September 2010

Report for APP and IEA 4E Standby Annex

Standby Power and Low Energy Networks – issues and directions

Prepared by Energy Efficient Strategies

FOREWORD

Standby power has been an issue of concern for many years now and a range of energy policies have been developed and implemented to redress the issue of excessive standby power. However, products are becoming increasingly complex and many now have dramatically increased functionality, both in active modes (primary function) and low power modes (where only secondary functions are active). The range of products which are now connected to networks is growing rapidly, with a proliferation of wired and wireless technologies used to connect products together.

This study examines the issue of networked products and identifies key areas where energy saving strategies can be implemented. A critical component is power management across all modes – shutting down unnecessary capacity or functions when they are not required while meeting all relevant user needs. Another element is to ensure that the power required for all functions is as low as possible, especially in low power modes.

While this study does not provide a comprehensive catalogue of all possible energy saving solutions for networked products, it does provide a preliminary review of the major elements that could contribute to future low energy networks. It also develops a policy framework that could be used to implement requirements across a range of product types. The report identifies strategies and technical standards that could be used to improve energy consumption as well as areas where more work needs to be done.

This report was prepared by Lloyd Harrington (Energy Efficient Strategies, Australia) and Bruce Nordman (consultant USA) on contract to the Australian Department of Climate Change and Energy Efficiency as part of the APP Alignment of National Standby Power Approaches (project APP BATF PR-022006). The project was managed jointly by the APP Standby Working Group and the IEA 4E Standby Annex. While this report was commissioned by APP and the IEA 4E Standby Annex, any views expressed are those of the authors.

EXECUTIVE SUMMARY

The issue of excessive standby power was identified more than 20 years ago and continues to be a concern because energy policies have still not curbed the continuing energy excesses in electronic products. The number of products that consume power in low power modes is growing as electronic controls permeate product designs and electronic “information based” products become ubiquitous. This issue is only exacerbated by the increasing prevalence of network connected products.

Network connectivity is not well-addressed in most existing policies that deal with low power modes of products. This policy gap appears to have occurred for a variety of reasons: the technology of networks is unfamiliar to many energy policy analysts and experts; there are significant complexities in network technologies and their associated protocols; networks are evolving rapidly on many parallel fronts and the number and type of products with network capabilities is expanding rapidly. However, there are a few examples where products with network capability have been successfully regulated or included in voluntary programs in recent years.

The main concern of network designers and developers of information equipment connected to networks is that the network function works fast and effectively – energy is usually a low (or even negligible) priority. Historically, the need to address excessive energy has rarely been given a high priority during the design of networks. And once protocols are designed and implemented, it can then be a huge effort to “retrofit” power management requirements into these protocols, as a large number of stakeholders are involved in, and affected by, such changes. So the unfortunate reality is that it is hard to get power management included into the design of network protocols and hardware specifications and even harder to get them retrofitted once these have been implemented.

There is a real fear on the part of network professionals that desirable innovation in network design may be unintentionally stifled if ill-targeted or poorly implemented energy requirements were to be imposed. The challenge for energy policy makers is to overcome that perception through better and more consistent communication, together with a focus on energy issues during the early development phase and revision process for network protocols. Effective 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, which makes the focus for policy somewhat diffuse.

This is further complicated by the issue that network connectivity inherently involves multiple devices and therefore some interdependency of devices (which can induce higher energy consumption in other devices on the network), complicating effective energy policy development and implementation. This is especially the case for legacy devices, which may remain connected to the system for many years after new hardware or network protocols are introduced.

Changes to specifications for hardware and software are important areas for energy saving. But there are many internal (often proprietary) approaches that can further reduce energy consumption, and these need to be encouraged through intelligent application of energy policy.

Analysis of network issues showcases the need for global cooperation and policy alignment in this area, both between countries and across product types as well as between energy & network professionals. It is critical for efficiency policy to be fully up-to-date and engaged with the topic so that efficiency is seen as a partner to technological progress, not as an impediment to it. Networks pose challenges to energy efficiency in terms of apparent complexity and their relative freshness to the efficiency policy arena, but these can be overcome with the plan of action that is outlined in the work plan of this report.

While the origin of this report is a concern about "network standby", the authors believe it only makes sense to address this topic within an integrated approach to two larger overlapping topics: low-power mode policy generally (which includes "standby"), and policy responses to digital networks. Armed with sound information and a clear policy framework to address energy used in networks, the objectives of efficient networks and elimination of excessive standby power can be achieved. For the purposes of this report, *network mode* means any mode (active or low power) where there is a network function present and operating.

The report examines the history of standby power and explains why this is still an important policy area, despite recent policies directed at non-networked connected electronic products. The report examines existing standby policies in place around the world, reporting the diverse policy approaches taken to date. Current programs deal with some parts of standby power, although coverage in terms of products is far from comprehensive and the approaches developed are not very consistent. In some cases, the same internationally traded products are covered in different ways in different regions. Network connectivity is often (but not always) exempted because of perceptions about complexity and the fear of limiting innovation, which allows wasteful energy practices to persist.

Specifying power management requirements for networked products is a complex technical subject. Many of the most important types of equipment commonly used in networks are not covered by current program requirements for low power modes. The default "normal operation" at present is that network equipment remains continuously in active modes, which makes specifying mandatory low power mode requirements largely irrelevant in any case. A few current programs, however, are addressing issues related to networks and power management, which offer foundations to build improved global cooperation. In an effort to foster the possibility of aligned standby power polices, the authors urge program managers to adopt common fundamental definitions. The report defines the concepts of mode and function and suggests that ultimately existing energy standards be the repository for these global definitions.

The issue of network design and definitions are also explored in some detail. A network is defined as the infrastructure that enables arbitrary connection between (multiple) nodes. The most common type of network is one that uses the Internet Protocol Suite (IP), although other types of digital networks, data links and analogue networks are also examined.

A recent estimate is that network equipment in the USA alone accounts for about 18 TWh of electricity per year, though all devices with a digital network connection exceed 150 TWh per year (this is already more than half of electronics energy use and rising). So, in rough terms in the USA, electronics are about 10% of buildings electricity, and network equipment about 1%, with networked devices accounting for over 5% and rising. So energy associated with networks is significant and growing.

A range of possible power management strategies within networks are documented. The main strategies proposed are to minimise direct power required to maintain network links, move products from active mode to low power modes without the cooperation of the network, move products from active mode to low power modes with the cooperation of (and in coordination with) the network, and to implement active mode power scaling in proportion to processing or data loads. A number of other power management options are also noted. It is critical that power management be implemented in a way that ensures that the product remains functional and usable from the end user's (and network's) perspective.

The key components of an effective policy to achieve low energy networks and eliminate excessive standby power are proposed within an implementation framework of:

- Guiding principles for good network design
- Incorporating power management as the default
- Capping power for network functions to existing reasonable levels within the technology bounds
- Setting power limits for all secondary functions through a horizontal standby requirement.

This new framework for the construction of a more global standby policy to enable coverage of network connectivity is advocated. This approach will also help improve existing standby policy as products become more complex. It has at its foundation a "functional approach" to define limits for low power modes. These can allow policies to be moderately aggressive without compromising product functionality or usability. These requirements have to be combined with power management to be effective.

The integration of horizontal requirements with existing requirements for product energy efficiency is also examined. This can be readily achieved by independent application of horizontal requirements and existing energy efficiency requirements for products that are already regulated.

Alternatively, low power mode energy can be combined with active mode energy over a defined duty cycle in a so-called vertical approach.

Finally, the report makes a qualitative assessment of the gaps in the existing technical standards and policy elements. It proposes a range of projects that aim to improve knowledge and understanding of issues surrounding energy and networks. Good information is essential in order to develop good policy. The work program will identify those areas where resources are required to facilitate the development and implementation of technical standards and to inform the creation of sound policy approaches to support low energy options within networks.

The main areas where additional research is recommended, together with a suggested priority, are set out in Table ES1. Proposed projects that rely on outputs from previous projects are noted in the implementation strategy as depicted in Figure ES1. Most of these projects are supporting the eventual development of an integrated policy framework to encourage low energy networks (Project I) which can be used as the basis for both voluntary and regulatory programs. These are documented in more detail in Section 9.

Figure ES1: Implementation strategy for proposed projects

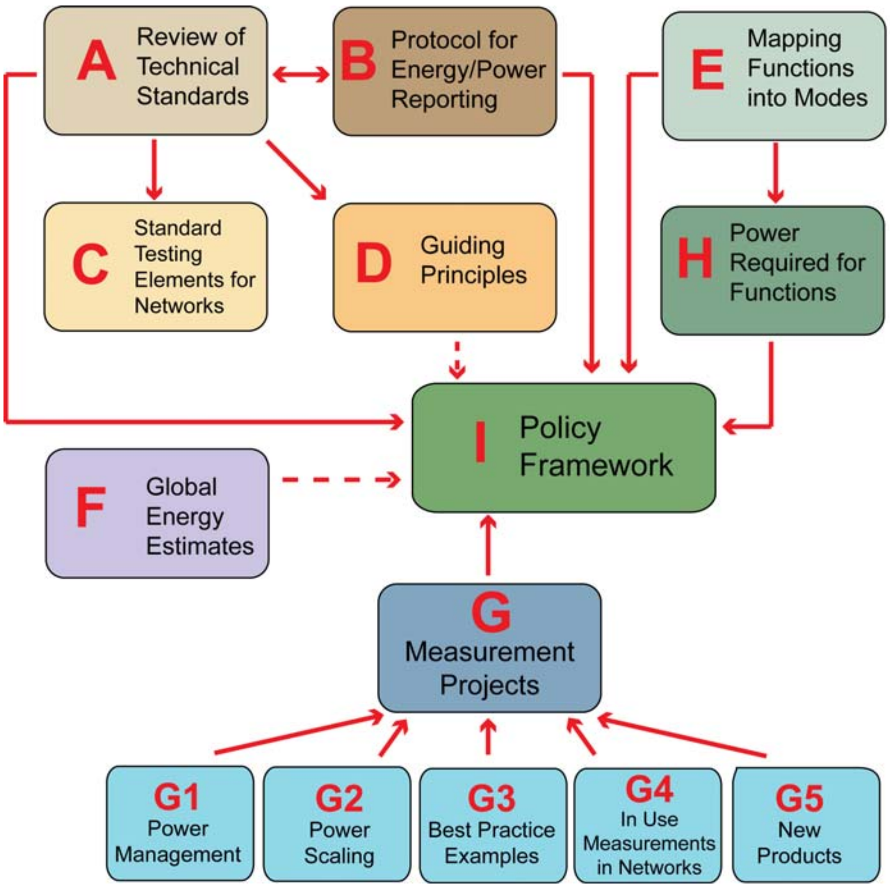


Table ES1: : Summary of recommended research and development projects

Project	Title	Priority	Objective
Co-ordinate	Developing a roadmap for technology and policy development for low energy networks and low-power modes	High	Coordination of all projects to ensure they are complementary and contribute towards the common objective of low energy networks
A	Review of technical standards relevant to networks and energy	High	Examine energy elements in network protocols: identify opportunities and gaps with respect to energy issues to support the development of new energy policies for networks
B	Standard protocol for energy/power reporting	High	Develop or extent existing protocols to allow querying network-connected devices for standard energy information, possibly based on the Simple Network Management Protocol (SNMP).
C	Standard testing elements for networks	Med	Develop the test procedure content (setup and configuration) to measure modes where network functions are present
D	Implementation of guiding principles for good network design	Low	Identify the key elements that need to be included into network architecture and operating principles to achieve universal low energy networks in the long term
E	Mapping functions into modes for common products	Med	Document the most common product designs currently on the market and identify typical configurations and groupings with respect to functions by mode
F	Global network energy	Med	Make global estimates of energy use of equipment connected to networks (edge devices) and their network links, as well as the energy associated with network equipment
G	Measurement projects		Undertake quantitative measurements on real products with a network function to quantify differences in design and impact of behavioural elements on existing products
G1	Power management in four product types	High	Quantify the energy savings from effective (or ineffective) power management where products are moved into lower power modes
G2	Power scaling in active mode	Med	Document power scaling techniques in active mode for network equipment
G3	Exceptional best practice examples	Med	Quantify the power characteristics of exceptional low energy products from around the world in a standardised reporting format
G4	In use measurements of products with network connections	Med	Undertake field measurements of selected equipment during normal use (in the commercial or residential sector) to assess their actual energy consumption and impact of different energy management approaches, usage patterns and other factors to be quantified
G5	Measurements of new products with network connections	Med	Measure a reasonably large number of new products offered for sale in retail outlets in order to establish key energy characteristics of products with a network function (where feasible)
H	Power required for functions	High	Liaison with “function providers” (suppliers of technology, hardware (chips) and software) in order to document best practice approaches to minimise energy for a range of common secondary functions found in products, especially network functions
I	Policy framework for low energy networks	Med	Develop a policy structure for a range of standard power “adders” for different types of functionality, for both network functions and other functions and develop relevant specification for power management
Other	International battery charger test method		Not a core objective, but a battery charging test method is a critical complementary requirement to other policies

Priority: High = Higher priority short term, Med = Medium term, Low = Lower priority longer term

