outlines a process that evolves to take into account new technology developments, policies and international collaboration efforts. The action plan proposes milestones that the international community can use to ensure that efforts are on track.

Importantly, this plan initiates urgent action on network standby and a necessary durable effort on network power consumption solutions. The plan covers four key phases:

- establish global governance and operational co-operation
- promote international processes for digital equipment
- develop policies and solutions for network standby
- stimulate ongoing operational development of digital energy efficiency solutions.

Box 6.1

Mirroring the G20 launch of the global 1-watt standby initiative

As has been demonstrated with stand-alone standby policy, international co-operation is key to driving change and to efficiently using available resources to develop policies and international technical standards such as test procedures. The 2005 G8 meeting of leaders at Glen Eagles was the catalyst that triggered close co-operation among governments on standby policy. Energy policy makers must now adopt a similarly collaborative approach to make sure that network-enabled devices power down and that energy consumption in low power modes is reduced.

Upcoming high-level international processes could highlight network standby as an issue requiring similar urgent collaborative leadership action by all stakeholders. This would create an opportunity to:

- encourage governments to commit to the IEA *Guiding Principles for Energy Efficient Networks and Efficient Network-enabled Devices*
- prompt governments and industries to establish a common platform for proposing and evaluating options.

Phase 1: Establish global governance and strategic co-operation

A starting point is to develop the essential co-operation mechanisms for sharing information and experiences.

Drawing on existing and planned policies. Two collaboration platforms are aligning efforts: The IEA Implementing Agreement for a Co-operating Programme on Energy Efficient End-use Equipment (4E) has already established such mechanisms for its 12 member countries; and the Super-efficient Equipment and Appliance Deployment (SEAD) initiative, which also fosters information and experience exchange across governments, covers 16 jurisdictions. These form the core of technical collaboration and broader international collaboration and sharing, but international organisations such as the IEA, Collaborative Labelling and Appliance Standards Program (CLASP), the International Organization for Standardization (ISO), the International Electrotechnical Commission (IEC), governments and industry groups all have roles to play.

Governments that have already started to develop networked standby policies are well positioned to play a lead role in establishing a global policy development system. The European Union, Korea and the United States could, for example, contribute their respective standards to new internationalised standardisation processes. An accountable governance process should be established within an existing international co-operation forum.

Table 6.1 Global governance and operational co-operation actions

Global governance and operational co-operation actions	Timeframe 2014
<ul style="list-style-type: none"> ■ Raise the profile of energy efficiency of network-enabled devices when in standby, stressing the urgent need for and benefits of robust, fit-for-purpose standards. 	<ul style="list-style-type: none"> ■ Endorsement by high-level international processes. ■ Governments, industry, 4E and SEAD agree on implementation and government resourcing of this strategy.
<ul style="list-style-type: none"> ■ Establish a global governance process. 	<ul style="list-style-type: none"> ■ Agree to establish an international digital energy efficiency governance entity with existing global co-operation systems.
<ul style="list-style-type: none"> ■ Ensure that opportunities for international alignment are identified and utilised, including use of international test standards and measurement protocols. 	
<ul style="list-style-type: none"> ■ Engage in international collaboration and global dialogues with the aim of establishing co-ordinated policies that will increase the demand for and trade in efficient network-enabled appliances and equipment. 	<ul style="list-style-type: none"> ■ ISO and IEC to establish necessary international standardisation platforms for implementation of this strategy.

Phase 2: Promote international processes for digital equipment

Tackling network standby will require effective technology standards for individual network-enabled devices and for network equipment. At present, there are more than 100 technology standards of relevance for network-enabled devices (BIO Intelligence Service, 2011b). It is essential to pool efforts in the development of standards and to ensure greater applicability and use of international technology standards.

Development of technology standards typically involves several stages, starting with a proposal, mobilisation of people to work on the issue, writing drafts and finally a voting process to reach consensus. Once a technical standard is published, the use stage often triggers further rounds of development and subsequent publication of an updated version.

Considering how rapidly network-enabled devices and networks evolve, it is vital to establish processes that ensure standards will keep pace with technology advances. An overriding challenge is that everyone wants fast results, while the time it takes to develop technology standards varies. Indeed, sometimes the first question is whether it is even possible to develop a standard for a particular case: some issues and technologies require a certain level of maturity before international standards can be developed.

Robust, fit-for-purpose technology standards can greatly aid improved energy efficiency and facilitate policy making. Policy makers need to invest time and effort to engage with standardisation organisations to ensure that energy efficiency considerations are integrated and that the standards developed will support energy efficiency policies. Considering the substantial effort and investment required for policy making, it is critical to identify and promote technical standard development in areas that have a high energy savings potential (e.g. proxying, Energy Efficient Ethernet). Policy makers need to engage in ongoing dialogue with international standardisation organisations about planned policies and policy making needs.

Standards processes actions

- Identify existing standards of relevance to energy use and energy saving potential.
- Assess whether relevant standards sufficiently address long-term goals for energy efficiency and energy management.
- Examine whether existing standards (e.g. test procedures) can be used to support policy implementation.
- Identify gaps in the existing standards landscape, including where they can be aligned and which standards require updating.
- Develop an international standardisation process that is technology-neutral, with consistent terminology to address these priorities. Ensure outcomes address, and are not hindered by, protocols and legacy devices.
- Stimulate participation in these standards processes by a balanced and wide range of governments, organisations and industry, and ensure the process is publically available.
- Robust test procedures are essential to the development and implementation of policies.

Test procedures actions

- Establish a collaborative mechanism to create a robust and durable system for developing test procedures for network-enabled devices.
 - Establish a test procedures group within the digital action plan.
- Develop an international agreement for data gathering and sharing of digital energy data (see also data collection below).
- Establish a library for existing test procedures and digital enabled equipment energy data (see data collection below).
 - Investigate the ability of established public databases (such as CLASP or IEA PAMS) to collate and make available test and related data.
- Develop internationally standardised test methods and procedures. Ensure practical methods are developed for real-time data collection.
 - Establish a test standards development process within the international standardisation process for digital energy efficiency.
- Investigate how network-enabled devices behave in-situ and under test.
 - Develop a global testing programme – engage governments, research facilities and test labs in an agreed research plan.

Establishing a library or repository of existing test procedures would help to address multiple challenges in developing policy for complex and rapidly developing devices. Organising existing procedures in an easy-to-use, fully searchable database would allow stakeholders to access a menu of test procedures that could apply to new devices or serve as the basis for developing additional tests (rather than starting from scratch). Such a resource would also allow for the mixing and matching of relevant, pre-defined test procedure components. Optimally, content would be updated as technologies change.

Such a solution could help save time and effort through horizontal approaches, while also ensuring that procedures are sufficiently device-specific to be relevant and effective. A library could significantly simplify the process of developing test procedures and decrease the time and costs required. Initially, the library could be generated by adapting content

from existing approaches (e.g. ENERGY STAR for personal computers, small network equipment, imaging equipment; European Union Codes of Conduct for broadband equipment; the Japanese Top Runner programme). Over time, it would be supplemented by identifying and filling gaps in content.

Further discussion is required to define an appropriate institutional and organisational set-up, including location, cost-coverage, access, processes for creating and reviewing content, and for updating and maintenance.

Data collection

Harmonised approaches to data collection and processing are central to building knowledge that can support policy development and implementation at lower costs and in shorter timeframes. As in other areas, the starting point is to assess existing data collection methods.

Various initiatives are underway to create a knowledge base on network standby and several governments are pursuing regulatory efforts. At present, these activities are distributed and no formal mechanisms exist for sharing information. Concerted effort is needed to utilise and expand this knowledge base to develop effective policies and approaches.

Development of a data collection and management strategy or plan requires robust technical processes to facilitate the collection and analysis of data. Stakeholders need to reach agreements on data collection procedures and global data-sharing protocols. Given the proprietary nature of such data, this is a particularly challenging area for transparency.

Establishing clear guidelines on what data should be collected and/or disclosed is a critical first step. Prime examples include power levels in networked low power modes and maximum power levels under full load. Additional power values applicable to other modes might be collected on a voluntary basis. This could form the basis for a more detailed standardised benchmarking procedure with more accountable values.

A single, global repository, where vendors are required to enter energy data upon making new network-enabled devices available to the market, would serve multiple purposes for diverse stakeholders:

- Policy makers could better track trends and periodically set and/or revise standards based on solid data (for example, the lower 25 percentile of power values for a given device category).
- Vendors could assess achievements of their competitors and set market-driven targets (e.g. vendor A might try to achieve 25% lower consumption than vendor B and use it as a marketing point).
- Potential customers, both home users and companies, could easily include power level and energy consumption information in their buying decisions.

Data collection actions

- Working with an agreed data gathering and sharing agreement, identify data priorities, establish a research programme and resource it.
- Establish standardised methods, practices and procedures for collecting and processing commercial data sources, and for collecting energy data by device type and mode. Align estimation mechanisms and assumptions.
- Draft agreement on methodologies for collecting in-store and on-site data.
- Develop methodologies and solutions for real-time data collection.
- Establish practices and procedures for processing and verifying manufacturer-declared data.

- Establish baselines for digital equipment energy consumption and wider ICT-based systems; set up procedures to regularly monitor changes in energy demand. Establish and update usage patterns.
- Establish energy consumption benchmarks for functions and for different devices, including mobile devices.
- Establish protocols and mechanisms for sharing data outputs.
- Establish a single, global repository for energy data including a library of test procedures and specifications, and energy consumption data. Clarify processes for access, depositing data, creating, reviewing and updating information and resourcing these activities.
- Document market information: prevalence and distribution of digital equipment, and market barriers to technologies such as the Energy Efficient Ethernet.

Phase 3: Develop policies and solutions for network standby

In parallel with the development of international processes, steps should be taken to ensure the implementation of policies and solutions. This requires actions and stakeholder collaboration at both national and international levels.

Policies and solutions for network standby actions

- Formulate global and national strategies and action plans for improving standby power and operational energy consumption of network-enabled and ICT equipment. Institute a global declaration to address digital energy efficiency. Set clear objectives, timelines and evaluation criteria.
- Ensure coherence and integration among network standby and ICT energy efficiency policies and with existing industrial, commercial and appliance MEPS, labelling, procurement energy efficiency policies.
- Governments, industry and energy suppliers co-operate to educate, communicate, reinforce and incentivise consumers to use low energy ICT options, including disclosing low energy communication protocols and publishing studies and device energy ratings. Promote “best-in-class” equipment and share best practices.
- Develop voluntary agreements and pro-active solutions to energy efficient ICT and network-enabled equipment.
- Commit to compliance with energy performance standards and labelling programmes.

Phase 4: Stimulate ongoing operational development of digital energy efficiency solutions

The IEA *Guiding Principles for Energy Efficient Networks and Efficient Network-enabled Devices* provide a good basis for advancing action across three areas: a) working towards the integration of energy efficiency considerations in the development of international standards; b) developing national or international voluntary agreements; and c) guiding policy making. Further work needs to be done, however, in terms of identifying where and how application of the guiding principles would be most useful and effective, and how increased commitment to abide by the principles could be generated along the ICT-device and network value chains.