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS AND ACRONYMS

4E	IEA Implementing Agreement on Efficient Electrical End-use Equipment
ADSL	Asymmetric Digital Subscriber Line (user end) – asymmetric form of DSL (usually faster down than up)
APEC	Asia Pacific Economic Cooperation
AP	A wireless Access Point (AP or WAP) is a device that allows wired communication devices to connect to a wireless network using Wi-Fi, Bluetooth or related standards. The AP usually includes router functionality (or acts as a switch connected to a router).
APP	Asia Pacific Partnership on Clean Development and Climate
ARP	Address Resolution Protocol for Internet Protocol Version 4 (IPv4)
AV	Audio visual equipment
BATF	APP Buildings and Appliances Task Force
CEA	Consumer Electronics Association (USA)
CEC	Consumer Electronics Control protocol under HDMI Version 1.4
CENELEC	European Committee for Electrotechnical Standardization
DCCEE	Department of Climate Change and Energy Efficiency (Australia)
DOCSIS	Data Over Cable Service Interface Specification
DPMS	Display Power Management Signalling (VESA specification)
DSL	Digital Subscriber Line (user end) - a data communications technology that enables fast data transmission over copper telephone lines
DSLAM	Digital Subscriber Line Access Multiplexer (exchange end of DSL)
DVD	Digital Video (Versatile) Disk
DVI	Digital Video Interface (usually a link from computer to a monitor)
EC	European Commission
ECMA	European Association for Standardizing Information and Communication Systems
EES	Energy Efficient Strategies P/L
EU	European Union
HDMI	High-Definition Multimedia Interface for transmitting uncompressed digital data
HE	Home Entertainment equipment (audio and/or video)
ICT	Information and Communications Technology (includes computers and their peripherals as well as communications equipment)
IEA	International Energy Agency, Paris
IEC	International Electrotechnical Commission, Geneva
IEEE	Institute of Electrical and Electronic Engineers, USA
IP	Internet Protocol - used for transmitting data across a packet-switched network using the Internet Protocol Suite, also referred to as TCP/IP
ISDN	Integrated Services Digital Network (telephone system)
ISO	International Standards Organisation, Geneva
ITU	International Telecommunications Union, Geneva
LAN	Local area network – usually limited to one or several buildings
MEPS	Minimum Energy Performance Standards
Modem	A device that uses an analogue signal to encode digital information

	(and then decodes) transmitted information (modulator-demodulator)
OSI	Open System Interconnection Model (ISO7498)
PSTN	Public Switched Telephone Network
PVR	Personal Video Recorder (device with tuner and hard drive)
Router	A router is a device that interconnects two or more computer networks, and selectively interchanges packets of data between them.
SCART	A French-originated standard and associated 21-pin connector for connecting audio-visual (AV) equipment together. It is common in Europe. Also known as 21-pin EuroSCART, Péritel (in France), Euroconector, EuroAV or EIA Multiport (USA). (from *Syndicat des Constructeurs d'Appareils Radiorécepteurs et Téléviseurs*).
SNMP	Simple Network Management Protocol (UDP-based protocol)
STA	A station (STA) is a device that has the capability to use the IEEE802.11 protocol. A station may be a laptop, a desktop PC, PDA, access point or Wi-Fi phone. A STA may be fixed, mobile or portable.
TCP/IP	See IP
UDP	User Datagram Protocol (member of the Internet Protocol Suite)
USB	Universal Serial Bus (serial communications)
VESA	Video Electronics Standards Association (international standards body for computer graphics)
VOIP	Voice Over Internet Protocol (see also IP)
WAN	Wide area network - a computer network that covers a broad area (connects LANs to each other or to the wider Internet)
WAP	Wireless Access Point – see AP
WLAN	Wireless Local Area Network based on the IEEE802.11 standards

Note: More information on many of the above terms can be found on Wikipedia. Some of the above definitions have been partly drawn from Wikipedia http://www.wikipedia.org/

1. Introduction

1.1 Study objectives and methodology

The study objective is to prepare a technical scoping study to examine the issue of network standby in order to document key areas of knowledge with respect to networks and to identify which areas related to networks and energy saving may require further technical development. The study aims to identify key technical gaps and omissions with respect to networks and energy savings so that further investigations can be undertaken and resources allocated to redress these issues. Where energy savings within networks can already be accommodated, the study will examine issues regarding implementation of such measures on a broad scale. The ultimate aim of this work is to ensure that technical approaches are in place to facilitate the development of the optimal energy policy approaches to reduced energy consumption of products connected to networks.

The broad objectives of this report are to:

- Explore technical issues in networks
- Identify potential solutions and low energy solutions
- Make recommendations regarding future resource allocation to ensure products attached to networks minimise energy consumption as much as possible.

The methodology used in this scoping study is to prepare documentation on the following areas:

- Examine the range of network related functions and their likely associated power levels and assess this as a basis for a future approach to developed functional allowances for different network functions.
- Review network based communication protocols to identify areas where power management responses can be incorporated into different network communication structures in order to reduce energy consumption while maintaining the required level of network connectivity and functionality.
- Document power management protocols within standard network communication architectures for mains power connected products.
- Investigate existing options for innovative power management and auto power down solutions for individual devices to move them from active mode to lower power modes, or from one low power mode to a second lower one, wherever possible.
- Identify key areas where additional work is required in order to realise the large energy saving potential within networks.

This scoping study aims to build on and enhance the substantial work in progress or planned in the USA and Europe on network standby issues. A comprehensive research program is proposed to support a proactive agenda of policy development towards low energy networks.

1.2 Study team and acknowledgements

This report was jointly commissioned by the APP Standby Power Working Group and the IEA 4E Standby Power Annex. The work was funded on contract by the Australian government as part of the work on APP Alignment of Standby Power Approaches Project and as an in-kind contribution towards the 4E Standby Power Annex. The contract for the work was with the Department of the Environment, Water, Heritage and the Arts (now managed by the Department of Climate Change and Energy Efficiency).

The authors would like to thank the following people for their guidance, assistance and input during the preparation of this study:

- Shane Holt, IEA/Department Climate Change and Energy Efficiency;
- Dr Alan Meier, Lawrence Berkeley National Laboratory, USA;
- Hans-Paul Siderius, Energy and Climate Change, Agentschap Netherlands and chair of IEA 4E;
- Roland Brüniger, Swiss Federal Office of Energy;
- Yung-Rae Kim, Korea Energy Management Corporation;
- Melissa Damnics, Maia Consulting, Australia; 4E Standby Annex operating agent;
- Mark Ellis, Mark Ellis & Associates, Australia, 4E EXCO operating agent.

This study was undertaken by Lloyd Harrington of Australia and Bruce Nordman of the USA with assistance from Robert Harrison of the United Kingdom.

Lloyd Harrington is an international expert on standby power. He has been chair of the IEC committee on standby power TC59 MT9 since its formation in 2001 and was previously chair of an IEC ad hoc committee on standby power prior to the establishment of MT9. He has been responsible for the preparation of the international test method on standby power IEC62301 which was published in 2005 and is currently leading the committee in the development of Edition 2 of the standard. Lloyd has extensive experience in data analysis with respect for standby and has prepared many papers and policy documents for governments since the issue came to the forefront in 1999. Lloyd was responsible for the inclusion of standby power requirements into the energy labelling of clothes washer and dishwashers and energy labelling and MEPS for air conditioners on behalf of Australian governments. He was a key contributor to the development of international standby definitions for several products in IEC TC59 household appliances and is active in the APP standby groups and the 4E Standby Annex. Lloyd is a director of Energy Efficient Strategies and was the project coordinator.

Bruce Nordman currently works as a researcher at Lawrence Berkeley National Laboratory in Berkeley, California, USA. His research focuses include networks (electricity use from network equipment, network interfaces, and ways to reduce this), user interfaces, building networks, low power mode energy use, and electronics and miscellaneous energy use generally. Bruce has studied electronics energy use for over 15 years, and focused on network issues for the last 10 years. He has worked on the development of network and other standards within the IEEE (Institute for Electrical and Electronic Engineers), CEA (Consumer Electronics Association), and Ecma International. He has worked on several studies on low power energy use, and contributed to the development of IEC62301 on standby power. Bruce contributed to this study as a private consultant.

Robert Harrison has contributed to numerous European Commission studies and working groups on the impact of standby power in consumer electronics and ICT products over the past 15 years. He produced the primary technical data and technological analysis for the foundation Commission report on Standby in 1997 "Leaking Electricity" which identified External Power Supplies, Televisions and Set Top Boxes as products for urgent consideration in the reduction of the global impact of standby power. He has been a member of the working group responsible for the production of the IEC62301 Standby Power and its subsequent review. Robert is currently a member of two key working groups on networked products, one producing protocols for the power management of networked consumer electronic products and one setting standards for the inter-operability, power management, and optimal utility loading of appliances and products controlled by home networks and third party wide area networks.

1.3 Disclaimer

While this report was commissioned by APP and the IEA 4E Standby Annex, any views expressed are those of the authors. While the authors have taken every care to accurately report and analyse the data and verify the information included in this report, the authors are not responsible for any use or misuse of data or information provided in this report or any loss arising from the use of this data.

2. Background on standby

2.1 Background

This report provides an overview of technical issues regarding power consumption of appliances and equipment that are connected to networks. Appliances and equipment connected to networks are becoming increasingly common in both the commercial and residential sectors. It is important that when appliances and equipment are performing secondary network functions that the power consumed be as low as possible. The interactions between a product and the network to which it is connected (including other appliances and equipment) need to be understood to allow effective power management strategies to be implemented, while maintaining the required level of functionality. This report examines the software and hardware interfaces found in common networks and identifies areas where further work or development is required to ensure that products can minimise their own energy consumption under a variety of network platforms and context.

Standby power is a general term commonly used to describe the low power mode(s) that many electrical and electronic products are in when not performing their main function. When appliances are connected to a power supply they may be performing one or more secondary functions or may just consume power because of the product design and configuration. Standby power has become ubiquitous in appliances and equipment as electronic controls become standard and, in most countries, there is evidence that energy consumption caused by products in standby modes is increasing. Much of this increase is coming about from the increase in the number of products which consume power in this way, rather than an increase in the power levels in these modes.

Regulations and approaches in some countries have been developed to cover low power modes in stand-alone products (standby, off mode etc). Sometimes similar requirements can be set across a wide range of products. This can be implemented as most stand-alone products have a fairly limited number of functions present and the power requirements for these functions are modest. Such approaches have been successfully implemented in Europe and Korea, for example.

Most current and proposed regulations that deal with standby do not include equipment that is attached to a network (or indeed equipment that makes up the network itself). This is because the power requirements for network functions are often quite complex and also because it is common that many more functions are present in low power modes of networked products. All this means that a simple horizontal approach to setting limits on low power modes for networked products is not usually possible.

The objective of any energy policy is to reduce and even minimise energy consumption as far as is technically possible while performing the functions that are required.

In the case of stand-alone products, this objective has been achieved by including a requirement for power management to enter the relevant low power mode after an appropriate time of no use of the primary function.

In the case of networked equipment, such a requirement is even more critical as setting limits on low power modes is of no value if the product never enters those modes. So, power management requirements are a critical part of any policy on networked equipment.

The complexity of networked equipment makes setting limits in low power modes and the associated power management requirements (to ensure products spend as much time as possible in those modes) somewhat complex. This is particularly the case with a diversity of number and type of network interfaces on products. This study examines the issues related to low power modes for products connected to networks and explores approaches which could be used to minimise future energy consumption across all modes with a view to developing a comprehensive policy framework for low energy networks.

2.2 History of standby power

The energy consumption of major household appliances is generally well understood. Many of these products are now regulated in many countries for energy efficiency through programs such as energy labelling or Minimum Energy Performance Standards (MEPS). These requirements generally cover the primary function (or active mode), but rarely include low power modes (at least at this stage). However, there is a significant proportion of residential sector and commercial sector electricity consumption, most commonly called “miscellaneous end uses”, that is not well understood or documented. A substantial share of this electricity consumption can be classified as standby energy. The miscellaneous consumption is estimated to be growing and could reach nearly 30% of residential electricity consumption in the USA by 2030 (Ecos, 2006).

Standby energy was really only identified in the mid 1980’s. With the advent of consumer electronics and changes in the design and features of appliances, low levels of power consumption have become the norm when a product is not in use. Also there are now many products which are designed to operate on a continuous basis at low power levels and which provide functions such as monitoring (e.g. smoke alarms, security systems, telecommunications). These end use products are now common and although individually their power consumption is small, collectively they consume a significant amount of electrical energy. While many of these devices offer increased flexibility, versatility and in many cases improved performance, their design also results in power consumption when they are not performing their main function. Such energy consumption is generically described as “standby energy” but it includes a range of modes from "off" through to "on" as well as small continuous loads, depending on the product and its function.

Standby energy is now one of the largest individual electrical end uses in the residential sector, estimated to be of the order of 10% in Australia (EES, 2006a), Europe (Fraunhofer, 2007) and California (Meier et al, 2008). It is probably equivalent to the energy consumption of refrigerators and freezers in many developed countries. Studies have confirmed that standby energy now represents one of the end uses with the largest potential energy savings in the residential sector.

While the amount of standby energy varies markedly between countries, in part due to the different penetration of appliances, but also to some extent due to differences in their standby attributes, the global energy consumption from standby has been estimated by the International Energy Agency (IEA) at between 200 TWh and 400 TWh per year (E3b, 2006), which is equivalent to 1% to 2% of global electricity consumption.

There is growing international concern about the impacts of all energy consumption on climate change. There is a need for urgent action to reduce standby energy. Attention focused now on the design and performance of products will ameliorate future standby energy contributions to global warming.

2.3 The lack of global information

Since the "standby problem" became apparent more than a decade ago, the area has attracted significant attention. However, the lack of information on, and understanding of, the impact standby power has on individual product and overall energy consumption remains generally poor and this is hampering effective policy development. This lack of information and understanding can be attributed to two primary causes:

- Challenges of data collection: These are many, including: the growing number of products which have low power modes; changes in the types of functions in equipment; uncertainty and variability in usage patterns; and the growing number of low-power modes in many electronic and other products.
- Poor data sharing: Even when such data are successfully collected, it is not necessarily shared among stakeholders or presented in a manner which is most effective in informing the policy debate. This lack of effective data exchange is partly through ineffective communications between stakeholders, but also due to incompatibility of the data that has been collected. One impediment is a lack of consistency and standardization in classification of product modes and product types. Global standards are needed.

Curiously, while some standby information on some products is available, there is little coherent information available around the world that provides a clear picture of overall trends in standby energy. Some countries have good information on the current status of some products, but there is a paucity of solid information on product trends over the past 5 years or more. Good data on trends is necessary to make reasonable estimates of standby energy consumption of the stock of products in use. Even in Australia, which has been assiduously collecting data every year on new products since 2000 (together with two detailed household surveys of the stock of products installed in 2000 and 2005), the trends at a product levels are not always clear (EES, 2006b).

There are several complications in determining the trends in standby energy. The first is that many products have a number of possible modes and generally speaking there is poor data on the usage patterns of products which dictate the frequency and duration of these modes. For a simple product like a television, for example, there is reasonable data on the average hours of use through the collection of data on viewing habits of consumers (which is driven by strong commercial interests such as advertisers). But even this simple data is not applicable to multiple televisions in the one house – it is recognised that viewing patterns of second and third televisions in the home are quite different to the primary television. Most developed countries now have a television ownership of 2 per household and this continues to increase (Harrington et al, 2006). Even if we know with great certainty the hours of television watched per week, little data on the frequency and duration of the relevant low power modes (when not in use) is readily available. (Outside of North America, many televisions have both an off mode and a passive standby (remote control active) mode). Determining the share of the relevant low power modes is fraught with difficulty.

Undertaking a face to face or phone survey of how consumers leave their products when not in use results in potential bias as many consumers are aware of the standby issue and may feel guilty about leaving their televisions in passive standby mode, for example. Intrusive surveys that record the mode of the product "as found" are more reliable, but this approach really only provides a random snapshot of the most common modes. The only reliable method to determine total energy consumption is end use metering at a product level over a substantial period (such as a year or more). Even where this data has been available historically, it is generally of little use as almost all end use metering devices used for such studies have a minimum power resolution of the order of 5 watts, well above the typical low power levels of relevant modes for many products. An extensive metering campaign in Sweden in 2007/ 2008, in 12 European countries and a study using similar methodology under way in the UK, are some of the first to use meters with good low power resolution that will provide detailed information on the time and energy consumption in various low power modes (Bennich 2006, REMODECE 2010, AEA/Intertek 2010). However, since some of the attributes influencing consumption are local, this will provide the most authoritative understanding of the situation just for the countries where monitoring takes place. In the USA some limited monitoring of 50 houses for a period of 2 weeks has been used to obtain preliminary data on usage patterns for a wide range of household products (Ecos, 2006).

The issue of usage patterns is less complex for products that have few relevant modes or even one dominant mode. However, more complex products like home entertainment equipment can be very difficult in terms of determining frequency and duration of all relevant modes. Some products have power management as well, which needs to be understood when developing such estimates. The issue is more complex again for products that have a network connection. Getting information on the frequency and duration of each mode in the field is very difficult. Even low power end use metering equipment can be difficult to interpret unless power levels of all the relevant low power modes are known prior to long term monitoring for each individual product monitored.

The other difficult aspect of determining "trends" (long term changes in a product attribute) is that there is a large and ongoing change on the mix and types of products on the market. Increasingly the boundaries between certain product types are starting to blur as well. Consider the DVD player. This started as a simple stand-alone product to play DVD discs. Then a DVD recorder version appeared, and now there are devices with hard drives and a tuner (or several tuners) to record programs from television broadcasts. These devices have effectively replaced VCR recorders, which are now almost obsolete. Many products can edit video, burn discs in a large variety of formats, can act as a music players, have USB, firewire and LAN connections and can stream music and video over a wired or wireless network. Consider also the new media centres which are a PC and display device but may be used as a television, set top box, DVD player and hard disc recorder. Many PCs now come standard with a television tuner. Even the range of televisions is now confusing with analogue tuners (disappearing in many regions), digital tuners, some with both, and some have none (technically monitors, but they are used as televisions). So called IPTV (television delivered through a broadband connection) adds another dimension to this once simple product. We now have refrigerators with LCD screens and internet connections, appliances that are part of an integrated home network, and air conditioners with remote communications capability. All of these variations make defining products and therefore tracking trends in standby difficult – do we treat each variation as a variation of an existing product type or as a new product type? How do we deal with such different levels of functionality? To further complicate product categorisation many only remain on the market for as little as 5 years before becoming obsolete. Care is required to make sure we are comparing apples with apples.

Given the rapid changes in technology and product variations, it is little wonder that the overall trend on standby energy is somewhat unclear internationally. And the increasing use of network connections for many types of equipment will add an additional layer of complexity to these trends.

In an attempt to improve the level of information available around the world, a number of governments are working cooperatively to track the low power mode attributes of a standard "basket of products". To this end, a set of 12 representative core products has been qualified and a data collection instrument and standardised data collection procedure has been developed (Standby Data, 2007) together with an additional 30 secondary products where data can also be pooled. Data has been collected in USA, Canada, China, Korea, Japan, Australia, New Zealand and Europe.

The purpose of these standby measurements for a common basket of products is to allow national and international comparisons of like products across different countries and regions. Such measurements will highlight the magnitude of standby power and enable comparisons across different regions. They will track the effectiveness of the policy mix used in individual countries and highlight the best products in a number of categories. Techniques to measure products with network connections in the field are also under development, but these of course add significant complexity.

Because information is collected at an individual product level, differences among brands and models can also be examined. The information can be used to encourage manufacturers which supply products with good standby attributes and to put pressure on manufacturers which supply products with poor standby attributes to make rapid improvements.

Eventually, the data collected will also provide trends in standby power attributes by product type, over time, so that the rate of improvement or deterioration can be quantified, within and between markets, as well as by product type and even brand.

Such improved information at a product level will assist national governments to formulate specific responses to the issue of standby energy. It will eventually allow specific manufacturers to be identified if they continue to supply products with poor standby attributes in selected markets. Such information is important for monitoring the market and for measuring program effectiveness, but it also underpins growing international cooperation on the standby issue.

Good data takes time to collect but it is clear that urgent action is required now on this issue. In an ideal world perfect policies would be developed on the basis of comprehensive information. Given the pressures of climate change and the rapidly changing market, we don't have this luxury. What is needed are sensible policies that are robust enough to give good outcomes while minimising the risks of failure or adverse outcomes. Policies can be adjusted and refined as data improves over time. This is widely understood and many countries have dealt with the issue in an expedient and pragmatic manner.

2.4 Policy context for standby power

A number of governments have understood that low power mode energy consumption will result in significant wastage of energy into the future and that there is a need for policy development to encourage improvements in standby energy design (including power management) in new products. As a result, policies have been developed in a number of markets to tackle excessive standby. These policies, which include a range of mandatory and voluntary measures, have been targeted at a number of the individual products which contribute to standby consumption, but not all products. Many of these are summarised in Section 3. However, many of the requirements only address some of the relevant low power modes, not all of them. Few address products with network functions present and activated.

While it is believed that these policies are making a significant contribution to a reduction in the growth of standby power (at least in the products targeted), a number of problems still remain, including:

- Difficulty in defining policy targets: While individual policy approaches vary, most are usually defined in terms of power limits for individual product types or categories. The rapid change in the design, purpose and functionality of products and the speed of development and penetration of "new" products, means that product definitions and exemptions need to be continually updated or they soon become redundant, unless a more a generic approach can be devised.
- Increase in the number of possible low power modes: As devices have become more complex in terms of functionality there has been a growth in the number of potential low power modes (a mode is defined as a collection of functions). The act of maintaining connection to a digital network is one example of a mode which is becoming more common, especially in electronic equipment. Therefore, while products may be using less energy in the minimum low power mode, the overall energy consumed by some products may be rising due to increased time spent in these higher power modes with additional functionality.
- Inability to evaluate policy: Because of the rapid market evolution, the shortage of ongoing market tracking data, and lack of common data collection and reporting methods, overall policy effectiveness is often difficult to assess and impacts are hard to quantify.
- Limited coordination of policy action: Many of the products incorporating standby are globally traded, yet policies for standby power are normally developed on a national basis which can result in competing policy pressures and possibly conflicting requirements for individual product designs. Where global approaches can be developed, they are more likely to be effective.
- Lack of a technology strategy: Experience has shown that the public sector can play a significant role in the identification, creation, market availability, and effective utilization of technologies that enable reduction of power consumption in low power modes and more effective power management. Many of these rely on technology standards. A roadmap for what activities of this type should be undertaken by the public sector is lacking, as are the necessary resources and institutions required for its implementation.

In the last couple of years, and as part of an ongoing process of setting mandatory minimum performance standards for energy-using products, several countries have addressed the issue of standby power by introducing regulations to target a large number of product types in these modes. However, despite these commendable efforts, there are limitations in the current policy approaches in terms of ensuring that excessive standby energy is adequately tackled into the future for all future product types and their associated functions.

In various countries, studies are underway to examine networked products and other specific aspects of standby. This study aims to further develop understanding of the technical and policy issues in this area and to identify areas where further work may be required.

2.5 The need for standby policies

Some policy makers advocate the provision of standby power information alone as a policy tool to reduce standby energy. However, there are some fundamental problems with this approach. While the power consumption in various low power modes of many products is significant, the level of this power needs to be kept in perspective. An emphasis on standby energy consumption through consumer information may distract from more significant aspects of energy consumption. The share of total energy consumption from various low power modes is highly variable at a product level and in some cases is highly dependent on consumer usage profiles. It is likely to be undesirable, for example, if consumers were encouraged to purchase products with low standby energy where the on mode efficiency was poor (or power consumption is high) – this could result in an overall increase in energy consumption.

The crux of the issue is that at an individual product level, standby energy is often small. However, when considered collectively, standby energy is now one of the largest single end uses in the average household. The negligible energy and small annual cost of standby power for an individual product provides no incentive for manufacturers to use low standby power attributes in their marketing material or as a point of product differentiation (hence there is little market pull potential to encourage low standby power designs). The transaction cost for consumers to take this information into their purchasing decisions is likely to be far too high for the 20 or 30 products that may use standby energy in a typical home over a purchasing cycle of 10 years (a study for California found over 40 products in a typical house using low power mode energy – Meier et al., 2008). In short, standby energy is typically too trivial at an individual product level for the consumer to build it into their decision making process. But collectively, consumers pay the cost of high standby energy that arises from poor product design. There is no doubt that extremely low standby designs are readily available at a small marginal cost. However, these are not being universally adopted by suppliers due to the perception of low value added.

Policy approaches to reduce excessive standby power are clearly warranted, but the relatively low energy consumption per product, the large number of product types and product numbers (sales volumes both now and in the future) means that careful consideration is needed. Setting targets or limits on standby power is a sound approach to address the issue. However, there are a number of challenges that policy makers need to consider:

- Continual changes in product definitions, splitting and merging of traditional product types, new products types appearing;
- Significant changes in product features and functionality (including network functions);

- New product features and functionality;
- A range of relevant modes of interest (rarely a single mode, or only the lowest mode, is important);
- Considering low power mode energy consumption in the context of total energy consumption (which includes active mode energy);
- Setting technically advanced but achievable targets at a product level.

Where regulations define requirements for standby power, exemptions are sometimes provided for certain types of products or certain types of modes. While this is often necessary in order to implement a practical policy measure, it can provide loopholes for unscrupulous suppliers. If a supplier can avoid regulatory requirements by the provision of a certain feature, then there could be strong encouragement for this feature to be included in their products as a cheap and technically easy means of complying (through avoidance) without improving their standby attributes[1]. A similar problem exists where technical requirements are only defined for particular modes – an unscrupulous supplier could remove such modes from their product in order to avoid regulatory requirements. Such provisions also add burdensome complexity to regulations and policies.

Policies that cover low power modes need to focus on the modes that are likely to be common during normal use of the product.

In all cases, the inclusion of effective power management requirements will also make a substantial contribution to future energy savings.

The concern for energy use in standby modes is only intensified with the addition of network connectivity, where it is more challenging to define relevant modes and acceptable power levels, particularly where products may interact with each other. Part of the problem rests with the design of products and whether some or all of the network related functions can remain operational (or are even required) when the primary function is not required. This introduces a complex interrelationship between the primary function(s), the network functions, low power modes and the how power management can minimise energy across modes. The other challenge within a network is to implement effective power management where there may be interconnections to poorly behaved equipment.

This report attempts to explore these issues and proposes a number of strategies to support technology and policy developments to redress these issues.

[1] For example, it has been reported that a supplier of set top boxes in Europe was fitting an Ethernet port to their products so that they become exempt from standby regulations, even though this port is not used by the product during normal use.

3. Current policies on standby power

3.1 Overview of policies

The issue of standby power has been around for many years. Energy Star in the USA set out the first quantitative requirements for standby modes in 1992 for computers and monitors. Since then, concern about standby power has grown and the number and types of products covered by different countries has also grown.

This Section provides a quick tabular snapshot of policies and program that have been implemented or announced to date in order to provide an impression of product and regional coverage. Some detail by country is included but it is not intended to be comprehensive – the source material referenced should be consulted for program details.

In Table 1, “Limit” means that a specific limit (in watts) on the relevant low power mode is defined in the program requirements. “Vertical” means that the energy consumption in low power modes is combined with active mode energy consumption for a defined usage profile (typically over a day, week or year in order to give a standardised total energy consumption. “Adder” is a system of functional adders which are used to determine a variable power limit for the specific low power mode based on the functions present. “Mixed” means that there is a combination of approaches – see notes to table. “Active” means active mode efficiency only specified.

3.2 Country summary

This Section provides a brief overview of current and proposed regulations by country with respect to standby and other low power modes. It does not necessarily cover all current or proposed program measures. A number of national requirements refer to “passive standby”. This is usually a low power mode that has a remote control activation function and also may include basic clock and memory functions.

3.2.1 South Korea

South Korea announced in 2005 that it was going to introduce mandatory limits for standby power for a wide range of products by 2010 in its publication Standby Korea 2010 – Korea’s 1 Watt Plan released by the Ministry of Knowledge Economy and Korea Energy Management Corporation (KEMCO 2005). The aim is to introduce a 1 Watt limit for a wide range of products by 2010. The program started with a voluntary framework in 2005 and introduces mandatory limits by 2010 after a transition period.