Ongoing operational development of digital energy efficiency solutions actions

- Maintain global and national strategies and action plans for ongoing improvement of standby power and operational energy consumption of network-enabled and ICT equipment. Set clear objectives, timelines and evaluation criteria.
- Ensure ongoing coherence and integration among network standby and ICT energy efficiency policies and with existing industrial, commercial and appliance MEPS, labelling, procurement energy efficiency policies.
- Governments, industry and energy suppliers co-operate to educate, communicate, reinforce and incentivise consumers to use low energy ICT options, including disclosing low energy communication protocols and publishing studies and device energy ratings. Promote best in class equipment and share best practices.
- Develop voluntary agreements and pro-active solutions to energy efficient ICT and network-enabled equipment.
- Commit to compliance with energy performance standards and labelling programmes.
Scope exists to further develop and refine the IEA *Guiding Principles for Energy Efficient Networks and Efficient Network-enabled Devices* through additional provisions or clarifications, including:
 - Power management of a device should not impede the operation of the network or other network-dependent devices.
 - Power management of a device should not drive un-negotiated energy consumption increases in other parts of the network.
 - Requirements for networked devices need to be reviewed against a holistic impact to the network.
 - Appropriate energy-saving modes should be implemented to be consistent with the inactive periods of the device.
 - Inclusion of co-ordinated power management among related devices to allow more rapid power management when services are not required.

A following step is to initiate a process to promote the application of policy and technical efforts globally. This could be done through sharing best practice information and by developing demonstration projects and voluntary agreements.

Stakeholder actions for tackling network standby

As described in Chapter 4, progress in tackling network standby relies on a range of stakeholders. Policy makers/national governments, standardisation organisations, service providers, device manufacturers and non-governmental organisations all have a role to play. In addition, international organisations are well-placed to facilitate interaction among stakeholders and develop approaches and foundations needed to accelerate progress. The following overview provides a short list of actions identified in the digital energy efficiency action plan, organised by which stakeholder group could effectively and appropriately take a leading role in implementation.

National governments actions

- Research on network standby and energy use; collect energy use data on by device type and mode; establish/update usage patterns.
- Initiate data collection to create a baseline for standby energy consumption of network-enabled devices and wider ICT-based systems; set up procedures to regularly monitor demand.
- Formulate national strategies and action plans for improving energy efficiency of ICT-based devices and systems; set clear objectives and timelines; establish evaluation methods.
- Ensure better coherence and integration among network standby-related policies and industrial policy for ICT.
- Ensure better coherence and integration between network standby-related policies and existing minimum energy performance standards, energy labelling policy and public procurement schemes.
- Develop a robust system to check compliance and monitor progress and results of policy implementation.
- Consider mandating energy data reporting from vendors placing devices on the market.
- Stimulate and participate in the development of technology standards by standardisation organisations to support network standby-related technology and policy making.
- Work with industry and energy providers to develop reinforcement and incentives for consumers to change behaviour.
- Support R&D in energy efficient hardware, software and systems; convene discussions with manufacturers and service providers to review and potentially streamline regulations that impede progress on network standby.
- Ensure that opportunities for international alignment are identified and utilised, including use of international test standards and measurement protocols.
- Engage in international collaboration and global dialogues with the aim of establishing co-ordinated policies that will increase the demand for and trade in efficient network-enabled appliances and equipment.

International collaboration actions

- Enhance efforts to develop standardised data collection methodology; establish mechanisms for data sharing; initiate joint data collecting activities; develop information-sharing mechanisms.
- Establish collaborative mechanisms to create a robust system for developing test procedures for network-enabled devices.
- Establish benchmarks on energy consumption for functions, including mapping what is state of the art in mobile devices.
- Make concerted efforts to move forward with understanding functions; explore possibilities to utilise knowledge about functions and associated energy demand to inform policy making.
- Identify opportunities for international alignment and co-ordination; enhance efforts to introduce internationally aligned schemes.
- Increase efforts to align technology standards.
- Stimulate international RD&D collaboration, making best use of national competencies.

- Document market prevalence and implementation barriers to technologies such as the Energy Efficient Ethernet (EEE).
- Refine and stimulate the uptake and implementation of energy efficient guiding principles for good network design.
- Create an international voluntary agreement or covenant for the implementation of relevant subsets of the *IEA Guiding Principles for Energy Efficient Networks and Efficient Network-enabled Devices*.
- Examine existing policy frameworks and compare energy allowances with measured power levels and energy consumption.

Standardisation organisations actions

- Develop test methods.
- Ensure technology standards that promote energy efficiency are technology-neutral.
- Develop standards that ensure efficient practices in new devices are not hindered by protocols or legacy devices that obstruct their implementation.
- Enhance co-ordination of standardisation processes, or at least provide a clearer publicly available overview of relevant standardisation processes underway or planned.

Device manufacturers (industry) actions

- Actively participate in existing voluntary agreements and take a pro-active role in establishing new voluntary agreements.
- Make efforts to communicate issues related to energy efficiency in network-enabled devices to consumers; ensure that devices are shipped with energy-saving features enabled; provide users with clear guidance on how to optimise performance of their devices to cut unnecessary energy waste.
- Take an active part in development of technology standards for more efficient communication protocols and their implementation in network-enabled devices.
- Share data on device energy use.
- Support energy efficiency by openly disclosing communication protocols.
- Commit to compliance with the energy performance standards and labelling programmes.
- Integrate the *IEA Guiding Principles for Energy Efficient Networks and Efficient Network-enabled Devices* in device design.

Service providers actions

- Monitor and share data on electricity consumption of network-enabled devices in all modes.
- Support the development of technology and energy performance standards.
- Establish voluntary agreements with government.

Non-governmental organisations actions

- Educate the public on the issue of network standby to create support and demand for action.
- Publish field studies and device/service ratings to raise the profile of the network standby issue.

The IEA digital energy efficiency action plan

This plan, which extends beyond network standby, aims to initiate an ongoing process to encourage the research, stakeholder dialogue and information sharing needed to enable energy efficiency policy makers to promote the integration of energy efficiency considerations as a core element of sustainability in increasingly digitalised societies.

As part of this plan, the IEA calls for governments to adopt three measures:

- Develop policies with key energy efficiency objectives:
 - promote power management in network-enabled devices
 - stimulate a reduction of energy consumption in low power modes with network connectivity
 - help consumers reduce the energy consumption of their networked devices
 - stimulate the development and uptake of solutions that promote energy efficiency in network-enabled devices and systems.
- Intensify international co-operation to develop technical foundations for policy making, including three key considerations:
 - energy efficiency metrics
 - data collection and data sharing

- international standards, in particular test procedures.

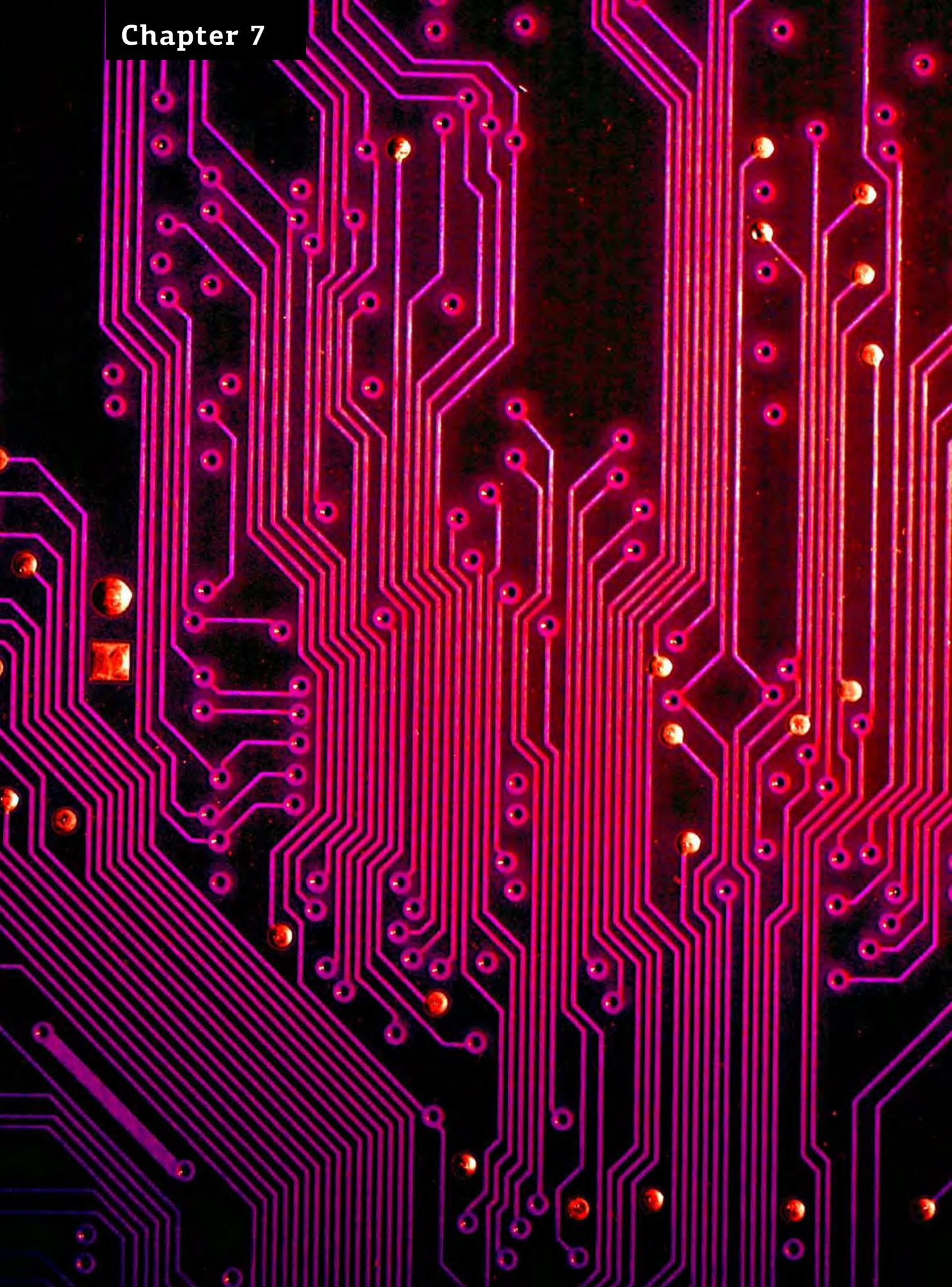
- Work towards establishing or supporting international initiatives to promote energy efficiency in the broader context of digital economies.

Implementation of this plan will require the engagement of industry, standardisation organisations and other stakeholders. In this publication, the IEA provides an action plan identifying key actions to be undertaken by stakeholders and providing a short list of priority actions.

To facilitate and accelerate the achievement of these objectives, while also ensuring that governments are well-placed to tackle upcoming energy efficiency challenges of increasingly network-enabled economies, the IEA proposes that governments:

- establish an international policy platform to enable dialogue, information sharing, tracking trends and the joint development of solutions
- establish an international policy-industry platform to enable enhanced dialogue on how to ensure that network-enabled devices and systems are energy efficient, and to discuss technology trends and how to ensure that energy efficiency becomes a strategic priority in development, deployment and use of network-enabled systems.

Chapter 7



Conclusions and recommendations

Network standby is a major issue that is building momentum, with two possible outcomes. Unconstrained, all trends point to dramatic increases in the use of network-enabled devices and associated energy demand – most of which is ultimately wasted while devices wait to perform their primary functions. By stepping in now, governments could harness the momentum to realise significant opportunities for energy savings, even as device deployment grows.