Table 1: Summary of low power mode requirements by country

Country	Home CE	IT	Comm Office	Appl-iances	Heat cool	Cooking	Other	Network
Korea	Limit	Limit	Limit	Mixed	Mixed	Mixed	Limit	Limit [a]
Europe	Limit [b]	Limit	Limit	Limit		Limit	Limit	Adder
Canada	Limit							
Australia	Mixed [c]	TBA	TBA	Vertical	Vertical	TBA		
Brazil	Label							
India	Limit			Limit				
Japan	Mixed [d]		Vertical	Limit	Limit	Mixed [d]	Vertical	Active
China	Limit	Limit	Limit					
USA	Limit [e]			Vertical				
California	Limit							
Energy Star Int	Limit	Mixed [f]	Limit					

Key:	Mandatory requirements in brown.	Voluntary requirements in green.

Notes to Table 1: Coverage within each product category varies by country. Home CE (consumer electronics) refers to a wide range of audio and video equipment, including TVs. IT is information technology, including computers, monitors, printers and network equipment. Comm-Office refers to communication equipment (including phones) and other office equipment (eg copiers). Appliances refers to major appliances such as whitegoods. Other refers to other equipment not otherwise included in other categories. TBA – to be formally announced (proposals are expected to be announced in due course).

Footnotes to Table 1:

Note a: Korea sets limits for modes with external communication for home gateways and for appliances.

Note b: Additional requirements specified as adders under voluntary code of conduct for digital television services (European Commission 2008).

Note c: Limits are in place for set top boxes and vertical requirements for televisions, requirements for other equipment TBA.

Note d: Japan has Top Runner (vertical) requirements for TV, DVD and VCRs and supply associations have also agreed to reduce low power modes for TVs, stereos, DVD and CD/cassette players. Top Runner requirements apply to microwave ovens and rice cookers and supply associations have also agreed to reduce low power modes for microwave ovens.

Note e: Limits for simple digital converter boxes applied in order to be eligible for government subsidies.

Note f: Energy Star International set limits for some products, active mode efficiency for some products, vertical requirements for imagining equipment. See Section 3.4 for more details.

Korea's e-Standby Program encourages the adoption of energy saving modes while appliances are idle with the aim of minimising standby power. The Energy Boy label (orange "*e*") is affixed to those products that meet the requirements for standby power. The standby warning label (yellow circle) is attached to those products do not meet the specified standby power requirements by product type. The e-Standby Program covers about 20 product categories as set out in Table 2.

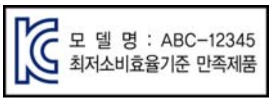
Table 2: Products and limits in Korea's e-Standby Program

Target Product	Off mode	Sleep mode	Passive standby mode	Active standby mode
Laptop Computers	≤1 W	≤1.7 W		
Desktop and Integrated computers	≤2 W	≤4 W		
Monitor	≤1 W	≤2 W		
Printers	≤1 W	Various Limits		
Fax Machine	≤2 W	Various Limits		
Copiers	≤1 W (w/o fax) ≤2 W (with fax)			
Scanners	≤1 W	≤12 W (with off) ≤5 W (without off)		
Multifunction Devices	≤1 W (w/o fax) ≤2 W (with fax)	Various Limits		
Energy-Saving Controlling Devices	≤1 W (Auto off)			
Televisions			≤1 W	
VCRs	≤1 W (w/o remote)		≤1 W	
Home Audio Products	≤1 W (w/o remote)		≤1 W	
DVD Players	≤1 W (w/o remote)		≤1 W	
Radio Cassette	≤1 W (w/o remote)		≤1 W	
Microwave Ovens (1)			≤1 W	
Set-top Boxes			≤1 W (optional)	≤10-20 W (Various limits)
Door phones (1)			Various Limits	
Cordless/Cord Phones (1)			Various Limits	
Toilet seats	≤2 W (with ACB) ≤1 W (without ACB)			≤15 W (Heating standby)
Modems (1)	≤0.75 W		≤2 W (xDSL) ≤5 W (cable)	
Home Gateways				≤10 W

Notes to Table 2: ACB is automatic circuit breaker. Door phones are also commonly called intercoms. Items marked with (1) have a requirement for "Standby Mode" (but is listed in the passive standby mode column).

In addition, Korea's Energy Efficiency Label and Standard Program sets an extra requirement for the highest efficiency category (Grade 1 is the most efficient category). To be eligible for Grade 1 efficiency, products must generally achieve a standby power of <1W. This means that products that achieve Grade 1 efficiency have the highest efficiency level in active mode and a standby power of below 1W. The specific requirements for each appliance category are:

- Air conditioners – passive standby mode ≤1W and active standby mode ≤3W (network function if present) to qualify for Grade 1 efficiency on the energy label.
- Washing machines (non-drum) and drum washing machines – off mode ≤0.5W and active standby mode ≤2W (network function if present) to qualify for Grade 1 efficiency on the energy label.
- Dishwashers – off mode ≤1W and active standby mode ≤3W (network function if present) to qualify for Grade 1 efficiency on the energy label.
- Dish dryers –off mode ≤1W to qualify for Grade 1 efficiency on the energy label.
- Rice cookers – no load ≤1W to qualify for Grade 1 efficiency on the energy label.
- Electric fans – passive standby mode ≤1W to qualify for Grade 1 efficiency on the energy label.
- Air cleaners – passive standby mode ≤1W to qualify for Grade 1 efficiency on the energy label.
- Household gas boilers – sleep mode ≤3W to qualify for Grade 1 efficiency on the energy label.
- Gas water heaters – sleep mode ≤3W to qualify for Grade 1 efficiency on the energy label.



External power supplies have a requirement of no load ≤0.5W (to 10W output) and no load ≤0.75W (10-150W output) to be eligible for MEPS (Minimum Energy Performance Standard). This label is also affixed to external power supplies to indicate their compliance with MEPS in Korea.

Korea provides an allowance in "active standby mode" for products with a network capability (remote communications) when a network activation function is present (but not actively communicating). Some of the equipment covered clearly has networking capability (most information technology equipment and some home entertainment equipment).

The implementation dates for each of the requirements for each program element and product type are set out in Table 3. Program details are contained in the report *Korea's Energy Standards and Labeling* (KEMCO 2010).

Table 3: Implementation dates for Korean program elements

Program	Element	Label	Date	Products
e-Standby	Warning		28 August 2008	TV
e-Standby	Warning		1 July 2009	Computers, monitors, printers, multifunction devices, set top boxes, microwave ovens
e-Standby	Warning		1 July 2010	VCRs, audios, DVD players, radio cassettes, toilet seats, cord/cordless phones, door phones, modems, fax machines, copiers, scanners, home gateways
e-Standby	Energy Boy		1 July 2001	Energy-saving & controlling devices
EELS	MEPS		1 January 2009	External power supplies
EELS	Efficiency label		1 January 2007	Washing machines, dishwashers
EELS	Efficiency label		1 January 2008	Rice cookers
EELS	Efficiency label		1 July 2008	Air cleaners
EELS	Efficiency label		1 January 2009	Drum washing machines, electric fans
EELS	Efficiency label		1 January 2010	Air conditioners, household gas boilers
EELS	Efficiency label		1 January 2011	Dish dryers, gas water heater

Note: EELS is Korea's Energy Efficiency Label and Standard Program.

3.2.2 European Union

The Ecodesign Directive (2005/32/EC) is a framework directive that describes the process for setting requirements on products. It envisages requirements for a large number of possible products. The technical investigations on standby power were done under Lot 6 Standby and Off Mode Losses of Energy Using Products. This original project lead to the publication of the European Commission Regulation (EC) 1275/2008 which was published on 17 December 2008 titled: *Implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to Ecodesign requirements for standby and off mode electric power consumption of electrical and electronic household and office equipment*. As this is a European regulation, it is directly applicable in all EU Member States and no separate implementation in national law is needed/allowed.

The type of equipment covered is:

(a) is made commercially available as a single functional unit and is intended for the end-user;

(b) falls under the list of energy-using products of Annex I (of the regulation);

(c) is dependent on energy input from the mains power source in order to work as intended; and

(d) is designed for use with a nominal voltage rating of 250 V or below,

(e) products marketed for non-household or non-office use;

The regulation defines requirements for off mode and standby mode.

Annex I of the regulation lists the following broad groups of equipment:

1) Household appliances: Washing machines, Clothes dryers, Dishwashing machines, Cooking: Electric ovens, Electric hot plates, Microwave ovens, Toasters, Fryers, Grinders, coffee machines and equipment for opening or sealing containers or packages, Electric knives, Other appliances for cooking and other processing of food, cleaning, and maintenance of clothes, Appliances for hair cutting, hair drying, tooth brushing, shaving, massage and other body care appliances, Scales.

2) Information technology equipment intended primarily for use in the domestic environment.

3) Consumer equipment: Radio sets, Television sets, Video cameras, Video recorders, Hi-fi recorders, Audio amplifiers, Home theatre systems, Musical instruments, other equipment for the purpose of recording or reproducing sound or images, including signals or other technologies for the distribution of sound and image other than by telecommunications.

4) Toys, leisure and sports equipment: Electric trains or car racing sets, Hand-held video game consoles, Sports equipment with electric or electronic components, Other toys, leisure and sport equipment.

Permitted power consumption for each mode is defined in Table 4.

Table 4: European Union Standby Requirements

Mode	Tier 1 – Dec 2009	Tier 2 – Dec 2012
Off mode	<1 Watt	<0.5 Watt
Standby mode with only reactivation function	<1 Watt	<0.5 Watt
Standby mode with any display function	<2 Watt	<1 Watt

Where there is no off mode and/or standby mode present, modes present shall not exceed the applicable power consumption requirements for off mode and/or standby mode when the equipment is connected to the mains power source.

From 2012 products are required to include a power management function "that switches equipment after the shortest possible period of time appropriate for the intended use of the equipment, automatically into off mode, standby mode or another mode with does not exceed the requirements for off mode and standby mode".

It is understood that the EU regulation does not cover:

- Network communication functions through LAN, HDMI, USB, etc., including network reactivation functions.
- Volatile memory preservation functions enabling instant reactivation without booting.
- Sleep mode as defined by Energy Star requirements for computers and imaging equipment.
- Sensor based protective functions.

It is unclear how the exclusion of network communication will affect the application of the regulation to information technology equipment.

In 2009 the European Commission launched the Networked Standby Study (so called Lot 26, TREN/D3/91-2007-Lot26). This study commenced in mid 2009 and is scheduled to conclude in late 2010. The intent is to define suitable requirement for network standby that may, after a defined consultation process, be included in future European Commission requirements. Information can be obtained from http://www.ecostandby.org/ An introduction report was released in 2009 (Fraunhofer 2009) and Reports for Tasks 1 to 3 were released in February 2010 (Fraunhofer 2010 a to c).

The European Commission has negotiated a number of voluntary agreements with industry (so called Codes of Conduct) which set a range of power limits or sales weighted targets for various equipment types which include some elements of standby power. These include:

- Colour televisions and VCRs (voluntary agreement with European Association of Consumer Electronics Manufacturers in the 1990's, now obsolete).
- Digital TV Services (includes complex set top boxes, devices integrated with televisions, PVRs etc) (European Commission 2008b).
- Broadband equipment (European Commission 2008b).
- Data centres (European Commission 2010).

The latter 3 codes of conduct cover equipment with network functions.

Some other voluntary programs in Europe cover standby requirements of IT equipment such as Nordic

Swan (Scandinavia), Blue Angel (Germany) and TCO (monitor certification system originating in Sweden but used globally – see http://www.tcodevelopment.com/)

The European Commission is an Energy Star partner for information technology equipment and with the EU having an explicit role in approving new or revised specifications (this different from the normal partnership with Energy Star).

3.2.3 Switzerland

While Switzerland is not part of the European Union, for the most part the technical requirements for energy efficiency are aligned with those for Europe. However, the implementation dates for some programs differ – Switzerland will often mandate requirements ahead of the European wide timetable.

One product of particular relevance to this study is complex set top boxes. Most of these have one or more network functions present. The Swiss requirements have mandated the *Code of Conduct on Energy Efficiency of Digital TV Service Systems* (Version 4, dated 5 October 2006) from 1 January 2010. It is envisaged that this requirement will be upgraded in the future. Note that the current version of the European Code of Conduct is Version 8 (15 July 2009).

3.2.4 Canada

Canada's Energy Efficiency Regulations, which came into effect in February 1995, are administered by Natural Resources Canada and reference energy efficiency standards that must be used to ensure that products comply with the minimum requirements of the Regulations. Canada will shortly be introducing regulations to limit standby power for a range of products under Amendment 11 of the Energy Efficiency Regulations which is due for publication in 2010.

The Canadian regulations will apply to the following broad product groups:

- Compact Audio Products – include clock radios, portable stereos and integrated stereos.
- Televisions.
- Video products – includes products such as DVD players/recorders, VCR players/recorders, digital video player/recorders, Blue Ray players/recorders or a combination of these technologies.

The proposed Canadian Tier 1 power levels for 1 July 2010 are set out below:

Table 5: Canadian Tier 1 Standby Power Levels

Mode	Off Mode	Standby Mode
Compact Audio Products	<1 Watt	<3 Watt
Televisions	<1 Watt	<4 Watt
Video Products	<1 Watt	<3 Watt

Note: All products must have an off mode and/or a standby mode

The proposed Canadian Tier 2 power levels for 1 January 2013 are set out below:

Table 6: Canadian Tier 2 Standby Power Levels

Mode	Off Mode	Standby Mode with display	Standby Mode without display
Compact Audio Products	<0.5 Watt	<1 Watt	<0.5 Watt
Televisions	<0.5 Watt	<1 Watt	<0.5 Watt
Video Products	<0.5 Watt	<1 Watt	<0.5 Watt

The Tier 2 requirements are intended to be broadly harmonised with the European Commission requirements that come into force in December 2012.

While video equipment and televisions may have some network related capability, the issue of network requirements is not specifically addressed in the Canadian regulations.

Canada is an Energy Star partner for almost all equipment types.