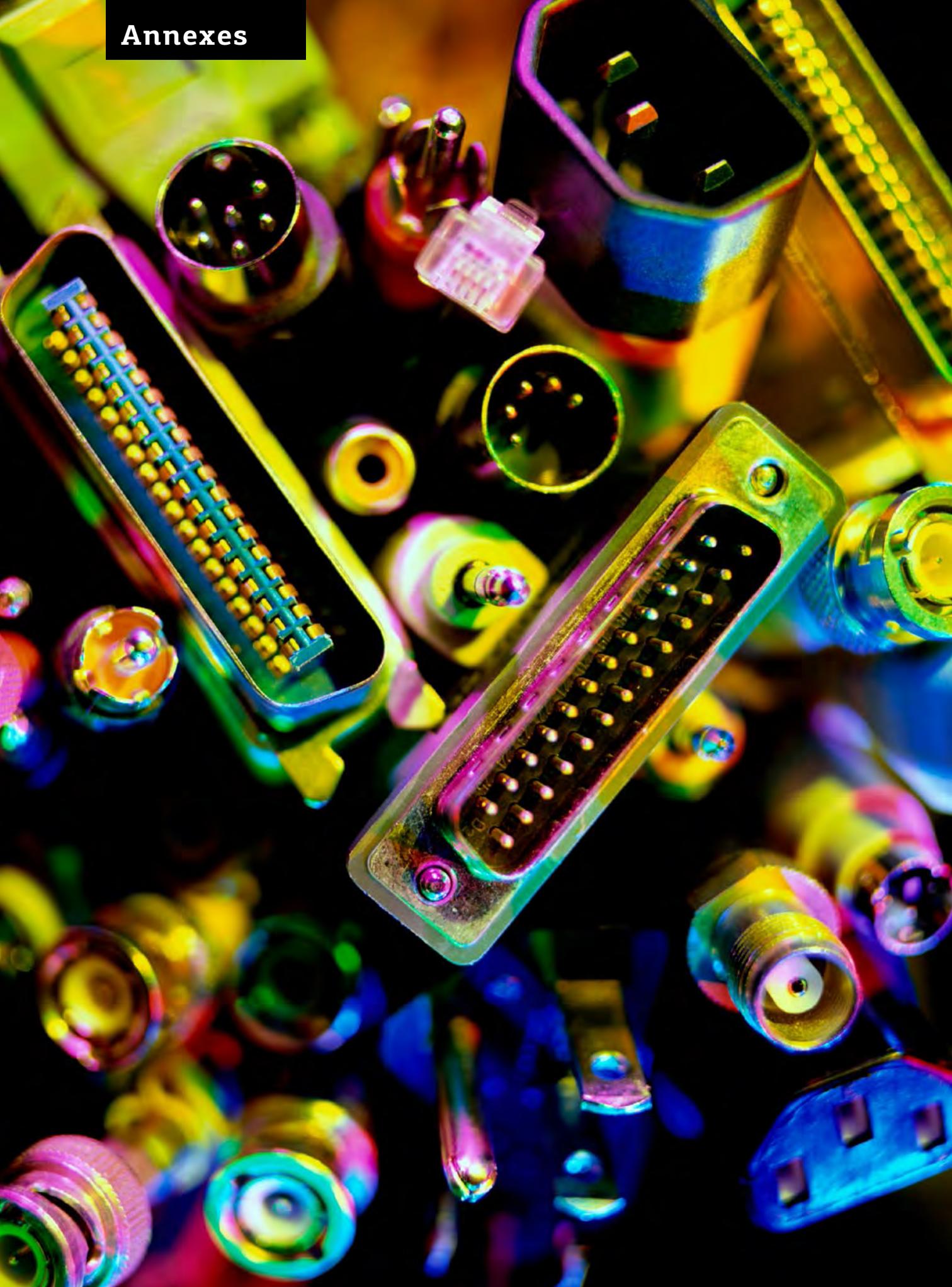
Considering the rapid rate of deployment of network-enabled devices, network standby should be a priority for energy efficiency policy makers. While this publication has outlined specific actions needed in diverse areas, they largely fall into five broad categories:

- **Assess, analyse and align existing policy approaches for globally traded devices.** The current proliferation of widely different policy approaches is counterproductive. Countries moving forward in policy development need not start from scratch: rather, they can capitalise on the considerable work done to develop energy efficiency policies and programmes for network-enabled devices (most notably, by the European Union and the Republic of Korea, and by ENERGY STAR in the United States). Assessing which policies exist, analysing their effectiveness and improving alignment will deliver broad short- and long-term benefits.
- **Pursue close interaction with industry.** In a rapidly evolving environment, it is critical to create close relations that allow technology and policy development to be mutually supportive. Policy needs to be stable enough to build industry confidence, yet flexible enough to allow innovation within the policy frameworks. Considering the rate at which technology advances, the onus lies more on policy to keep pace: technology will not wait. Again, alignment of effort is vital: an over-proliferation of initiatives that aim to establish international dialogue with industry associations or with industries directly can lead to sub-optimal use of resources for all parties involved. The result is often unclear messaging and outcomes. To the greatest extent possible, co-ordination or joint initiatives are desirable.
- **Establish international technology standards at the earliest possible date.** International standards for definitions, metrics and test procedures are valuable to all stakeholders and across many levels. They also serve the public good by ensuring consumers are informed about the quality and energy efficiency of devices on the market. Governments have a role to play in ensuring international standards developed are fit for policy making purposes. Standardisation organisations should seek to avoid overlap and

duplication of effort by working jointly or collaboratively to the greatest extent appropriate and possible.

- **Encourage development of communication protocols that support energy efficiency.** Governments should launch and/or promote programmes and initiatives that incentivise and reward device developers for the creation of communication protocols that enable energy savings. This can be done through certification schemes or labelling, for example, that recognise front runners, or by adjusting policy to reflect the top achievements in industry. Such incentives should, however, remain technology-neutral.
- **Prioritise data collection.** At present, the use of disparate scopes and methodologies leads to incomparable data sets that undermine collaborative data collection efforts. While it is evident that different approaches and methodologies will be needed to collect different kinds of data, coherence across device types is vital. Developing a data collection and data management plan is a key first step, followed closely by international collaboration to reach consensus on data collection methodologies. This second step must incorporate dialogue with industry, particularly in relation to how industry can provide relevant energy data for devices and systems while protecting proprietary information. The third step is to initiate data collection projects, ideally in parallel with establishing a system or repository to enable international data sharing and data management. Such a repository must be sufficiently resourced to ensure sustainability.

Network standby is one aspect of the much broader field of networked systems. Over time, further international efforts and collaborations are warranted to ensure that energy efficiency aspects are integrated considerations throughout the development and deployment of related technologies, as they continue to evolve.



Technical foundations

This Annex highlights some of the challenges and actions needed to advance technical foundations essential to establishing robust policy frameworks and to accelerating progress in developing energy efficient solutions for network-enabled devices. It provides greater detail on some of the actions proposed in the IEA Digital Energy Efficiency Action Plan.

Section 1 covers the issue of energy efficiency metrics. As network-enabled devices are very heterogeneous and deliver a wide array of services, more refined metrics are needed than a simple comparison of watts consumed in different modes. A network-enabled coffee machine uses network connectivity in a very different way than a router or a modem, for which the primary function is data transfer and processing. Progress in metrics can help inform policy making and contribute to ensuring that energy efficiency efforts lead to an optimal outcome – i.e. devices deliver the highest value services for the lowest possible energy consumption.

Section 2 deals with data collection methodologies for network-enabled devices and standby power, which is even more challenging than collecting data on the energy consumption of standard appliances and equipment. Several methods are available to collect the data needed to inform policy making, establish baselines and monitor progress in terms of improved efficiency. Opportunities exist to further develop relevant data collection methodologies.

Section 3 addresses test procedures, an essential element of policy instruments. As with metrics, testing is more complex for network-enabled devices than for stand-alone appliances and equipment (particularly for minimum energy performance requirements and labels described more in detail in Chapter 5). Test procedures underpin the technical standards (either national or international) for establishing policies as to when and how manufacturers should report energy consumption or power levels of equipment or appliances, or of network-enabled devices. Currently, different jurisdictions measure energy consumption or power levels for network standby in disparate ways – if at all. Several challenges need to be resolved to develop robust test procedures for network-enabled devices that would capture energy performance in low power modes with network connectivity.

While addressed in separate sections, these three topics are interconnected. Energy efficiency metrics, for example, can be a key component of test procedures. Results from testing network-enabled devices (or indeed, appliances and equipment) can be a component of data collection approaches.

Section 1: Defining energy efficiency metrics in a digital context

According to a classic definition, energy efficiency implies that the energy used by a device should commensurate with the work done (delivery of the same or better service output with less energy input). The diversity of devices and functions in an increasingly networked world makes it extremely difficult to define the work done, as does the fact that a given device may have primary and secondary functions and may perform different types of work

in different operational modes. In the case of network standby, multiple levels of energy efficiency metrics are needed, with particular emphasis on low power mode (where current energy loss is greatest). While this is not the only factor to consider when developing solutions, it is a significant and necessary step.

Defining output for network-enabled devices, network infrastructure and networked systems is equally challenging as the service output varies and can comprise a range of different service outputs. Some metrics consider performance, while others only focus on power demand – a combination of both may be needed.

While many parameters could be considered in the development of energy efficiency metrics, at the highest level two main aspects should be covered: performance parameters for network-enabled devices and their energy efficiency in various modes or states.

Possible energy efficiency metrics include the following measures:

- Energy consumption watt-hour (Wh) in relation to delivered quality of service over defined time intervals.
- Energy consumption (Wh) or power requirement (W) in relation to performed work (i.e. volume of traffic) over defined time intervals.
- Energy consumption (Wh) in relation to a set of provided services or functions over defined time intervals.
- Energy requirement (Wh) for specific sets of provided services or functions (e.g. energy required to stream a movie or energy required to deliver Internet Protocol phone services for 24 hours).

Network-enabled devices typically deliver services that require very little energy but need to draw power to maintain the capability of providing such services. In such cases, it may be more appropriate to define power limits with respect to capability, not as a function of the work performed (Energy Efficient Strategies, 2010). Energy consumption associated with network functions is usually determined less by the volume of data than by network technologies and requirements set by communication protocols.

Key performance parameters include:

- **Resume-time-to-application:** the time required for a device to resume its functions fully. In the context of network standby, it is the time to resume functions following a signal or trigger from the network.
- **Resume-time-to-connection:** the time required for a device to resume full connectivity.
- **Latency:** the time a device takes to change state and respond to a request from the user, or to provide a given function (including start-up).
- **Level of network interaction:** a measurement of the volume of information transmitted.

When it is not possible to define an appropriate metric, “proxy metrics” can be used to describe and define assessed energy efficiency by analysing indirect performance indicators.

Progress has been made in the area of developing energy efficiency metrics for some ICTs such as data centres. Establishing similar metrics for network-enabled devices and equipment is more challenging as their energy consumption depends on many parameters that are inherently diverse, such as technology, performance and applications. This complexity makes it more difficult to determine the actual energy efficiency of network-enabled devices and to monitor progress towards greater efficiency.

Box A.1

The general case of energy efficiency metrics for network equipment

The general principle behind efficiency metrics for network equipment – which typically needs to remain “on” all the time – is that energy usage should be assessed in traffic conditions that match normal usage. This energy usage is weighed against the useful work that the network-enabled device performs in terms of its maximum useful throughput.

It is vitally important to consider the nature of network operations, which is often characterised by rare bursts of intense activity and much longer periods of being available but largely idle. The efficiency will depend on the performance of the equipment under intense load compared to the energy consumption under typical loads.

A further issue to consider is if and how to factor in the energy consumption effect that one device

may have on others participating in a given network. For instance, if network equipment enables energy savings in connected edge devices, is this a factor that should be included in energy efficiency calculations?

Finally, the configuration and design of edge devices on the network also comes into play. Many networks are made less efficient by outdated (legacy) devices that do not have appropriate power down capacity and generate unnecessary network traffic.

These principles and factors are followed by the Telecommunications Energy Efficiency Ratio, developed by Alliance for Telecommunications Industry Solutions (ATIS) or similar approaches.

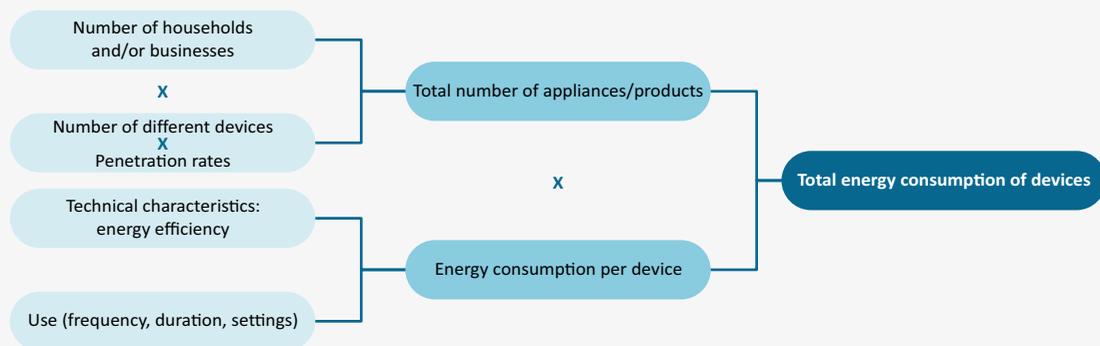
While work in this area is ongoing, for instance within the International Telecommunication Union (ITU) and the Alliance for Telecommunications Industry Solutions (ATIS), consensus on metrics is currently lacking. Moreover, as network-enabled devices are part of a wider system, the need for system energy efficiency metrics should also be explored. As yet, no examples of system efficiency metrics exist, and the initial steps in defining network standby system efficiencies are likely to start with priority network sub-systems such as devices and their interactions with a LAN. When some practical experience has been developed in LANs, upstream network system efficiencies can start to be developed. This all takes time – highlighting the urgency in starting work in priority areas.

Ultimately, the quality of metrics depends on the quality of test procedures, which ensure that results are robust and reproducible across different vendors and test laboratories.

Section 2: Measurement and data collection

While the focus of this publication is on reducing the large-scale, cumulative energy waste of network-enabled devices, it is important not to lose sight of the fact that total energy demand derives from two main factors, each with their own contributing elements. Traditionally, the total energy consumption of stand-alone devices has been calculated using the following formula:

- **The total number of devices deployed:** reflecting the number of businesses and households using such devices, the number of different devices employed and the level of penetration.
- **Energy consumption per device:** reflecting technical characteristics (including energy efficiency) and actual use (which brings into play frequency, duration and settings).

Figure A.1 Calculating the total energy consumption of devices


Source: Adapted from Siderius, H-P. (2011), "The future of appliance efficiency policy: net zero energy using appliances", presentation at the 6th International Conference EEDAL (Energy Efficiency in Domestic Appliances and Lighting) 2011, 24-26 May, NL Agency, Ministry of Economic Affairs, Agriculture and Innovation, The Hague, www.eedal.dk/Conference/Programme%20and%20Presentations.aspx (accessed 7 March 2014).

While this approach provides an adequate framework for stand-alone devices, for network-enabled devices, the impact of network connectivity and other devices on the network need to be taken into consideration. Energy calculations for network-enabled devices are further complicated by the need to consider the demand of the device in question, of the network equipment that enables it and of any other devices on the network with which it interacts. This adds several degrees of complexity to developing effective measures.

As network-enabled devices are a relatively new phenomenon, an ongoing process is needed to build up knowledge and understanding on how these devices are used, what types of functions they have, their network functions (including device-to-device interactions in typical deployment scenarios) and how much energy is required for different functions.

Measurement and data collection are needed for three fundamental purposes: to establish baselines; to prioritise which devices should be within the scope of policies; and to set power or total energy consumption limits, make impact assessments, and estimate savings potentials. Ultimately, they also support tracking policy progress and evaluating the effectiveness of policies.

None of this is straightforward. Device power usage depends on how people set up and operate systems, and the other technologies with which they interact. These operator and interaction dynamics need to be carefully analysed and the context understood.

To have a firm basis for policy making and prioritisation, data need to be collected on types of devices in the market, and on current and projected market developments. To target the areas with highest potential for efficiency gains, information is needed on how much electricity these devices consume. Here disaggregated data will be helpful, such as an understanding of how much power is consumed in different power modes and how much time is spent in different modes. Information on the maximum, average and minimum power levels in different modes, based on a reasonable selection of models, can further inform what types of requirements can be set.

Box A.2

What data to collect

The basic data needed for informed decision making cover three main areas, i.e. power demand, consumer use patterns and market trends:

- power demand of devices operating in all modes (i.e. active, idle, all network standby, stand-alone standby [including sleep], and off modes) before and after solutions are introduced
- power demand of networks for different bandwidths
- minimum technical power requirements to perform different functions
- consumer use patterns of every device type, reflecting time spent in each mode and including specific network requirements distinct from those of network providers and device settings
- network traffic patterns on networks (i.e. times of data throughput)

- device shipment and sales
- device stocks, including age and lifetime
- average device lifetime to give a stock average value in each year
- trends in terms of device replacement
- key characteristics (attributes and functions) of new device types entering the market each year.

Alternatively, systems for real-time data collection, linked with a limited set of survey and market data, are required to better understand energy consumption in networked systems. Measurement methodology standards would benefit from inclusion of methods to define and measure duty cycles to calculate the energy consumption over the entire duty cycle including low power and active modes.

While data are available on usage patterns for some device types, similar data will need to be collected for new devices coming on the market, particularly as many technologies are now converging and have increased functionality that changes usage patterns. Games consoles are used to watch DVDs and connect to the Internet, for example, and TV screens are used to watch content from computers. Industry reports for devices are frequently used as data sources; however, these are not updated as frequently as needed to develop device specifications, especially for converging devices. Creating a system to regularly update information on usage patterns would be useful.

Data are also needed to understand the interactions among devices on networks and the associated energy consumption, as the energy performance in such cases will vary depending on factors outside the device itself. The length of a cable, for example, affects energy consumption. This is a complex undertaking as technologies are evolving and a multitude of factors need to be considered.

In addition, there is a pressing need for more data, coherent and comparable by country, to deliver solid energy efficiency analysis and to track progress. Robust technical processes are required, including systems for measuring and monitoring energy consumption, on a device and an aggregated level, on a continuous basis. Survey data from 2010 will not provide sufficient information on the uptake of networked devices in homes in 2012.

Measuring and collecting data that the diverse technologies encompass in network-enabled devices implies considerable resources of time and financing. It is essential to identify and prioritise the measurable variables that would provide sufficient basis for decision making and give enough information to assess the impact and performance of policy solutions.

Box A.3

Data collection and data-sharing efforts

In 2012, the International Telecommunications Union (ITU) developed Recommendation ITU-T L.1420 – *Methodology for energy consumption and greenhouse gas emissions impact assessment of information and communication technologies in organisations*. This recommendation describes the process to follow when an organisation (e.g. commercial company, administration or university) intends to assess and report its environmental impact in terms of energy consumption and greenhouse gas (GHG) emissions. The process includes the selection and declaration of the emission factors databases used by the organisation.

Prior studies show that organisations use a wide range of databases containing information on

emission factors when assessing their own impact, which makes comparison of results difficult or even impossible. This difficulty is increased by the fact that the accuracy, the coverage and the updating process of these databases are not homogeneous.

The ITU Study Group 5 “Environment and Climate Change” concluded on the need to better analyse the characteristics of these databases with the objective to identify duplicated information or lack of data that could jeopardise the environmental impact assessment provided by these organisations.

In this context, ITU Study Group 5 developed an online questionnaire to gather information on emission factors and their databases repositories.

Quantifying the overall impact of network-enabled devices that reflects actual consumer use requires market penetration data for every device type on a country and regional basis. This information would support future performance monitoring to assess the efficiency of policy solutions introduced.

Experience with approaches to track changes and quantify the impact of policy actions on regular standby shows the need for many different power measurements. Diverse sources can be mined, ranging from metering records (whether intrusive or remote), sample tests and laboratory measurements, to surveys on use patterns and appliance stock in buildings, device inventories and commercial data. Household or business audits involve collecting information about appliances and equipment, such as the age, model and energy consumption. Socio-demographic and physical surveys involve face-to-face interviews and provide information on the characteristics of household members and energy behaviour. Monitored end-use data collection provides information on how much each device draws in different power modes and how long the devices spend in different modes.

But challenges arise with combining data from different sources, including potentially high error rates. Initially, it may be better to focus on a smaller number of devices to establish methodologies and approaches.

Experience also reveals the importance of researching and understanding local market conditions (Tait, 2012), while underscoring a key challenge: getting reasonable consistency, particularly when device definitions vary in different jurisdictions.

The study *Low Power Mode Energy Consumption in California Homes* (Meier et al., 2007) is an example of a procedure to quantify the energy footprint of low power modes. It outlines a methodology to measure the energy used by domestic appliances in these modes, defining a device scope and building a collective estimate on device saturation data, technical specifications and usage patterns. The study, which also aimed to measure how many hours were spent in each mode, focussed on energy (not power) using the following methodology: a) define device and modes; b) conduct explorative studies; c) proceed to data collection;

and d) carry out aggregation and analysis. A procedure to measure network standby consumption locally could be drafted from an extension of this method.

Box A.4**Sources and gaps in data collection**

Data to support policy making and best practice in business can be drawn from multiple sources. While vital to efforts to build knowledge and establish standards and policies, current data collection efforts are hampered by methodology and technical gaps.

Power levels in different modes for different device and network types

- **Data sources:** laboratory testing, field trials of new devices (retail or in-shop testing), field trials of existing devices (household/business testing), manufacturer supplied data or real-time data collection.
- **Methodology gaps:** standardised test conditions (including type of network, length of measurement), tools for network simulation, standardised methodologies for field trials.
- **Technical gaps:** limitations in terms of technical solutions for measuring very low consumption and millisecond shifts between different modes of operation.

Consumer use and network traffic patterns

- **Data sources:** field trials of existing devices (household/business testing), manufacturer/network-provider data.

- **Methodology gaps:** user trends for different device types, power measurement techniques on networks with different traffic.

Energy metrics

- **Methodology gaps:** lack of clearly defined energy efficiency metrics for network-enabled devices, and of international agreement on suitable metrics.
- **Technical gaps:** tools to measure the efficiency or amount of data transmission and data processing, and relevant energy usage.

Energy use in networks

- **Methodology gaps:** a device-by-device approach to measuring energy consumption will not provide an adequate representation of the actual consumption within a network. There is a need to develop a holistic approach that defines the value chain across a network and enables measurement of energy consumption of network-enabled devices when connected while also accounting for energy impacts among devices on the network.

Section 3: Test procedures

Irrespective of policy approach, test procedures are a prerequisite for policy making. Test procedures are typically developed by standardisation organisations (national or international) and then integrated into policies together with policy specifications on how results should be reported to authorities and communicated to end-users.

Test procedures need to deliver the measurements, outputs and assessments required for (the range of) regulations and energy programmes. Ideally, they should assess energy efficiency over the expected range of typical usage conditions to allow an assessment of device design, versatility and performance. A substantive difference between stand-alone and network-enabled devices must be accounted for. In stand-alone devices, functions are usually similar in given modes. By contrast, network-enabled devices reflect a number

of possibilities: a) the function exists, but is unavailable as configured; b) the function is available, but not active; and (c) the function is active. Most importantly functions are evolving. Consequently, several states need to be considered when developing test procedures and testing devices, and standards and procedures will need to evolve over time.