3.2.5 Australia

In 2006, Australia announced that it would introduce a 1 Watt limit on standby for a range of products (E3 2006). The details of this legislation has not been formally released yet but should be released in mid 2010 and implemented in 2013. It is likely that the requirements will be broadly harmonised with the European Commission requirements for December 2012.

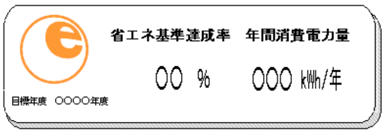
Australia has included standby requirements for a number of products under their energy labelling and Minimum Energy Performance Standards schemes as follows:

- Clothes washers and dishwashers – in 2006 it included an average of the value for off mode and end of cycle mode (broadly equivalent to IEC "left on" mode) into the annual energy consumption and star rating for these products (vertical requirement).
- Set top boxes – in 2008 it introduced MEPS levels for simple set top boxes in standby mode and active mode.
- External power supplies – in 2008 it introduced MEPS levels for external power supplies, which has requirements for no load mode and active modes as per the international requirements.
- Televisions – in 2009 it introduced energy labelling for televisions which included passive standby power and active standby power (where applicable – downloading of the electronic program guide) into the annual energy consumption, the star rating for the product and MEPS (vertical requirement).
- Air conditioners – 2010 it included non operating power (standby power and any energy from crank case heaters or other devices when not operating) into the energy consumption and star ratings for these products and from 2011 into the MEPS levels for these products (vertical requirement).

Australia is an Energy Star partner for information technology equipment and home entertainment equipment.

3.2.6 Japan

The Top Runner Program was introduced in 1999 to reduce energy consumption in the residential, commercial and transportation sectors. This program sets an energy efficiency target for some 23 products categories prescribed under the Energy Conservation Law. Once a product is selected, a review assesses the range of energy efficiency currently on the market. The most efficient product within each category or type is then selected as the “Top Runner”. All suppliers in the market are then required, on a sales weighted average basis for products that they ship, to reach or exceed this “Top Runner” efficiency level by the target date (usually set 5 years ahead). A number of products carry a label to indicate whether that model fall short of (orange label) or exceeds (green label) the Top Runner target.



Within the Top Runner program, there are 7 product categories which specify and include energy consumption from low power modes in the overall energy consumption requirements. Generally under Top Runner, a vertical approach is used for the Top Runner assessment, where each of the relevant modes in a specified duty cycle is used to calculate the energy consumption (ie specific requirements for low power modes alone are not stated).

Products categories that include low power modes in combination with active modes under Top Runner are:

- Televisions
- Electric toilet seats
- Microwave ovens
- Copiers
- VCRs
- Electric rice cookers
- DVD recorders

Japan recently released Top Runner requirements for network equipment such as small routers and network switches, however, these focus mainly on active mode efficiency. This type of network equipment usually has no low-power modes (or where they exist, they are rarely used).

In addition, a number of manufacturer associations in Japan have undertaken to reduce standby levels for products such as air conditioners for home, televisions, DVD player, stereo systems, CD radio-cassettes, electric rice cookers, clothes washing machines, electric clothes driers and microwave ovens. JRAIA (The Japan Refrigeration and Air Conditioning Industry Association), JEITA (Japan Electronics &

Information Technology Industries Association), and JEMA (The Japan Electrical Manufacturer's Association) have undertaken to reduce standby for products with remote control and timer functions to be less than 1W and for other appliances to be as close to 0W as possible. JGKA (Japan Industrial Association of Gas and Kerosene Appliances) has made a declaration to reduce the standby power to <1W for gas space heaters and <2W for gas water heaters (mostly instantaneous system with electronic startup and controls).

Japan is an Energy Star partner for information technology equipment.

3.2.7 China

China has had a Voluntary Endorsement Energy Efficiency Labelling Program in force since the late 1990's. The concept of standby power was introduced in 2000 and now some 10 product groups now have requirements that specify standby power levels including televisions, DVD players, printers, faxes, copiers, computers, monitors, multifunction devices, projectors and external power supplies.

Government bodies at all levels (public sector non-profits units and organizations) are required to give priority to products certified as energy-efficient in the procurement process. In 2007, the Chinese government made it mandatory to select energy efficient equipment – 4 of these product categories include standby requirements: televisions, computers, printers and monitors.

China was an active partner in the development of the international efficiency specification for external power supplies that included no load power requirements.

3.2.8 USA

Currently, the USA requires measurement of standby power for household dishwashers which is included in the annual energy consumption shown on the energy label.

Government subsidies were offered for the purchase of certain digital television adaptors (DTAs - simple set top boxes to convert digital television broadcast signals) if they meet certain power requirements in specified modes, and implement auto-power down through the implementation of the National Telecommunications and Information Administration (NTIA) coupon program. All coupon-eligible DTAs must comply with the following energy efficiency standards set by NTIA (NTIA 2007):

- Sleep state power consumption of no more than 2 Watts, measured in accordance with industry standard CEA-2013-A.
- Capability to switch from On state to Sleep state (or auto-power down) after 4 hours of user inactivity.

Government purchasing requirements mandate Energy Star specifications in many cases and there are also separate requirements on standby power for a wide range of products. Many local and state governments also use the same Energy Star specifications for their purchasing requirements. Federal purchasing requirements in the US specify a 1 watt standby limit for a range of other equipment (some are nominated Energy Star categories and other equipment is also specified under the Federal Energy Management Program) (Bush 2001).

Federal standby requirements are being considered for a wide range of products. There are some utility programs that cover standby power requirements.

3.2.9 California

The state of California in the USA was able to regulate certain products for standby power that were not regulated at a federal level.

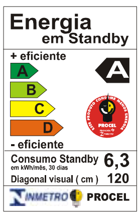
Table 7: California Standby Power Requirements

Product	Effective Date	Power Requirements
Compact Audio Products	1 January 2007	<2 W in Audio standby-passive mode for those without a permanently illuminated clock display <4 W in Audio standby-passive mode for those with a permanently illuminated clock display
Televisions	1 January 2006	<3 W in TV standby-passive mode
DVD players and recorders	1 January 2006	<3 W in Video standby-passive mode

California was an active partner in the development of the international efficiency specification for external power supplies that included no load power requirements. Subsequently, California set mandatory efficiency requirements for external power supplies, which includes no load maximum power levels. From 1 January 2007 the no load power permitted was <0.5W for a rated power of 0W to <10W and <0.75W for a rated power of 10W to 250W. From 1 January 2008 the no load power permitted is <0.5W for all external power supply models irrespective of rated power.

The California Energy Commission (CEC) had also adopted its own energy efficiency standards for DTAs. The CEC required converter boxes to have On and Sleep mode power consumption of no more than 8W and 1W, respectively, but had no requirement on the auto-power down feature, unlike the NTIA coupon program (CEC 2007a). In October 2007, the CEC repealed its existing efficiency standard on DTAs, because the NTIA coupon program was believed to generate an equivalent or greater level of energy efficiency (CEC 2007b).

3.2.10 Brazil



In 2008 Brazil introduced an energy label for standby of televisions. The Brazilian program is broadly based on the European bar style energy label and awards a rating from A to D depending on the standby power of the product. No information regarding active mode power is included in the program.

3.2.11 India

India set limits on the permitted power consumption in off mode (or passive standby mode where this is not present) to be eligible to carry the voluntary comparative star rating label. An endorsement label based on power requirements by mode is being implemented for set top boxes. Requirements for a number of other electronic products are under consideration.

3.3 Energy Star International

Energy Star is an international endorsement labelling program that is operated by the US Environmental Protection Agency. While much of their work concentrates on domestic programs in the USA (where the US Department of Energy co-operates), many of the specifications for consumer electronics and IT equipment are used internationally by many countries. Energy Star was the first program to specify low power mode requirements for any product and its specification for computers and monitors in 1992 launched the program.

The list of product specifications that are used internationally (at least to some extent) and that include some requirements for low power modes are:

- Audio/Video
- Battery Chargers
- Computers
- Cordless Phones
- Digital to Analog Converter Box
- Displays
- External Power Supplies
- Imaging Equipment
- Set-top Boxes & Cable Boxes
- Televisions

Of course there are Energy Star specifications which are used only in North America (USA and Canada) and a couple of these include some requirements for low power modes.

Some recent trends in the international specifications for Energy Star are:

- Most low power mode specifications are tending towards 1 Watt level
- A number of products are now adopting a duty-cycle based approach for an annual consumption (or equivalent) level summing many modes.

3.4 Energy Star and Network Connectivity

The Energy Star program has long taken network connectivity into account in its specifications. In fact, the very first specification in 1992 covered PCs and monitors and specified that each must be able to use a standard method for signalling that the monitors should go to sleep (DPMS). This required referencing the technology standard which defined this communication, created by the VESA (Video Electronics Standards Association) organization. While not technically a digital network connection, this data link served the same purpose. Over the years, the specific requirements for PCs related to networks evolved and expanded, and other products also gained some network-related requirements. In October 2009, the program announced a specification process for Small Network Equipment.

Network connectivity has deep roots in the Energy Star program. At present, at least eight specifications deal with network connectivity in some way, as do two specifications under development (data centre storage and small network equipment). The most common requirement is (during the test procedure) to require that the product be tested with at least some network connectivity engaged (assuming it has any at all), to ensure the product performs well in that circumstance and can enter the requisite modes. In some cases, the speed of the network connection is specified, since that can affect the power required.

Five of the specifications (AV, Game Console, PC, Set-top Box, and Imaging) provide extra power allowances for network connectivity in sleep. Four specifications (AV, Small Network Equipment, Server, and Set-top Box) provide an extra allowance for network connectivity when the device is fully on. In both cases these are usually an incremental power allowance per port active during the test. The imaging and server specifications take the speed of the link into account in the power level determination.

Seven of the specifications have an auto-power-down requirement (AV, Game Console, PC, Digital Television Adaptor, Set-top Box, Imaging, and Displays). Some of these specify that the device should maintain connectivity in sleep.

Three of the specifications (Imaging and Displays, plus the small network equipment specification in development) provide for products that use standard low-voltage DC. This commonly is delivered along with data/network communications, as with USB and Power over Ethernet (PoE), though the specifications do not limit which technology is used.

The PC specification has the most detail on network connectivity. The test procedure requires an Ethernet connection (or WiFi if it is one of the rare PCs without Ethernet). The data rate on the link must be reduced in sleep. The PC must have a short latency in waking. It must ship with Wake-On-LAN enabled, if intended for a business market. And finally, there is a significant reward for systems that support network connectivity proxying (the transfer of network integrity data package exchange from one or more high power devices to a low power device in the system, that is capable of “waking “the high power device(s) as required-see section 6.4).

The imaging specification has the most well-developed system of adders, including differential power values for network ports active during the test, and for those present but not active.

The server specification refers to reporting energy-related information over the network in a standard way, but does not name a specific standard, so different devices use different protocols to implement this requirement.

Energy Star requirements for DTAs are stricter than those under the NTIA coupon program. To qualify for Energy Star DTAs must meet:

- On mode power consumption of no more than 8W, measured using Section 6 of CEA-2022, and Sleep mode power consumption of no more 1W using Annex A of CEA-2013-A.
- DTAs may come out of Sleep Mode in order to scan for program and system information or private data. When doing so, DTAs may exceed the 1W Sleep Mode requirement for no longer than one hour in an eight-hour period.

In the near term, a number of network-related issues have to be faced by the program. One is when it is feasible to begin to require Energy Efficient Ethernet (and even earlier, to require that the device at the other end of the link of the unit under test in the test setup have EEE if the unit under test does). The EEE standard is expected to be ratified in September 2010. Another is to extend low-voltage DC powering to more product types. The degree of network connectivity in sleep (eg what proxying covers) will likely need to be specified for some product types. The program should refer to a single standard for reporting energy-related information over the network, once it becomes clear what that should be, and when it is approved. Finally, power management requirements for consumer electronic products will need one or more standards to define behaviour, and this is yet to be created.

3.5 International Energy Agency 1 Watt Plan

Since the launch of the IEA's aspirational 1-Watt target in 1999, the issue of standby power has gained an international profile. Almost all recent national policy statements in the OECD now mention standby power explicitly. Follow-up processes to the G8, Asia Pacific Partnership, APEC and the Commission on Sustainable Development Marrakech accord have all called on Governments to make a greater commitment to the IEA 1–Watt standby target and on other programs to tackle standby power.

Information on background to the development of the IEA 1 watt plan is given in the IEA report "Things that go blip in the night" (IEA 2001). More recent information is provided in the IEA report "Gadgets and gigawatts" (IEA 2009a).

3.6 Analysis of policies

3.6.1 Overview

In countries most which have an energy efficiency policy, standby power is usually an important component. However, while there has been a steady growth in the implementation of national programs to address standby power, the geographic and product coverage is still quite scattered. This is despite regular international conferences and other efforts which are designed to share up-to-date information and provide co-ordination of policy and program activities.

Setting limits for specified low power modes is the most common policy approach. This is easy to understand and quite explicit in its application. The most common target level is now 1 watt, although this does vary at a product level and by country. Korea has the most comprehensive product list as they specify limits for around 30 different product categories (and many sub-categories). However, this approach does become quite complicated as the specified levels often have to be varied at a product level (in an attempt to take into account different product designs and low power mode functionality). The evolution of products over time can make this approach a lot of work to keep up to date.

The approach adopted by Europe under their standby regulation is the first large scale attempt at a "horizontal approach" to cover standby requirements – just a few different power levels (by mode) are specified and these apply across the board to a large number of product types. While this is quite comprehensive, it does have some significant gaps, most notably equipment connected to networks (this is being addressed by the current Lot 26 study – see Fraunhofer 2010a). The requirement for energy management to move a product out of active mode into one of the specified low power modes from 2012 is also a very desirable requirement and arguably could be the major component of energy savings arising from this regulation, if implemented as intended.

A number of broad mechanisms within the horizontal approach were found as follows.