Robust test procedures for energy efficiency of network-enabled devices and network equipment are critical to ensuring that results are reproducible and repeatable. Testing delivers value at multiple points. Device testing provides insight on compliance and the effectiveness of policies; by avoiding ambiguities, it also supports possible enforcement action (Ellis and Rozite, 2013). Test procedures are also important to ensuring consumers have access to accurate, objective information.

Global alignment of test procedures enables comparisons and benchmarking, thereby facilitating trade of network-enabled devices that are produced and traded internationally. This has clear benefits for both industry and policy makers, including saving time and resources for national administrations. The *IEA 25 Energy Efficiency Policy Recommendations* highlight the need for governments, when possible, to use international test standards and measurement protocols to assist performance comparisons and benchmarking for traded devices, and to reduce industry compliance costs. The recommendations also reinforce that standardised test procedures are an integral part of energy efficiency policies including mandatory energy performance standards (MEPs), voluntary agreements for energy requirements, and comparative or endorsement labelling schemes.

To date, international standardised testing procedures for horizontal testing have not been established for low power modes with active network functions. Vertical test procedures that address network connectivity do exist (i.e. Ecma-383), and while most policies specify a minimal requirement, these are not aligned or consistent. This lack of aligned and consistent test methodology will hinder the implementation of effective policy for network-enabled devices (Energy Efficient Strategies, 2010). Incorrect or inadequate testing has a direct impact on the effectiveness of policies and the energy savings achieved. Initiating international standardisation processes is a priority.

What to test

As a minimum, test procedures should determine what configuration or configurations the device that is to be tested is in. A starting point is to establish a base case (i.e. to test the device without network connection) and then to conduct subsequent testing in accordance with pre-determined requirements regarding further configurations (i.e. standard communication with a single connection, standard communication with multiple connections and/or maximum communication). Procedures should also establish the interface speed at which a device should be tested and, if appropriate, specify how many cycles need to be covered to capture energy consumption due to network maintenance functions.

Across all of these parameters, effort should be made to ensure that device testing is carried out in a manner that provides an adequate semblance of typical use. At the same time, it is important to recognise that network-enabled devices are a very diverse group, and different approaches or specific requirements may be needed for different types of devices (Nordman, 2011a).

Optimally, testing should cover as many different types of configuration and conditions as possible, but cost and time requirements are important considerations when developing test procedures. Thus, it is crucial to determine at an early stage what data are essential and to develop steps and tools to obtain these data in the most effective way.

Due to rapid technological developments in network-enabled devices, test procedures may need to be frequently updated and refined (i.e. more often than for conventional stand-alone devices) (Nordman, 2011a).

Box A.5**Parameters for test procedures**

Generally, five main components have been identified for inclusion in test protocols of network-enabled devices:

- clear definitions, including different network types and technologies
- device configuration and set-up requirements
- determination of type of network connectivity
- determination of network states and modes covered
- definition of network traffic during testing.

Additionally, it is important to test the device under diverse conditions/states:

- disabled – the network function has been deactivated in the configuration

- absent (wired) – network interface is activated but there is no network connected to the device
- absent (wireless) – network interface is activated but there is no network connected to the device (this is far more complex than wired)
- linked – link established but not fully activated
- fully connected – link established with full communication
- special modes – in a lower power state and looking for specific network signals (i.e. Wake-on-LAN).

Source: Energy Efficient Strategies (2010), *Standby Power and Low Energy Networks – Issues and Directions*, report prepared for the Asia-Pacific Partnership and IEA 4E Standby Annex, Energy Efficient Strategies P/L, Warragul, <http://standbyiea-4e.org/files/other-files/0000/0023/Network-Standby-2010-09-final.pdf>.

What to consider

Several factors need to be considered in the development of test procedures for network-enabled devices and network equipment, including the reality that it may not always be clear in advance what factors affect energy use:

- Network connectivity adds complexity to the testing of devices, primarily related more to the type of network technologies used than to the device type (e.g. TVs). Moreover, network connectivity can be active in any mode (including “on”, “off”, “sleep”, “ready”).
- Time comes into play, since devices and equipment may have periods of higher power activity, which can be either internally or externally generated.
- Different devices of the same type (e.g. TVs) have different network capabilities and functions. In some device types, some models have network connectivity while others do not.
- In the case of network equipment, a single device can perform significantly divergent network functions. Whenever network equipment can transcend class definitions and be redeployed or co-deployed for an additional role, its efficiency may change significantly and multiple test protocols may be required.

Existing international standards for test procedures

The International Electrotechnical Commission (IEC) standard IEC62301 edition 2 (*Household Electrical Appliances – Measurement of Standby Power*, published in February 2011)

mentions network mode and led to improvements in measurement approaches that ensure more reliable and accurate measurements. IEC62301 ed. 2 covers issues such as ambient conditions, power supply and power quality (e.g. from direct current, power over Ethernet, or dual transmission of data and power via Ethernet cables). The document also outlines the type of power measurement equipment that should be used and methodology for how to obtain valid readings.

Critical elements related to testing and set up, however, are not defined in IEC62301 ed. 2. These include cable type and length, radio conditions, capabilities of connected device(s), functions provided to or by other devices, service provider or cloud context, network service environment (i.e. how addressing and discovery is conducted), data traffic details (e.g. quantity, timing, packet size, content), energy management and typical usage. Further, while the standard recognises that devices may operate in diverse network modes and the recommended test procedure can measure the power associated with these modes quite accurately, there is no standardised approach to set up network-enabled devices in terms of the type of network connection(s) and the level of traffic. As a consequence, energy consumption measured could vary from laboratory to laboratory, depending on the configuration selected.

There is a clear need to formalise test set-up requirements to allow consistent and reproducible measurements of devices with network functions, which requires the definition of test procedure elements that complement IEC62301 ed. 2. This will facilitate measurement of relevant modes of equipment when a network function is present, i.e. across all the different levels of network functionality that are likely to occur during normal use. The IEC is planning to investigate further various issues related to network connectivity and standby for inclusion into the existing IEC62301 structure.

Test procedures around the world

A range of national programmes also undertakes to define test procedures. Requirements of these programmes have been developed locally, resulting in a situation where the same devices are subject to different test procedures for different countries or regions. Still, it is encouraging that diverse bodies are attempting to define some elements of network connectivity for testing purposes. In addition to advancing the issue of network standby at a national level, their work will provide important inputs to future international efforts. But they now need to become inputs to an international standardisation harmonisation process. Four programmes are described in more detail below:

- United States ENERGY STAR
- European Union Code of Conduct on Energy Consumption of Broadband Equipment
- European Union Code of Conduct on Energy Efficiency of Digital TV Service Systems
- The Republic of Korean standby requirements for networked equipment.

Test procedures in the United States

The Regulatory Test Procedure developed by the US Department of Energy (US DoE) covers all modes, not just low power modes. Voluntary programmes, particularly the ENERGY STAR initiative, also use the US DoE test procedures. Manufacturers are responsible to conduct tests before they start selling devices on the US market. The US DoE recently released for comment proposed test procedures for set-top boxes and smart TVs:

- Set-Top Box Proposed Test Procedure, published 23 January 2013
- Television Proposed Test Procedure, published 19 January 2012

- Television Supplemental Test Procedure, in pre-publication 28 February 2013.

The American National Standards Institute (ANSI) and the Consumer Electronics Association (CEA) recently developed (in 2013) the ANSI/CEA-2043 standard “Set-top Box (STB) Power Measurement”. The ANSI standard clarifies test procedures, definitions and terms, and defines a method for measuring set-top box power levels and energy consumption. Although intended for use in North America, the document uses the measurement parameters of the IEC standard IEC62087 *Methods of measurement for the power consumption of audio, video and related equipment*.

Test procedures in the European Union

Currently, CEN/CENELEC are tasked by the European Commission to develop test procedures for network-enabled devices. The currently proposed test procedure is defined in the regulation and is based on measurements of energy consumption when only one network port of the device is connected to a network. While this simplifies test procedures, it does not correspond well to how devices are actually used. The proposed procedure may motivate manufacturers to optimise the device for conditions of a single-port connection rather than for connection to several WAN and/or LAN ports (which for some devices, such as a home gateway, is a more realistic use case).

Test procedures in Korea

Korea currently has no specified test procedure on how to measure standby in network-enabled devices: it is up to the manufacturers to choose the set up that consumes the most energy. How tests are set up influences the results. Generally higher connection speed leads to higher energy consumption. If a manufacturer tests at a low network speed and a market audit tests at a higher speed, the device will be found to be non-compliant. In cases of non-compliance, company owners are summoned to public hearings and given two chances to change the label on their device.

Examples of ongoing co-operation and initiatives

As highlighted in the publication, multiple initiatives to address network standby energy consumption are already underway; some focus on international policy initiatives; others are driven by the industry and research communities. Collectively, these initiatives help to raise awareness about the need for energy efficiency action to develop solutions that tackle both network standby and broader energy challenges in digital societies. The following list is not comprehensive. Rather it highlights some of the types of initiatives and projects underway, and identifies an initial set of organisations that could be involved in the implementation of the IEA Digital Energy Efficiency Action Plan described in Chapter 6.

Section 1 covers international organisations and platforms for international policy dialogue, which enable sharing of information and experience. These are instrumental in expediting policy development, particularly on new and emerging issues.

Section 2 highlights industry and research led initiatives, some of which directly target network standby and some of which focus more on progressing knowledge and developments in the wider context of digital energy efficiency.

Section 1: International organisations and policy platforms

IEA Implementing Agreement for Energy Efficient End-use Equipment (4E) Standby Power Annex

From standby to network standby: developing new knowledge and understanding needed to tackle network standby

The Standby Power Annex of this IEA Implementing Agreement 4E (IEA 4E)¹ aims to provide information and tools that support the development of policies to combat the energy wasted by devices in standby power modes. Current members of the Standby Annex are: Australia, Austria, Canada, Denmark, the Republic of Korea, the Netherlands, Sweden, Switzerland, the United Kingdom and the United States.

The Annex has played an instrumental role in promoting the development and implementation of standby policies across the globe and has taken a lead role in collecting information and conducting analysis to help the development of effective policies in the area of network standby. One key area that the Annex has been exploring is the energy requirements of functions. Policy design, standardisation and the development of test procedures can benefit from having a clear list and definitions of functions, which can then be associated with relevant power limits. Identifying functions and the minimum energy

¹ Until the end of February 2014, IEA 4E was called the IEA Implementing Agreement for Efficient Electrical End-use Equipment.

required to carry them out will help drive the push towards improved energy efficiency. This is an ongoing process as minimum power requirements for functions will change over time as technology evolves (Nordman et al., 2009).

The IEA Implementing Agreement 4E is currently analysing and addressing three aspects related to functions of network-enabled devices:

- collection of information on the range of secondary functions, and assessment of trends in regards to what types of functions are currently present in devices and expected future trends
- assessment of the power requirements for common functions, identification of variations in power requirements and reasons for these variations
- development of an action plan for low-energy functionality for devices.

The Standby Power Annex has identified the need for additional efforts to develop a continuous approach to identifying network-related functions and their associated power levels in order to set technically robust functional allowances for different network functions. A priority in this area would be to establish an international process to ensure continuity in updating a library or repository of functions and associated power levels. This project supports efforts in the areas of metrics, data collection and test procedures described in Annex A.

In 2014, IEA 4E launched a new Annex known as the Electronic Devices and Networks Annex (EDNA), which will continue international collaborative work on efficient connected devices and networks.

The Clean Energy Ministerial Super-efficient Equipment and Appliance Deployment (SEAD) initiative working group on network standby

Towards standardised definitions and innovative approaches to understanding how network-enabled devices are used

The Super-efficient Equipment and Appliance Deployment (SEAD) initiative, a five-year initiative under the Clean Energy Ministerial (CEM) and the International Partnership for Energy Efficiency Co-operation (IPEEC), aims to make it easier for governments and the private sector to reduce the energy demand of appliances and equipment. SEAD's member governments are: Australia, Brazil, Canada, the European Commission, France, Germany, India, Japan, Korea, Mexico, Russia, South Africa, Sweden, the United Arab Emirates, the United Kingdom and the United States. The SEAD Network Standby Collaboration group has commissioned a number of studies contributing to improving the basis for policy making in the area of network standby.

In addition to its work in promoting the development of international definitions that can be used to support policy making in the area of network standby, the group is exploring approaches to better understand how network-enabled devices are used and how this understanding can be utilised to inform policy making. One of the group's key projects is aimed to gain a better understanding of real-life usage of network-enabled devices and of the periods when such devices may be on standby. Investigating how consumers and their devices interact with networks in real-life situations will help ensure that future policies are based on reality rather than theoretical assumptions, thereby ensuring that maximum energy savings can be gained without interfering with functionality desired by users. Understanding usage patterns could be used to require certain devices to power down to

low power modes during certain periods. If, for example, it could be shown that there are regular periods of negligible traffic common to the majority of users, it might be possible to achieve energy savings by requiring these devices to power down. A further objective of the project is to provide transferrable and reproducible methodologies that could be used by other countries. Further efforts in this area are warranted. Additional studies with larger samples and longer duration would provide additional insights into usage patterns. An additional aspect that warrants further investigation is the function of network traffic. Furthermore, similar efforts in businesses are needed to understand usage patterns in the commercial sector. This project supports efforts in the area of data collection described in Annex A.

International Energy Agency

Creating platforms for industry-policy dialogue, and exploring innovative approaches to facilitate data collection and compliance surveying

As part of its project on network standby, the IEA has, in close co-operation with SEAD and 4E organised three international workshops to create platforms for discussions among policy makers, researchers and industry. The IEA is also supporting the development of an approach that would enable quick, cheap and easy measurements of power consumption of devices when they are in low power modes with network connectivity. One of the challenges to understanding how much power such devices draw is that they need to be connected to a network when power measurements are made. Software that simulates a network connection and forces devices to power down could dramatically reduce the cost and fuss of such measurements. By enabling in-store and on-site measurements of energy consumption, such a tool would be valuable in terms of gathering data on energy consumption, establishing baselines, identifying priority device groups and providing a uniform replicable methodology. At a later stage, it could facilitate initial compliance spot-checks and be used to assess the impact of policies and measures.

The project is an initial feasibility study to develop a prototype approach. Further work would be warranted to initiate surveys in multiple countries to test the viability of the approach. In extension, it is also warranted to explore whether it is possible to develop tools that would facilitate the measurements of integrated systems (multiple devices that are connected). This project supports efforts in the area of data collection and can inform the development of test procedures outlined in Annex A.

Section 2: Initiatives led by industry and research community

Industry and research communities have been active in developing approaches to enhance efficiency in network-enabled devices and address network standby. Diverse national and international associations, working groups and projects are currently working to improve information gathering and energy efficiency in both network infrastructure and specific devices. While not comprehensive, the examples below highlight opportunities to extend the reach and integration of ongoing initiatives, and thereby to hasten greater network energy savings potential globally.

The advantages of such international and fast-paced collaboration among primary stakeholders – researchers, industry experts, developers, manufacturers and service

providers – is that it is accountable and responsive to global market forces and advances in practices and technology. There is also dynamic “cross-pollination” with policy drivers and consumers. As new efficiency possibilities emerge, solutions are developed and inform policy making. It is important that these efforts cover the whole market. Working to improve isolated aspects of the network-enabled value chain, while initially productive (and seemingly responsive and innovative), will not leverage the potential for optimal energy efficiency.

GreenTouch Consortium

Target to increase network efficiency by a factor of 1 000 over 2010

Established in 2010, GreenTouch is a global research consortium with over 50 members from leading industry, academic and research organisations. It currently has 16 research projects and activities, including the Large-Scale Antenna System (LSAS) and the Bit-Interleaved Passive Optical Network (Bi-PON) projects, which are already demonstrating how innovative technologies can increase network energy efficiency. By 2015, the consortium aims to deliver architectures, solutions and specifications, and to demonstrate key technologies necessary to reach the target.

Three years in, GreenTouch has released a comprehensive *Green Meter* study assessing the overall efficiency impacts and benefits from the portfolio of technologies, architectures, components, devices, algorithms and protocols being investigated, developed and considered by the consortium. The study not only quantifies the energy benefits of individual technologies, it focusses on the end-to-end network perspective that includes a full range of technologies. As a result, the research provides insights into both relative and overall impacts of the technologies considered. It also explicitly includes traffic growth in calculations of future network energy efficiencies and energy consumption (GreenTouch, 2013b).

Green Meter concludes that the combination of advances could reduce net telecommunications network energy consumption by up to 90% by 2020. This dramatic reduction, while taking into account increased traffic, is fuelled by significant improvements in the energy efficiencies of the component networks: reduction by a factor of 1 043 for mobile networks, a factor of 449 for fixed access networks, and a factor of 64 for core networks.

The International Engineering Task Force (IETF)

Develop Internet standards that allow networks and devices to become energy-aware

The IETF is an international association of voluntary members that develops and promotes Internet standards, co-operating closely with other standards bodies and dealing in particular with standards of the Internet Protocol suite (TCP/IP). In 2010, the IETF established an Energy Management Working Group (EMAN) to explore avenues for operating telecommunication networks and other network equipment with minimal energy while meeting service requirements.

Powerlib

Collect and share power consumption data towards more efficient ICT

Short for power library, Powerlib is a Europe-based online public database of ICT network equipment power consumption established in 2012. Registered users can contribute their

own data. Part of the European Commission 7th Framework Programme project TREND (*Towards Real Energy Efficient Network Design – The Network of Excellence on Energy Efficient Networking*), Powerlib's initial and main purpose is to collect and provide these data for research towards more power-efficient ICT networks. Plans are underway to keep the site running beyond its 2013 end date, with an ultimate objective of creating a viable mechanism to collect and share historical data sets.

The Green Grid

Improve the resource efficiency of data centres and ICT, and open up all the sustainable ecological and economic benefits

Established in 2007, the international Green Grid works closely with end-users, technology providers and governments around the world to create standards for more efficient use of resources in data centres. It collects data, conducts analysis, assesses emerging technologies and develops best practice guidance for data centre operators. The Green Grid develops metrics and measurement methodologies to determine data centre efficiency, with the following criteria in mind:

- Not just energy; all aspects of sustainability.
- Not just data centres; the entire business computing ecosystem.
- ICT accounts for 2% of global carbon emissions.
- Energy expenses for data centre power and cooling have risen by over 35% in the past five years.
- Every 1 kWh spent on ICT saves 10 kWh in the economy.

The Storage Networking Industry Association (SNIA)

Reduce the environmental impact of data storage through energy efficient storage solutions and drive “green” storage decisions by consumers and vendors

The SNIA, incorporated in 1997, is an association of some 400 member companies spanning the global storage market. It develops solutions for storing and managing large volumes of information by promoting the development of storage solution specifications, technologies and standards. In particular, the SNIA Green Storage Initiative (GSI) works on advancing energy efficiency in all network storage technologies while minimising the environmental impact of data storage, with these criteria in mind:

- Resizable storage volumes can increase efficient capacity utilisation to 70% or more.
- Up to 75% of corporate data is dispersed outside the data centre in remote offices and regional centres.
- In 2008, data centres represented 2% of total US energy consumption at a cost of USD 4 billion annually.
- US data centres require the equivalent of six 1 000 MW power plants to sustain 2008 operation levels; global power consumption for data centres is more than twice the US figures.
- An Emerson Power survey projects that 96% of all data centres will not have sufficient power by 2011.
- Between 2000 and 2008, the amount of global corporate data grew from 5 EB to 300+ EB, with projections of 1 ZB (1 000 EB) by 2010. This data must be stored somewhere.

- The “rule-of-thumb” for energy has been: 60% servers, 20% networking and 20% storage; recently, the proportion of energy used by storage is increasing.

Low Energy Consumption Networks (ECONET)

Reduce the energy requirements of wired network equipment by 50%

ECONET, a three year project (2010-13) co-funded by the European Commission, is exploring how dynamic adaptive technologies can enable energy savings when wired network-enabled devices are not in use. Dynamic adaptive technologies and protocols adapt to changing data conditions; e.g. dynamic adaptive streaming over HTTP senses network and equipment capacities and adjusts accordingly, breaking content into appropriately sized segments for optimal playback. The European Commission 7th Framework Programme project aims to stimulate re-thinking and re-designing wired network equipment and infrastructures for increased energy efficiency. The solutions investigated could reduce wired network equipment energy requirements by 50% in the short term and by 80% in the long term.

Institute of Electrical and Electronics Engineers (IEEE)

Promote leading technological innovation and excellence, e.g. a proposal to reduce network standby power virtually to zero, with a reduction of 1.11 kgCO₂ emissions per year per device.

United in 1963, IEEE is now the world’s largest association of technology professionals with more than 425 000 members in more than 160 countries. IEEE groups are active in publications, conferences, and building technical communities, involving member outreach at both the local and global level. The IEEE Xplore Digital Library contains more than 3 million documents and has more than 8 million downloads each month. In particular, the Green ICT Community, a technical sub-group of IEEE, provides a forum for knowledge exchange in green ICT, sustainable computing and energy efficient networks. IEEE is also a leading developer of industry standards covering a broad range of technologies.

Alliance for Telecommunications Industry Solutions (ATIS)

Advance the ICT industry’s most critical business priorities

Since the 1980s, ATIS has created solutions that support the rollout of new devices and services in the areas of information, entertainment and communications in the United States and internationally. Key areas of work span existing and next-generation Internet protocol-based infrastructures, reliable converged multimedia services including Internet protocol television, enhanced operations and business support systems, and improved service quality and performance.

Korean Smart Convergence Household Appliances Forum (KSCHAF)

Get different brands of appliances to communicate

Since 2011, major Korean electronics companies, education institutions and R&D labs participating in KSCHAF have been working to establish standard platforms and protocols to allow different brands of appliances to communicate and operate within a smart house or home network. The forum is expecting to achieve easier user interfaces and an interoperability guarantee.

Greentech Leadership Group Smart Electronics Initiative (SEI)

Empower consumers to power down

Launched in 2009 in the United States, the SEI aims to raise awareness about the consumer's role in reducing electronic edge device energy use in homes and businesses. It is a collaborative of consumer electronics developers, manufacturers and retailers working with policymakers, academia and technical analysts to develop a framework to incentivise the production and use of energy efficient consumer electronics devices. The SEI identifies smart technologies, educates consumers and develops new policy recommendations to improve energy efficiency in consumer electronics. Some of its findings include:

- Portable computers use 80% to 85% less energy than desktops.
- Each consumer who swaps out a desktop and LCD monitor for a laptop or notebook will save at least 80% in computer energy costs.
- In aggregate, energy obligations of computer systems sold in the United States in 2010 fell by more than 40% from the peak in 2000, despite a 25% increase in base unit sales.