3.6.2 Product by product targets

This approach sets clear requirements for each product type. The requirements can take into account typical product designs and variations (functionality) and provide a basis for putting pressure on manufacturers to improve their products to meet the specified targets. Different targets can be set for different modes. However, there are several possible problems. The sheer number of products which have to be considered, classified, analysed, documented and targets set and maintained is daunting. As many as 100 different potential product types exist (nearly 200 are noted in Meier et al., 2008). The law of diminishing returns applies – for how many products (and what share of standby energy) do we set targets? This is a common approach for many standby programs, where the most obvious and prevalent products with significant standby are usually targeted.

3.6.3 Uniform targets for all products

Under this approach a flat target is set for all products irrespective of type or function. This is a product by product approach but with a single requirement. An example is the IEA-developed 1 watt aspirational target for standby power. This has been adopted in general terms by the US Presidential Executive Order 13221 (Bush, 2001) and in broad terms by the European Union in their standby regulation. Under these programs the maximum permitted power in standby mode is generally one watt, although there are usually some exceptions. This approach has simplicity as its key benefit. The uniform target is clear and it avoids the problem of product definitions and changes over time. The concept was that a standby power attributes of the order of 1 watt is small enough to be insignificant (although 30 products at 1 watt still equates to 250 kWh/year), so if a product meets the target, then it is deemed satisfactory. However, a uniform target (a one size fits all approach) does have some drawbacks. Such a target does not take into account how easy or how difficult it may be to achieve for particular product types – it is a fairly blunt instrument. For products with only a simple off mode with no intermediate states, a 1 watt target is very easy to meet. On the other hand, products or modes with displays, remote controls and communication or network functions are usually exempted from such requirements as 1 Watt is considered unrealistic; however, these are becoming more prevalent. Uniform targets tend to apply to only lower power modes and they tend not to deal with higher intermediate or secondary modes.

3.6.4 Horizontal functionality

This is where a maximum power level that potentially covers a wide range of product designs and product types is developed on the basis of the level of functionality offered by each individual product, potentially across the range of different low power modes that may be present. Conceptually, it is a system of providing a power budget or allowance for the provision of a specified level or type of functionality (or combination of functions) that are active in the product in the particular mode. This has been used for some of the Code of Conduct requirements in Europe (eg for complex set top boxes) and for some Energy Star specifications (e.g. imaging equipment).

3.6.5 Vertical approaches

Analysis of policies indicated that some countries applied a vertical approach to cover low power modes for products that used significant energy consumption and that were already regulated for energy consumption (most commonly major whitegoods, televisions, some heating and cooling products). Vertical requirements can be the basis for energy labelling as well as MEPS. This approach appears to ensure that product suppliers pay close attention to low power modes when they are designing products, which is desirable. For some air conditioners, non operating energy can be substantial and this appears to be a large hole that is not addressed by any program except in Australia. Vertical approaches were used for some products in Australia, Japan and the USA.

3.6.6 Mandatory versus voluntary

It was found that the most common program approach was to mandate requirements through legislative requirements. There are some notable exceptions to this approach:

- Energy Star – this is a voluntary endorsement program. However, it is a prerequisite for many government purchasing contracts in the USA (so there is significant market pull, at least in North America). Energy Star specifications are used in many countries as a base specification for purchasing contracts. Some countries are now using old (since revised) Energy Star specifications as a basis for national or regional mandatory requirements.
- European Codes of Conduct – these are also voluntary, but are only workable and effective where there is cohesion within the relevant industry associations and a high level of participation by market participants.
- Top Runner – on paper this is a voluntary scheme. However, the civil sanctions associated with non compliance are quite strong (fines and negative publicity) and the Japanese corporate approach to such matters means that the requirements generally have a high level of compliance (it is in effect quasi-mandatory).

3.6.7 Targeted products

Consumer electronics (focused around home entertainment equipment) appears to be the most popular product group to be covered by specific requirements (especially televisions and audio equipment). These products are ubiquitous and for the most part fairly simple in terms of the modes usually present (remote control is often the only function, sometimes with a display) so it is fairly easy to develop maximum power requirements in low power modes. Some countries (eg Canada and Japan) cover only a handful of products in this group. Other programs like in Korea and Europe are much more comprehensive and cover a wide range of product types in this category (and most other categories). While modes are generally clear today, these products are expected to rapidly gain digital network connectivity which will quickly complicate modes and power management.

A few countries include requirements for information technology equipment and equipment such as communications and office equipment, but the number of countries and the product coverage for these product groups is surprisingly limited. There appear to be some types of common products that are not covered by any programs. One of the most obvious issues is that many types of products are connected to networks and therefore include network related functions. Almost none of the current programs include requirements that can effectively cover these aspects of their operation, these products are either excluded from the program or requirements are only specified for low power modes (which may never be used in practice).

3.6.8 Other policy findings

Brazil appears to be the only country that uses comparative labelling for standby as a program tool. Many of the endorsement labelling programs (eg Energy Star) use power consumption in low power modes as a primary criterion for their schemes, but low power mode data is not shown on the labels.

For major appliances that are already regulated for energy consumption (in active mode), a vertical approach (combining low power mode energy consumption with active mode energy consumption) is used in some countries. This effectively allows the suppliers to balance and optimise costs associated with achieving low total energy across both active and low power modes. Australia seems to be the only country that includes the energy consumed in any non-operational mode for air conditioners (including heating functions of so called crank case heaters which operate when the product is not being used) into the vertical requirements for energy labelling and MEPS. The energy consumed by these heaters can be substantial (up to 200W in some cases) so they can impact on the overall energy consumption. However, strictly speaking these "heating" functions (when not operating) are neither standby nor low power (they are not providing the user with any tangible function – they are about protection of equipment – see EES (2008) for more technical details).

Some countries specify requirements for products that are rather specific to the regional or cultural requirements. For example, Japan has requirements for rice cookers and toilet seats: requirements for these products are of course warranted in that market, but as they are not widely used in other regions and are not likely to be globally adopted.

Detailed analysis also found that many countries had requirements for external power supplies which were broadly aligned with the international requirements originally developed by the USA, China and Australia. These include limits on the no load power consumption (which could be regarded as a relevant low power mode) as well as active mode efficiency requirements. However, it should be noted that most products that remain connected to an external power supply during normal use (including low power modes) will not be operating at the EPS "no load" condition that is specified in these requirements.

Almost none of the current program requirements deal in any great depth with equipment attached to networks where the network functions are active. However, there are several exceptions.

There is a suite of voluntary Codes of Conduct that are operated by the European Commission for broadband equipment, digital television equipment and data centres (European Commission 2998a, 2008b and 2010). The most common approach is to specify a functional allowance approach to setting limits for the specified equipment types. These requirements do not set explicit requirements for power management, although the limits implicitly require this in some cases.

Energy Star International has a number of specifications that deal with products that are connected to networks, most notably PCs and imaging equipment. These are mostly based on a functional allowance approach, which recognises the diversity of product design and functionality in this product group. These allowances imply significant internal energy management in order to meet the specified limits.

Japan sets out some Top Runner requirements for routers and switches, but these are essentially active mode ”efficiency” requirements (effectively a watts per megabit of data processed type specification). This specification does not deal with energy management or low power mode requirements.

3.7 Issues arising from analysis of policies

The clearest observation from the analysis of all standby policies and programs currently in force is that the range of products covered varies considerably at a country level and the technical requirements also vary considerably, both in the specific levels applied (where levels are set) or in the overall approach (eg levels versus a vertical approach, which combines low power modes with active modes in order to calculate a total unit energy consumption). This creates a fairly complicated patchwork of requirements for suppliers. It also means that some products have lots of different program requirements applied and some products have few or no requirements (even though these may be warranted). The current requirements can hardly be characterised as comprehensive.

While suppliers will generally offer no reaction where products are not subjected to regulatory requirements (where there are product gaps), where there are multiple conflicting requirements for the same product type in different regions, suppliers could legitimately express their unhappiness, especially for so called “global” consumer electronics which are designed for global markets.

The approach used in Korea is very comprehensive (in that the product range covered is large) but the complexity of requirements at a product level are likely to be hard work to keep up to date.

The approach used in Europe is also very comprehensive but in some areas is somewhat simplistic as it does not take into account different levels of functionality that may be present in some products. For example an off mode power consumption of 0.5W is fairly easy for all products while 1W for standby mode with any display could be challenging for complex products with many additional functions present. The current regulation does not appear to cover equipment connected to networks, but this is being addressed by the EuP Lot 26 study which is currently in progress.

The concept of mandatory power management in the European regulation is excellent, but it remains to be seen how effective the implementation of this requirement is in practice. As no quantitative requirements have been stated in the regulations, it is unclear how this will be enforced at a product level. Dealing with energy management in networks is considerably more complex and is one of the key areas of concern of this report.

Just about all of the existing programs have limited cover for network related functions. Some network equipment is covered, but in modes of little relevance (eg low power modes which are rarely used). The Codes of Conduct in Europe and some

Energy Star specifications use a functional adder approach, which seems to be highly workable for more complex products. But these do not seem to always explicitly deal with the issue of power management (in active mode or into low power modes), which needs careful considered.

One of the key problems facing all program approaches is to ensure that the modes that are commonly used are covered by specifications. There is little impact from specifying limits for particular low power modes if the products spend little or no time in these modes during normal use. This is particularly complex as many products have software settings that can change the functionality (and power consumption) of products in low power modes. To some extent this is also relevant to power management – how quickly can products enter lower power modes (and maintain functionality) and how quickly can they reactivate their primary function when required. The issue of product usability is discussed in more detail in Annex B.

One of the dangers of setting a maximum power level for low power modes is that there may be a temptation for manufacturers to avoid or circumvent the requirements (in practice, if not on paper) through gaming or adjustment of modes. For example, a manufacturer may provide a product mode that has very low standby power attributes which meets a specified target but in reality this mode is difficult or inconvenient for the consumer to activate (or there are negative consequences such as loss of presets or clock settings, slow startup etc.). Another variant of this type of circumvention of requirements is to remove low power modes from the product design so that the product remains in “on mode” or in some higher mode which is not covered by a target. This of course results in a highly negative outcome and policy makers need to remain vigilant to ensure that such perverse outcomes are not occurring as a result of new policy measures.

One of the interesting policy questions to be considered is whether products that are covered by vertical requirements should also be subjected to so called “horizontal” requirements, where limits on low power modes are independently set. It can be argued that once a product is covered by a vertical requirement, then additional horizontal requirements for the same product are not warranted and it could force a supplier to adopt a design which may not be the optimal balance between active and low power modes. However, it is true that horizontal requirements can provide an additional level of protection of energy savings in a few cases where high power designs remain on the market (in the short term). It is also true that there are few product design requirements where the design of the low power mode functions affects the active mode power/energy (an exception may be the crank case heater case for air conditioners mentioned previously, but even that effect is quite indirect). So the interaction between vertical and horizontal approaches would appear to be an issue that needs to considered and resolved within each country or at a regional level. As discussed in Section 8.6, independent application of horizontal requirements with existing active mode efficiency can provide a workable policy solution.

Most of the program measures reviewed concentrate on low power modes rather than active modes (a notable exception is Japan). This is understandable, as policy to address “excessive standby power” should naturally focus on low power modes and not active modes. Apart from the European standby regulation, few specifications appear to explicitly require power management within active modes (scaling power to suit load or capacity requirements) or moving products into low power modes when primary functions in active mode are not required (although these are implied in some Energy Star requirements). Scaling power within active mode is particularly important in networks (and especially for network equipment) as for much of the time network traffic can be at low levels. Moving out of active mode into low power modes is particularly important for edge devices that are connected to a network (while maintaining the required functionality by the user and network).

3.8 Conclusions from the analysis of policies

The policy instruments adopted at a country level vary, but the approaches to establishing criteria to date fall into several main categories as follows (which can generally be voluntary or mandatory):

- Limits: set maximum permitted targets at a product by product level for several specific modes;
- Horizontal: set maximum permitted targets for a large general pool of products for a few general modes;
- Vertical: integrate relevant low power mode energy into the total energy consumption for the product.

While each of these approaches has merit, they also have problems and limitations. It is fairly clear that, while the vertical approach is of value for selected products, this program option has a fairly limited scope and could only realistically be expected to deal with a small proportion of products of interest (i.e. those with large active mode energy consumption which are already regulated). Even under an aggressive or optimistic scenario, vertical measures could only address at most 20% of all low power mode energy. So while it is a useful tool to have in the policy toolbox, it is by no means a panacea for the problem.

It appears that cover of current programs to address standby power is incomplete at a product level. Therefore the cover at a country and regional level is very patchy and incomplete.

Some products are regulated in many different ways by different countries while other products appear to have no requirements in any country.

There are some significant gaps in program approaches, most significantly for products attached to networks and network equipment.

The issue of energy management is only explicitly addressed in the European standby regulation and this would appear to be a critical element of any integrated specification to address low power modes and minimise overall product energy consumption.

Irrespective of whether a horizontal or vertical approach is used to address low power modes, care is required to ensure that all relevant product modes are covered.

The main policy approaches used to date have some advantages but they also have some limitations. Is it possible to develop a new approach that is somehow more flexible yet deals with the shortcomings of the existing systems? The main issues that need to be addressed with such an approach appear to be:

- Continual changes in product definitions, splitting and merging of traditional product types, new products types appearing (these make product by product approaches very difficult to maintain);
- Differences in product features and functionality – differences between similar product types and differences in the same products over time (these make broad ranging horizontal requirements difficult to implement and potentially unfair – possibly too strict or too lenient);
- A range of relevant modes of interest (rarely a single mode, or the lowest mode only, is of interest);
- Setting technically advanced but achievable targets at a product level.

Options for achieving these objectives are explored later in this report.

4. Key concepts used in this report

The concept of products, functions and modes are important elements in any product policy. This section sets out concise definitions for each of these elements. These terms form the building blocks that are used in later sections for policy approaches and proposals with respect to networks. More details and background with respect to these terms (and related issues) can be found in Annex D.