Industry associations

Promoting the implementation of Guiding Principles to foster energy efficiency in network-enabled devices

In 2013, eight national consumer electronics associations adopted the *Guiding Principles for Energy Efficiency in Networked Consumer Electronics* (based largely on the 2007 IEA *Guiding Principles for Energy Efficient Networks and Efficient Network-enabled Devices*).

Work to raise global industry awareness and support industry-government interaction is ongoing. All parties acknowledge that a substantial challenge arises from industry and research initiatives being project-based. In the absence of sustainable mechanisms to ensure the continuation of these activities, valuable data, experience and solutions may be lost. To build momentum and accelerate progress, there is a case for greater engagement by both governments and industry in establishing and participating in broader international processes and information sharing.

Acronyms, abbreviations and units

Acronyms and abbreviations

4E	Energy Efficient End-Use Equipment
AC	alternating current
AHAM	Association of Home Appliance Manufacturers
AMI	advanced metering infrastructure
AMR	automatic meter reading
ANSI	American National Standards Institute
APEC	Asia-Pacific Economic Cooperation
APP	Asia-Pacific Partnership
ATIS	Alliance for Telecommunications Industry Solutions
AVoD	audio and video on demand
Bi-PON	bit-interleaved passive optical network
CE	consumer electronics
CEA	Consumer Electronics Association
CEET	Centre for Energy Efficient Telecommunications
CEM	Clean Energy Ministerial
CLASP	Collaborative Labeling & Appliance Standards Program
CNIS	China National Institute of Standardisation
CO ₂	carbon dioxide
CoC	code of conduct
CPU	central processing unit
CSCI	Climate Savers Computing Initiative
DAM	download acquisition mode
DC	direct current
DCE	data communication equipment
DHCP	dynamic host configuration protocol
DLAN	direct local area network
DLNA	Digital Living Network Alliance
DVD-R	digital video disc – recordable (once)
EC	European Commission
ECONET	Low Energy Consumption Networks
EEE	Energy Efficient Ethernet
EER	energy efficiency ratio

EINS	Network of Excellence in InterNet Science Consortium
EMAN	Energy Management Working Group
EPS	external power supplies
ESMIG	European Smart Metering Industry Group
ETSI	European Telecommunications Standards Institute
FTTP	fibre-to-the-premise
G8	Group of Eight
G20	Group of Twenty
GHG	greenhouse gas
GPS	global positioning system
GSI	Green Storage Initiative (SNIA)
HDD	hard disk drive
HFC	hybrid fibre-coaxial
HiNA	high network availability
HVAC	heating, ventilation and air conditioning
ICT	information and communication technologies
IEA	International Energy Agency
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IoT	Internet of Things
IP	Internet Protocol
IPv6	Internet Protocol Version 6
ISO	International Organization for Standardization
IT	information technology
ITU	International Telecommunications Union
KEMCO	Korea Energy Management Corporation
LCD	liquid-crystal display
LoNA	low network availability
LPI	low power idle mode
LSAS	Large Scale Antenna System
M2M	machine-to-machine
MEPS	minimum energy performance requirements
OECD	Organisation for Economic Co-operation and Development
OSI	Open Systems Interconnection model
P2P	peer-to-peer
PC	personal computer
SDN	software-defined networking
SEAD	Super-Efficient Equipment and Appliance Deployment
SEI	Smart Electronics Initiative
SFOE	Swiss Federal Office of Energy

SNIA	Storage Networking Industry Association
STB	set-top box
TEC	typical energy consumption (approach)
UPnP	universal plug and play
US DoE	United States Department of Energy
US EIA	United States Energy Information Administration
US EPA	United States Environmental Protection Agency
USB	universal serial bus
UUT	unit under test
VCR	video cassette recorder
VoD	video on demand
VOIP	voice over Internet protocol
WoL	wake-on-LAN
WoW	wake-on-wireless

Units of measurement

bit	measurement unit for data quantity; 8 bits equals 1 byte
bps	bits per second
byte	measurement unit for data quantity; 1 byte equals 8 bits
GB	gigabyte
Gt	gigatonne
GWh	gigawatt hour
kWh	kilowatt hour
MB	megabyte
Mbps	megabytes per second
ms	millisecond
Mtoe	million tonnes of oil-equivalent
MW	megawatt
mW	milliwatt
PB	petabyte
TW	terawatt
TWh	terawatt hour
W	watt

Glossary

A	Active mode	The energy-using device is connected to a mains power source, has been activated and provides one or more main functions (see also mode).
	Bandwidth	The volume of data that can be sent through a network connection, typically measured in bits per second (bps); greater bandwidth supports faster transfer of more data (see also data transfer rate).
B	Central processing unit (CPU)	The “brain” of ICT-based devices, which processes all activity – from basic instructions to complex functions. CPUs make all the calculations needed to perform activities such as installing and later operating software. Also called processor or core.
	Cloud computing	The practice of using a network of remote servers hosted on the Internet to store, manage and process data, rather than a local server or a personal computer.
	Communications	See telecommunications.
	Communications equipment	See telecommunications equipment.
	Communications network	A set of technologies and connections that enables exchange of information among two or more devices.
	Communications protocol	Within computer science, a system of digital rules that determines how messages can be exchanged among network-enabled devices. These protocols define formats for exchanging messages, including that each message will have an exact meaning designed to stimulate a particular response by the receiver. A protocol must define the syntax, semantics and synchronisation of communication; the specified behaviour, however, is usually independent of the rule by which it will be implemented. A protocol can be implemented as hardware, software or both.
	Consumer electronics (CE)	Electronic equipment intended for everyday use, most often in entertainment, communications and office devices: e.g. audio equipment, television sets, MP3 players, video recorders, DVD players, digital cameras, camcorders, personal computers, video game consoles, telephones and mobile phones. Increasingly, CE devices are able to connect to networks, and thereby exchange information with other devices.
D	Data	The “bits” of information processed or stored by a computer or other device, which may be in the form of text documents, images, audio clips, software programmes, etc.
	Data centre	Facilities designed to house information technology (IT) equipment.

Data throughput	The average rate of successful message delivery over a network, usually measured in bits per second (bit/s or bps), or sometimes in data packets per second or data packets per time slot. Also called throughput or network throughput.
Data traffic	The amount and characteristics of data being transmitted on a network, e.g. quantity, timing, packet size, content. Also called network traffic.
Data transfer rate	The volume of data that can be sent through a network or modem connection, typically measured in bits per second (bps); a higher data transfer rate supports faster transfer of more data. Also called bandwidth or (<i>colloq.</i>) network speed.
Demand response	When used to describe network-enabled devices, the capability of a device to interpret and act upon signals from power utility networks. This functionality can, for example, enable the power utility to remotely turn off air-conditioning units in customer homes to avoid peak load issues. Devices enabled with demand response typically have some form of wireless networking capabilities to communicate with other devices.

E

Edge device	<p>End-user devices that are connected to networks; two main types of edge devices exist:</p> <ul style="list-style-type: none"> ■ Electronic edge device comprises those for which the primary function is data storage or use; e.g. networked devices, network-enabled devices, and networked end-user devices (which include entertainment and communication type devices, such as smart TVs). ■ Other edge device comprises those for which the primary function is not data-related; i.e. all appliances and equipment other than electronic devices. These includes kitchen and laundry appliances, cooking equipment, heating and cooling equipment, lighting, and all manner of commercial and industrial equipment.
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F

Function	A pre-determined operation undertaken by the electricity-using device and carried out by means of a network connection (e.g. file sharing, content upload/download). Functions can be primary (resulting in the output the device was intended for) or secondary (enhancing the primary function). For network devices (such as routers, modems and switches), the network connection is a primary function. Edge devices (such as televisions, personal computers and appliances) perform other primary functions with network functions being a secondary function. In addition to network functions, network-enabled devices may also have functions that are not necessarily network-related but may require network connection. For example, if the timer on a coffee machine is connected to a network, the user may (via a smart phone or other device) signal that coffee should be ready at a certain time. Broad categories of functions include: communication between devices or with users and the environment, power- or time-related functions, and other functions. Functions can be controlled by an interaction of the user, of other technical systems or of the system itself from measurable inputs from the environment and time.
Functional adders	In policies, additional energy consumption allowances provided for extra device functions, such as network connectivity.

H	Home or building automation	Refers to systems that integrate diverse electrical devices in a house or building, which allow control on site or remotely, e.g. through Internet access or automatically in accordance with selected settings. Such automation has convenience, energy efficiency and safety benefits.
	Horizontal approach	In the context of establishing energy efficiency requirement policy, setting an energy limit that could be applied to all types of devices (as opposed to vertical approach, which would set limits on individual devices).
	Hybrid networked device	An edge device that has a definite primary function but can also function as a network device: e.g. a set-top box that includes multiple network links and can perform the functions of a small router or switch is considered a hybrid device. Also called a hybrid device or a hybrid network-enabled device.
I	Information and communication technology (ICT)	Used in this publication in the broadest sense to include all types of devices connected to networks, consumer electronics, network equipment and infrastructure needed to support networking (e.g. data centres and network cables).
	Internet	An example of a wide area network (WAN) that can transmit data over long distances. The Internet “backbone” consists of several ultra-high bandwidth connections that link many different nodes around the world. In turn, these nodes route data to smaller networks. Note that the Internet and the World Wide Web are distinct entities: the capacity to use the World Wide Web to surf websites, use e-mail, FTP and instant messaging are among the many features of the Internet.
	Internet access	The electronic infrastructure that connects individual computer terminals, computers, mobile devices and computer networks to the Internet, enabling users to access Internet services (for example, e-mail and the World Wide Web).
	Internet Protocol (IP)	An internationally accepted set of rules that govern how data are sent and received through the Internet.
	IP address	A code (four sets of numbers from 0 to 255 separated by three dots) that identifies a particular computer or device on the Internet. To be part of the network, and able to receive and send messages, each device must have a unique address.
L	Latency	The time it takes for a device to change state or mode, so that it can respond to a user request or to provide a given function (including start-up).
	Layer	Layering is a technique that divides protocols into smaller parts, each of which accomplishes a particular sub-task and interacts with the other parts of the protocol in specific and well-defined ways. By making it possible to simplify the design of each layer, this technique minimises overall complexity while also enabling protocols to adapt to specific needs or circumstances. Most protocols are based on the Open Systems Interconnection model, which consists of seven layers (see also protocol and Open Systems Interconnection model).

	Link	A digital connection between two devices.
	Load	The level of network interaction of a network-enabled device, which influences its power consumption.
	Local area network (LAN)	A computer network that links devices, typically in geographically limited area such as an office building, university or residential home. LANs can be connected via cables or wireless, or a combination of the two.
M	Mains	The general-purpose alternating-current (AC) electric power supply, i.e. the power available through electricity sockets.
	Mobile device	A portable device such as a smart phone or tablet computer.
	Modal approach	In policy, one of two basic methods used to set thresholds on energy consumption; this approach specifies and measures one or more low power modes, then establishes individual limits for each mode or collection of modes.
	Mode/state	The terms “mode” and “state” are used interchangeably to signify the status of a device in terms of functionality (including both primary and secondary functions) and/or level of energy consumption.
N	Network	A digital structure that allows the transmission of data or information between two or more connected devices; networks can interconnect with other networks and contain sub-networks. Different types of networks include local area networks (LANs) and wide area networks (WANs) e.g. the Internet.
	Network availability	The timeframe devices need to power up and re-initiate activities in response to network signals or triggers, based on resume time.
	Network capability	Having the ability to connect to a network and/or any function that enables connection with a network.
	Network connection	The component that provides connectivity between a computer or other end-use device and the Internet, a network or another computer.
	Network device/equipment	Comprises the devices that support communication between edge devices. Network devices typically comprise equipment used by end-users (computers, printers, etc.); network equipment refers to the equipment that allows devices to interact (includes switches, routers, modems, etc.). The primary function of both is to enhance connectivity over a number of network links. Within the context of network standby, network equipment is usually required to maintain its primary function as data may come from any network device at any time and must be passed on to the intended edge device(s).
	Network function	The capacity of a device to connect to and communicate on a network. Functions can be primary (resulting in the output for which the device was intended) or secondary (enhancing the primary function). For network equipment, such as routers, modems and switches, the network function is a primary function. For edge devices, network functions are usually secondary functions. See also function.