It is important to note that the terms discussed in this section mostly included in the forthcoming IEC62301 Edition 2. It is important that fundamental nomenclature of this type be formally documented in an accessible document such as a standard or technical specification. IEC62301 has been written by energy experts so, at this stage, it is suitable for reference in energy policies. Additional terminology for testing of products with network connections or complex products with multiple functions may need to be developed and placed into related testing documents. In the longer term, it is important that a repository for critical definitions like these be developed and maintained. Such a repository is an essential resource for governments and regulators and should be kept up to date and relevant in a way that facilitates current and future energy policy development. Unfortunately, poor definitions can thwart the development of effective energy policies. Care is also required to avoid "locking up" key regulatory definitions in international standards that can take 5 years to modify, even where there is consensus.

4.1 What is a product?

For this report, a product is a stand-alone appliance or piece of equipment that is AC mains powered (or DC powered) and performs one or more primary functions (primary functions in case are what we normally think of as "energy services" or useful outputs from the product). Products can also be supplied from another product with mains power (or with DC power although the approaches to deal with these types of products are less well developed).

Products that are battery powered can fall within the scope of this definition if they spend at least some of their life being charged via a mains powered connection (eg mobile phones and notebook computers). Further discussion regarding product definitions are included in Annex D.

4.2 What is a function?

According to IEC 62301 Edition 2 (CDV), a function is:

a predetermined operation undertaken by the energy using product. Functions may be controlled by an interaction of the user, of other technical systems, of the system itself, from measurable inputs from the environment and/or time

In broad terms, functions are spilt into primary functions (which encompass the intended purpose or use of the product – the main energy service the product provides for you) and secondary functions (which are all other functions which can enhance the primary function or can assist with the use and operation of the product). There may be several primary functions in a product (although often there is only one) and there are usually many secondary functions (some of which may not be apparent to the user, or sometimes no secondary functions).

Examples of primary functions are washing clothes for a clothes washer, display of a picture with sound for a television, undertaking calculations and running programs on a computer.

4.3 What is a mode?

A mode is essentially just a collection of functions – these may be primary and/or secondary functions.

In many cases, products have secondary functions which are present some or all of the time (and may or may not be related to the operation of primary functions). In most cases secondary functions enhance the performance of the product in some way. Secondary functions can include remote controls, timers, memory related functions, safety related functions and sensing functions. In most products, network functions are a secondary function (but a very important one). For network equipment (eg switches, routers, and modems), network related functions are the primary function. Modes can be broadly categorised into active modes, low power modes and disconnected (from mains power, but it may still be connected to a network via use of battery power). These mode categories are discussed in more detail in Annex D. For the purposes of this report, *network mode* means any mode (active or low power) where there is a network function is present and operating.

4.4 Product modes

A product mode is essentially a list of all the functions that are actually present and activated in a particular state on a product. For simple products, there may be only one or two modes. For complex products, there may be many possible modes (some which can be altered through software and user settings), although in practical terms, there is usually a finite number of possible combinations of functions (as not all possible functions can be controlled/activated individually by the user).

The important point is that product modes, even within the broad mode categories for lower power modes, vary somewhat at a product level, depending on the design and configuration. Such variation occurs both within a single product type (eg PC or TV) as well as across product types. This is a fundamental problem when modes are used to set power limits in regulations, as what may be defined as the "same mode" in two different products (even of the same type) may in fact have different sets of functions present and therefore different fundamental power levels. This is particularly critical for many products that have network related functions.

4.5 Categorising functions

Recent years have seen an increasing interest in disaggregating low-power modes into listings of “functions” present in any particular product mode, as a way of defining and evaluating their energy performance. Collections of functions have been previously listed in the EuP Lot 6 study (Fraunhofer 2006), in the revision of IEC62301 (Edition 2 2010), in the EU Codes of Conduct on Broadband Equipment and Set-top Boxes (European Commission 2008a and 2008b), as well as in several Energy Star specifications (imaging equipment, computers, and set-top boxes).

As noted above, ultimately a mode is just a collection of functions.

It is desirable to have a list of functions (and their definitions) that span all product categories and that can be applied globally, as this is likely to form the basis of all future approaches to developing policies to minimise power requirements for these functions (in low power modes). Harmonization of any limits on power levels associated with these functions is ultimately desirable, but this may well vary across products and will definitely vary with time as functions evolve and technology allows them to become more efficient (rather use less power).

While there are a large number of possible functions that can be present in products, these can be grouped into a finite number of types or categories. Functions can be broadly grouped as follows:

- Communication – between devices (products)
- Communication – with people and the environment (can be collection of data and inputs or provision of data and outputs, or both)
- Power related
- Time related
- Other

These are described in some detail in Annex D. These are assumed to be classified as secondary functions in most cases for the purposes of this discussion, although many are critical to ensure the correct operation of products and to make products usable and useful.

The concept here is that the functionality of products while in low-power modes can be described by collections of discrete “functions”, and that these functions are finite in number and fall into a number of categories. Much like the concept of molecules in chemistry, a product mode can be unambiguously described by its functional components (which are like elements). In addition to these categories, there are other ways to group or classify similar functions, such as the amount of power typically involved in the function (there is usually a big difference between the “typical” power used by a function and the technical minimum required to provide that function). Having functions as the basic unit of analysis in this area is an alternative to having named modes at the core (which can prove to be impractical for complex products).

Functions present in products can be pictorially set out as shown in Figure 1.

Figure 1: Periodic table of functions

Communication - devices	Communication - people and environment	Time	Power	Memory	Other
Remote power	Temperature sensor	Timer	EMC filter	Volatile memory	Quick wake
Remote other	Light sensor	Clock	Surge protection	Non-vol. memory	
Data	Audio sensor	Schedule	Not Charging		
Network	Motion sensor		Charging		
	Pressure sensor		Powering		
	Fluid/gas sensor				
	Audio display			Color Code	Category
	Tactile display				Low power
	Visual display				Medium power
	Power indicator				?
	User input device				High power

Source: Lawrence Berkeley National Laboratory

4.6 Naming of modes

For an energy regulation, modes have traditionally been defined, but this is accompanied by a test procedure that specifies how to get to that mode in a laboratory. Functions might be specified as being required by the procedure or specification, might be universal for that mode/product type, or might be present on some models of the device but not others. The mode name will usually correspond to the expected functions of that mode, but additional "bonus" functions might put the device into a different named mode from the one anticipated. For example, a test procedure might instruct the tester to put the device into a "standby" mode, but a product might have a network connection that is always on when the device is powered, so that it stays in a network mode, not standby.

As the number of functions present on devices in low power modes rises, and as the number of possible functions that are present in a particular mode is increasingly dependent on configuration (by the user), the number of potentially unique modes that a device may have becomes increasingly large. What we find is that universal horizontal mode naming with specific meaning has become almost impossible in many cases for some product types. The process of steadily increasing the number of named modes will eventually halt as the number of possible modes will become too large to be readily (and correctly) understood by technical people or by the average consumer. It is arguable that we have already reached that point.

What has been successful is general mode categories (“buckets”) that cover many modes and make no attempt to have highly specific meaning (as in Edition 2 of IEC 62301). The dividing lines between these buckets can be product-specific. The most common categories here are On, Sleep, and Off (eg a PC), and for some other products On, Ready, and Off (eg microwave oven). Some products are still just On or Off. In this context, “standby” is a synonym for a “low power mode” and refers to the general topic area, not a specific mode. A product may in fact have several off modes and/or several standby modes (ie broad fall into the mode category but with different functions active). This is particularly important in networks as some products like computers can have multiple network connection options and the ones that are active depends on the network context in which it operates.

Product experts and standards committees can (do and should) designate product-specific modes in the context of the product and its typical use. Modes defined in test procedures and regulations should be specified in terms of their functions; the actual mode names used are less important.

4.7 Modes and energy efficiency

The issue of energy efficiency is well understood in broad terms – this is the level of energy service that you get out of a product for a particular amount of energy input. For a clothes washer, for example, the measure of energy efficiency is the kg of clothes washed for the amount of energy required to achieve this output. Measuring the energy input is usually straightforward. There can be many complex issues surrounding the definition of energy service or outputs of products – in the case of a clothes washer, the energy service of “clean clothes” has multiple possible measures to assess the level and quality of service provided such as soil removal, remaining moisture, retained detergent (rinse performance) and so on (and some of these can be subjective in terms of acceptability). Other examples of energy efficiency are for an air conditioner, the amount of heating or cooling produced for a given energy input and, for an electric motor, the amount of shaft power that can be delivered for a given energy input.

In broad terms, the efficiency of many products performing their primary function (active mode) is dictated to some extent by the laws of physics. This is the main focus of energy efficiency policy – to make these primary functions as efficient as possible. In contrast, many electronic products have “information” as their primary function, which is not tied to physics in the way that other end uses of energy are: in addition they often have multiple primary functions, so that the efficiency paradigm works only imperfectly, or not at all, for these types of devices.

In contrast, it is hard to measure the “technical efficiency” of many secondary functions. Many of these functions require a certain amount of power to remain active, even through their usage may be quite irregular and infrequent. For example, a remote control on a television requires some energy to ensure that the sensor on the television is activated so that it can see the remote control signal when sent, but this may only occur for a few seconds each day. The circuit has to remain powered all the time. How is the efficiency measured in this case? In such cases it makes more sense to define power limits with respect to capability, not as a function of the work performed (which is effectively zero).

This also applies to some extent to many network functions. The majority of the power requirement to maintain the connection of a network interface is fixed, with only a modest amount of marginal power used to send and receive data under normal circumstances (to some extent this depends on a number of network layers – see Section 5). So the energy consumption associated with network functions is usually dictated less by the volume of data (usage related parameters) and more by the internal rules about how the network operates, the configuration of the network interface and underlying specific technologies in use.

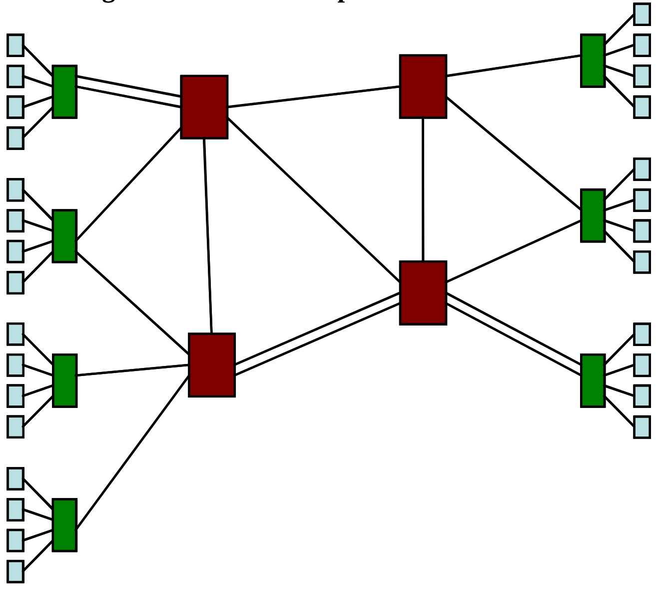
A related problem is how power is supplied to those functions that are present in low power modes. In the case of a television, for example, infrared remote control sensors are available that require only a few milliwatts to operate. While some product designs have achieved standby power levels this low, most products have much higher standby power levels. Actual products vary from as much as 30W to as little as 0.01W, which is clearly more an issue of design and application rather than the underlying technical requirement. High power usage in many cases is because low power components are not used and also because the infrared sensor is supplied by a single larger internal power supply, which is sized for much higher active mode power levels. Achieving low power levels for small loads like this requires the use of separate dedicated high efficiency small power supplies, which has been resisted by many product designers. While this is not really a core issue for this report, it does illustrate that low energy product designs and configurations are possible and need to be encouraged – this is especially important if considering allowance or power budgets for various functions. The issue of power supply design and product configuration is discussed in more detail in Annex H.

5. Networks and energy

5.1 Network definition

A network is infrastructure that enables arbitrary connection between nodes, regardless of the topology of the links that make it up. In most cases, a product connected to a network will have one interface, although some types of equipment can have several network interfaces (e.g. servers, network equipment such as switches and routers, notebook computers). Networks may be local (e.g. within a building), or global (e.g. the Internet). This report is nominally about products that include some form of network technology, but our practical scope is all communications technologies. The broader scope also includes digital data links, as well as analogue connections. We first review these other mechanisms, to put them into the network context. Figure 2 shows a sample network topology. Any node on the network can communicate with any other node, through the same mechanisms. Data links only provide communication from one device, to another adjacent device through a dedicated connection. Nevertheless, these are an important case within the scope of networks in general.

Figure 2: Schematic representation of a network



Source: Lawrence Berkeley National Laboratory. In this illustration, blue nodes are edge devices connected to a network, while green and red nodes are network equipment. Packets of data are transmitted between edge devices by network equipment. The exact path used to transmit each packet can change dynamically.

The reason for considering all "communications" is that non-network technologies affect energy use in the two principal ways that networks do; that is, they increase power levels in many modes (including low-power modes), and change the time spent in various modes. The policies that we might design only for network connectivity will for the most part also be the best ones for other communications (for the most part this is data links such as USB, Infrared, HDMI, DVI, etc).

In this report we use the term “network” strictly for Internet Protocol connectivity across links designed primarily for that connectivity (a fine point, but it is possible to “tunnel” IP packets over a data link not designed for IP connectivity, but this is a small part of how these links are normally used).

5.2 Main functions within a network

There are a number of basic functions that a network connection is usually required to perform:

- Establishing a network link
- Maintaining a network link
- Establishing a network connection
- Maintaining network presence
- Ordinary data transmission (includes AV and other data streams).

For our purposes, we can divide network functions into three broad groups:

- Maintaining a link (data or network)
- Maintaining a network connection or network presence
- Maintaining a network application.

These are ordered, in that each bullet relies on the bullets above it. Searching for a network and establishing a connection to a network is required when a product is first switched on (or wakes up) and is quite important in wireless systems, as the available networks can change over time (or disappear or reappear) as the product may be physically moved by the user from time to time (wired network access points for most edge devices tend to be stationary).