Network infrastructure	Includes all devices that play a role in supporting network connectivity, such as servers, data storage equipment and enterprise storage, activity schedulers and load balancers, data security systems and data centres. Collectively, network infrastructure manages and manipulates data within the network as well as service application requests from edge devices. Servers and data centres, which can be located either in buildings and businesses or in remote sites, provide services to multiple edge device clients on the network. Network infrastructure devices are typically operated and maintained by service providers.
Network protocol	The rules and conventions that determine how messages are exchanged through a computer network, including how individual devices will identify and connect with each other. Protocols for computer networking typically use packet switching techniques to send and receive messages in the form of packets. Network communication is continually evolving and network protocols are interrelated; hundreds of network protocols have been developed, each designed for specific purposes and environments. Some protocols support message acknowledgment and data compression for reliable and/or high-performance network communication. Many modern network protocols are “layered” (see also Layer). Importantly for this publication, protocols can facilitate energy efficiency but can also hinder it. Currently, most protocols require devices to remain awake and respond to signals (messages from other devices) within a short time frame, which makes it difficult and in some cases impossible for these devices to power down to energy-saving modes. Energy management can require changes to a number of elements within the network, such as: the physical layer, data link, network, transport and/or application layers (Energy Efficient Strategies, 2010). See also protocol.
Network standby	A topic area covering (a) how to get network-enabled devices to power down to low power modes and (b) how to ensure that network-enabled devices remain in as low power modes for the longest period of time possible.
Network topology	The characteristics that define how all devices and equipment within a network are arranged and connected to each other.
Network traffic	The amount and characteristics of data being transmitted on a network, e.g. quantity, timing, packet size, content. Also called data traffic. Network traffic pattern refers to recurring or prevalent characteristics of network traffic (e.g. times of data throughput).
Networked standby	In EU policy, used to denote devices that are in a low power mode with network connectivity.

	Networked system	Energy is consumed along all parts of networked systems: from devices when they are not being actively used, to edge devices (televisions, set-top boxes), network equipment (routers, switches) in active mode, local networks and servers, and network infrastructure (servers, data storage equipment). Focussing on one part of the system can deliver energy savings. However, full energy efficiency potentials can only be tapped by extending boundaries to encompass sub-systems or larger systems. Furthermore, focussing on improving efficiency in part of the system without consideration of system implications can result in shifting of energy consumption to other parts of the system. See also network-enabled system.
	Node	An electronic device that can send, receive or forward information; nodes can be network devices (such as a modem) or edge devices (such as a digital telephone handset, a printer or a computer).
O	Off	The state in which an energy-using device may be connected to a mains power source but is not providing any functions.
	Offline	The state in which a computer or other device is on, but not connected to other devices, i.e. the opposite of being "online," when a device can communicate with other devices. Offline can also mean not being connected to the Internet: the device is disconnect from the ISP or from the Ethernet cable.
	On-demand	Implies that data or content is stored virtually and can be accessed for viewing or download at any time. Video on demand (VoD) and audio-video on demand (AVoD) systems, for example, allow users to select and watch/listen to video or audio content at any time, in any location with network connection. IPTV technology brings VoD to televisions and personal computers. Alternatively, television VoD systems either stream content (through a set-top box, computer or other device) to allow real-time viewing, or download content to a device (such as a computer, digital video recorder or portable media player) for viewing at any time.
	Online	The state in which a device is able to access information from and/or provide information to other devices via networks.
P	Port	A port is a connection through which devices can be hooked up (e.g. keyboard, mouse, printer, digital camera) either via cables or wirelessly.
	Power down	In this publication, "powering down" refers to a device transitioning from active mode to low power mode(s); it should not be confused with turning devices completely off.
	Power scaling	The capacity of a device to dynamically and proportionally change its energy consumption in relation to its variable workload; it may involve voltage and/or frequency scaling.
	Proxying	A mechanism that allows network-enabled devices to enter into a lower-power, non-active mode when their main function is not being performed – without losing the network connection. This is done by transferring of the task of managing network messages to an alternative entity (either within or outside the device itself); the proxy responds to routine network interactions and wakes up the edge device only when it needs to respond to essential messages.

R

Resume time

The time required for a device to resume a primary function after detecting a remotely initiated trigger. Definitions and interpretations vary, and can be based on:

- Resume-time-to-response – how quickly a device can respond to a remotely initiated signal or trigger
- Resume-time-to-connection – how quickly a device can to resume full connectivity
- Resume-time-to-application – how quickly a device can transition from a low power mode to re-start operations and/or resume fully its tasks.

S

Smart device/appliance

Network-enabled devices with integrated information and communication functions that allow them to transmit and receive information.

Smart grid

An integrated electricity system that uses advanced software applications and communication network infrastructure, together with sophisticated sensing and monitoring technologies, to optimise the management of energy supply, demand and transmission. Smart grids use ICTs to both gather and act on information (such as data regarding the behaviour of suppliers and consumers), thereby improving the efficiency, reliability, economics and sustainability of the generation and distribution of electricity.

Smart home

A home or building equipped with a system or combination of systems to enable real-time monitoring of energy use and allow remote control or programming of home electronics. Smart home networks typically encompass security, convenience, entertainment and ICT systems; they may also include an option to programme appliances to respond to external stimulus (such as changes in temperature or signals from the power supplier). See also home automation.

Smart meter

Usually an electrical meter that records electricity consumption in intervals of an hour or less, and communicates that information at least daily back to the utility for monitoring and billing purposes. This type of advanced metering infrastructure (AMI) differs from traditional automatic meter reading (AMR) in that it enables two-way communication between the meter and the central system.

Standby

A state/mode in which an energy-using device is connected to a power source, but not performing its primary function(s) and has powered down to lower energy consumption (sometimes this state is called “sleep”). The device is, however, providing secondary functions and can be woken up to an active state by a signal (either automated or provided by a user, for example by pressing a button on a remote control). Typically, the secondary functions are user-orientated or provide additional services, and may continue for an indefinite period: they include the ability to transfer to other modes or states by remote switch (including remote control); to respond to internal sensors or timers; or to perform continuous functions such information or status displays. More complex devices, such as computers, maintain the capacity to provide multiple functions when they have powered down.

	Standby energy consumption	The energy consumed when devices are not delivering their primary function but are connected to power mains and drawing electricity. Two general types of secondary functions use energy in low power modes: the ability to be activated via a remote control and quicker start-up; and supporting continuous features (such as monitoring temperature or other conditions, powering an internal clock, battery charging or information display). See also standby.
	State	The terms “state” and “mode” are used interchangeably to signify the status of a device in terms of functionality (including both primary and secondary functions) and/or level of energy consumption.
T	Technology standards	Consensus-based documents that specify operational criteria for devices, components or communication protocols to ensure interoperability and device quality. By providing consensus-based definitions, test procedures and data collection methodology, technology standards play an important role in policy making at national, regional and international levels.
	Test procedures	Instructions for manufacturers or test laboratories on how to measure device operations, including energy use.
	Test procedure specifications	Additional instructions provided by governments on how data from test procedures, including that of energy use, should be compiled and reported.
	Total energy consumption (TEC)	A calculation that sums up, based on an operating pattern, the energy consumption of a device across all modes (including active). This is one of two basic methods of setting thresholds on energy consumption: in TEC, limits are placed on the sum, not on the energy consumption in specific modes.
V	Value chain	The complete range of activities comprising the development of network-enabled devices, which includes device and component manufacturing, software development, network design, network architecture, communication protocol development, technical standardisation processes and service providers. The networked-enabled device value chain spans the computing and electronic sector, the appliance and equipment manufacturing sector, and the media and telecommunications sector.
	Vertical approach	A means of establishing energy efficiency requirement policy that sets limits on a device-by-device basis, as opposed to a universal limit or horizontal approach.
W	Wide area network (WAN)	A large network that covers a broad geographic area, such as an entire city or district, often using telephone lines, fibre-optic cables or satellite links to span long distances. The Internet is a wide area network. WANs can also be composed of smaller LANs that are interconnected. See also local area network (LAN).

Infographics sources

Think you understand “standby”? Think again! (p. 14)

Connectivity delivers clear benefits, but comes at an energy cost

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What will the future hold: Increased demand or substantial savings?

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Device operation à la mode (p. 16)

Low power modes with network connectivity

Image: Adapted from Maia Consulting (2012), *Staying Connected: Unravelling Energy Waste Issues in Network Standby*, prepared for the Australian Government, Department of Climate Change and Energy Efficiency, Maia Consulting, Melbourne, <http://standby.iea-4e.org/documents-results/chronological-list-of-documents> (accessed 27 February 2014).

A short history of standby power (p. 18)

Technology development at breakneck speed

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Massive ICT deployment set to up the ante (p. 20)

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Grasping the scale of data volumes

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Who’s responsible? What can we do? (p. 24)

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IEA 1-watt standby plan – A groundbreaking approach (p. 50)

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Now is the time for an action plan for network standby (p. 55)

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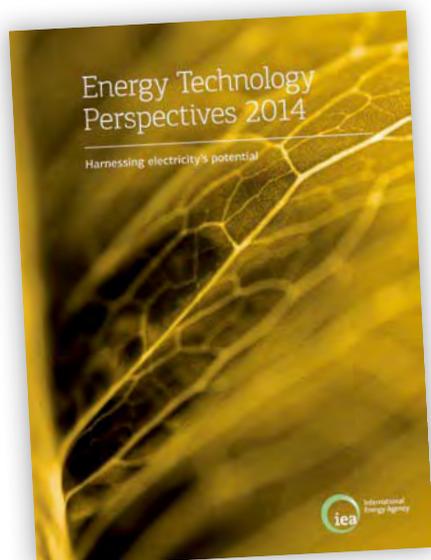
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More Data, Less Energy

Making Network Standby More Efficient in Billions of Connected Devices

The electricity demand of our increasingly digital economies is growing at an alarming rate. While data centre energy demand has received much attention, of greater cause for concern is the growing energy demand of billions of networked devices such as smart phones, tablets and set-top boxes. In 2013, a relatively small portion of the world's population relied on more than 14 billion of these devices to stay connected. That number could skyrocket to 500 billion by 2050, driving dramatic increases in both energy demand and wasted energy.

Being connected 24/7 means these information and communication technology (ICT) devices draw energy all the time, even when in standby mode. This publication probes their hidden energy costs. In 2013, such devices consumed 616 terawatt hours (TWh) of electricity, surpassing the total electricity consumption of Canada. Studies show that for some devices, such as game consoles, up to 80% of the energy consumption is used just to maintain a network connection. Implementing best available technologies could reduce the energy demand of network-enabled devices by up to 65%. In the absence of strong market drivers to optimise the energy performance of these devices, policy intervention is needed.

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Building on its experience in setting international policy for standby energy consumption of stand-alone devices, the International Energy Agency uses this publication to set the stage for tackling the much bigger challenge of network standby. In

exploring both policy and technology solutions, the book charts a path forward and identifies which stakeholders should take the lead in particular areas. An underlying message is that there is a need for international cooperation across all parts of the ICT value chain.