The power required in a low power mode will increase as one increases the level of functionality (as layers are added). For example, maintaining functionality at the application level requires more power than simply maintaining a link.

For most products, establishing the connection only occurs when the device is active, so that low power modes only need to maintain it.

5.3 Link types

A link is an electronic medium between two devices. There are essentially 3 different types of links between products – analogue links, data links (dedicated connections between two products) and network links (multi node).

5.3.1 Analogue links

For decades, electronic communications was defined by analogue (non-digital) communications, most notably, the old landline (PSTN) telephone system. Other examples are audio connections between electronic devices (even an iPod uses an analogue link to communicate to the earphone, which is part of the iPod, not a separate product), and many video connection technologies still predominant in audio visual equipment such as televisions and videos (component, composite, etc.). Some building controls are also analogue (eg temperature controls or thermostats).

Analogue connections are diminishing as a determinant of energy use, but will still be around for many years and so must be considered in any approach to networks. Analogue connections are usually uni-directional, but can be bi-directional in special cases.

5.3.2 Data links

Data links enable digital communications, but only between limited sets of nodes (usually just two, at the ends of a single wire or cable) and are often limited to only certain types of information. Data links are common, as with USB links from a computer to peripherals, cordless phones to their base station (not strictly a network connection), the VESA link from a computer to an attached monitor, and an HDMI links from an AV source to a TV. Some data links are within a product, while others are between products.

While most data links enable two-way communication, there is a special case of links that provide communications in only one direction. Examples are the IR link from a remote control to a TV, and some broadcast signals that indicate time, operational commands, software upgrades or information (such as electronic programming guides for digital televisions). The requirements for one-way links are distinct from those with two-way communications (the device sending the information has no way of telling how many end use devices are receiving and using the broadcast data, or whether they are received at all). Most digital broadcast media (television and radio) also fall into this category, but this is not usually considered to be a network.

5.3.3 Network links

Digital networks are built from collections of network links, which are essentially just data links organised into larger groups. The key is that the devices at each end of each link uses protocols to enable communication not just across that link, but across the whole network. Lower layers of functionality enable higher layers to communicate transparently across many links to the destination device.

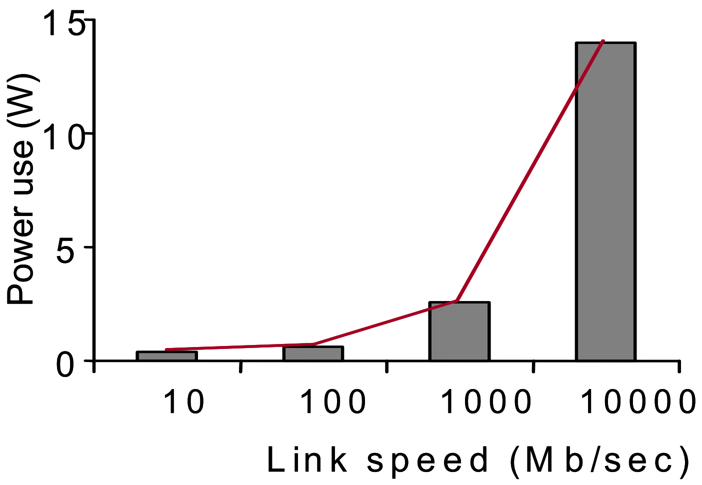
The much greater capability of networks (compared to data links) make them more useful and pervasive, as well as important for energy. That said, data links have some advantages and will be with us for the foreseeable future. Even analogue links will be around for a long time, since some components (e.g. speakers) can be powered from the power on the link alone, not requiring an external power source.

5.4 Link Characteristics

Another distinguishing aspect of a digital network link or connection is the capacity or bandwidth – the amount of data that can be transferred across the network, usually measured in bits of data per second (bps). This can be expressed as raw data capacity available over each link, or the actual capacity available to an ultimate application (some of the maximum possible bandwidth is consumed as overhead). To some extent, the available bandwidth is (or should be) driven by the bandwidth required by the application that is using the network connection. Bandwidth can be classified roughly into low speed (less 1Mbps), medium (1-100 Mbps) and fast (>100 Mbps).

For most technologies, once a network link is established, it will operate at the connection speed until it is disconnected. This is a significant issue with respect to energy consumption of network related functions, as in general terms the connection speed dictates the power consumption of the link – the majority of energy is used to maintain the link while the marginal energy consumption to transmit each additional packet of data is small or close to zero.

Figure 3: Relationship between link speed and link power

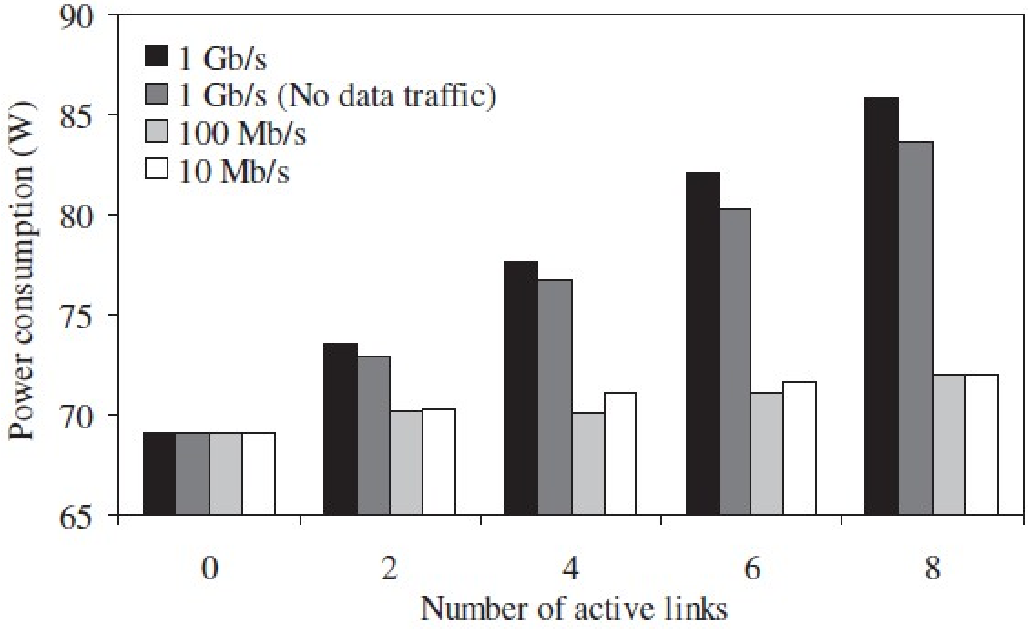


Source: Nordman, 2007

With today's technology, it is usually a given that "speed costs power". That is, the higher the basic data rate of transmission across a link (data or network), the more power it requires to drive the physical bits, as well as to prepare them on the transmission side, and receive and interpret them on the reception side. This is due to both the hardware directly associated with the network "physical layer" as well as other parts of the system (processors, memory, busses, etc.) that are involved. This is true of both network equipment and edge devices.

For a wired connection using the Ethernet protocol (IEEE 802.3), the power consumed by the link increases exponentially with link speed. This is illustrated in Figure 3 for a network card and in Figure 4 for the example of a LAN switch. The link power remains fairly constant, irrespective of whether it is operating at full bandwidth or is idle (i.e. the marginal power per bit transmitted is quite low relative to the fixed power required to maintain the link). Remedying this limitation is the goal of Energy Efficient Ethernet (IEEE 802.3az) which will dramatically reduce the fixed energy 'cost' of a link and makes the majority of the energy use proportional to the amount of data being transmitted across the link (see Section 6.3 for details).

Figure 4: Power consumed by a LAN switch for various connections



Source: Gunaratne et al, 2005

With attention to this issue and by using newly developed protocols, this problem can be significantly mitigated. Energy Efficient Ethernet (IEEE P802.3az) is an example, in which the ability to put the link into a sleep mode during times of non-use can significantly reduce power, and so long as the balance of the system can do the same, the energy 'cost' of speed can be significantly reduced or even eliminated. Some of the same concepts are employed in WiFi, to enable transmitters and receivers to negotiate link speed during times of no or low communication. There is always some cost in latency in these approaches, but with knowledge of the application involved, these can be kept well within acceptable limits.

This does raise the possibility that many products allow for or require higher network speeds than are really needed for their use (at any particular point in time). Policy needs to be attentive to how much this is happening, and respond appropriately.

There are physical limits on the maximum speed possible for links (eg USB 1.x has a technical limit of 10 Mbps, USB 2.x a limit of 480 Mbps, IEEE 802.11b wireless has a limit of 10Mbps and so on). As illustrated above, the speed of connection can also affect the energy consumption. Most network connections have a symmetrical data rate for sending and receiving. However, some special types of equipment such as ADSL modems (Asymmetric Digital Subscriber Links) are often configured to download at much faster rates than they are for upload (on the basis that users tend to download much more data to their computer than they upload or send out).

5.5 OSI layers

Modern digital networks are based on the OSI Model ("Open System Interconnection Reference Model") that describes seven "layers" of functionality. The layering enables a change in the implementation of a layer while (usually) only affecting the immediately adjacent layers. This provides for easy technology advancement, interoperability, and ensures that application protocols are independent of physical layer transmission mechanisms and vice-versa. Layers are important for energy as the complexity and capability required of a device on a network depends on the layers that it implements. In the short term, this means that energy allowances for network functionality need to be aware of network needs, including layers and protocols supported. In the long term, we should expect that network technology will become aware of the energy consequences of network architecture, and take this into account in different layers. While the OSI model has seven layers, a common simplification reduces this to five groups: physical (layer 1), data link (layer 2), network (layer 3), transport (layer 4), and application (layers 5-7). Formal OSI layers numbers are:

1. Physical
2. Data link
3. Network
4. Transport
5. Application (Session)
6. Application (Presentation)
7. Application

Any network begins with its physical layer, which specifies how arbitrary information is encoded in the physical world, usually as electromagnetic waves or photons. The link layer moves data from one device on the network to the next one. The network layer moves data across potentially many links (eg from one node on the Internet to one that might be on a different continent). The transport layer provides order and reliability to data movement. Finally, the application layers accomplish the actual service desired (e.g. web browsing, email, phone calls, etc.).

The reason why such layering matters for energy is that the amount of computation (and hence number of transistors and hence the power) to implement additional layers rises as you go "up the stack" (to higher layers).

The point of layers is to isolate details of functionality so that only adjacent layers need to know about them, and other layers are indifferent. This greatly increases interoperability, scaling and evolution of physical layers, reliability, and ultimately simplicity (compared to alternatives). We have a "narrow waist" at layers 3/4 with universal protocols, with diverse and evolving physical layers below, and diverse and evolving application layers above.

The user interface is not formally considered an OSI layer, though often referred to as the "8th layer". It is important nonetheless for energy saving to ensure that devices are interoperable with people, so that users of a device can best understand what it is doing and instruct it to meet their needs but no more.

Policies will usually target individual layers, but it is occasionally necessary (but not desirable) to address groups of layers. Energy policy in some cases affects layers 1 & 2, and in other cases just layer 5.

More details on the OSI layers are set out in Annex F.

5.6 Network architecture

A network is composed of two types of devices: edge devices (eg computers, servers, TVs, printers) and network equipment (which forms data links between a range of nodes). The edge devices usually connect only to pieces of network equipment, though some technologies allow them to talk directly to each other. The edge devices are those that provide us with useful services. Network equipment are devices whose primary or only function is to route or process network traffic between edge devices (today generally using Internet Protocol (IP) packets). Examples of network equipment are switches, routers, wireless access points, modems, and network security devices.

5.7 Measuring network modes

While most functions are either present or not in a mode, for network connections the situation is more complex. There are three levels of "presence" that can be distinguished:

- the function exists (but is unavailable as configured)
- the function is available (but not active)
- the function is active

The following possible states need to be recognised when testing a product for energy:

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

- Absent (wired) – network interface is activated but there is no network connected to the product
- Absent (wireless) – network interface is activated but there is no network connected to the product (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 (eg Wake on LAN).

The different states of network interfaces that need to be considered during testing are discussed in more detail in Annex C (testing issues).

6. Technical options for power management and power reductions in networks

6.1 Introduction

This section sets out a range of technical options to reduce power consumption of products in networks through power management and other approaches. The main areas considered are:

- Reducing power required for network links (and network functions)
- Energy management - changing power state of the product (mode) without cooperation of the network
- Energy management - changing power state of the product (mode) in coordination with the network
- Energy management - scaling internal power in proportion task requirements or throughput
- Reducing services delivered by the product
- Other possible options.

These are discussed in more detail in the following sections. It is possible to use combinations of these approaches in the same product at the same time. In fact, implementing many of these in parallel will maximise energy saving potential. Energy policy needs to ensure that devices are encouraged to contain these innovations wherever applicable. This means that benefits must be reflected in the relevant test procedures and any technical requirements.

6.2 Product usability

Before considering how products can reduce their energy consumption through energy management and other approaches, it is useful to consider the issue of product usability. From a high level perspective, the primary objective of energy efficiency policy is to minimise the total energy consumption of products while delivering adequate (or the required minimum) energy service required of them.

When considering the effects of power management on a product's energy consumption, it is important to understand how this may affect the usability of the product (does the product still provide adequate energy service?) — how does the user perceive changes in performance introduced by power management. A key issue is latency.

In simple terms, latency is the time that it takes for a product to start up and be ready for use, or the time that a product takes to change state (or mode) and respond to a user request to provide a certain function. It can also be defined as the delay time "beyond what is considered to be a reasonable delay" from the users perspective. What is acceptable depends on the product and the user context.

Latency is quite critical as it affects the usability of the product. For some products, users expect some start-up time and this is considered normal and acceptable. For some types of products, very low latency is essential to ensure usability of a product. The most obvious example is equipment used for voice telecommunications — in these cases the system has to be available for use when required almost instantly (within a second or so) and the time delay during use has to be close to zero. Failure to deliver this consistently renders the system unusable.

Latency is usually a function of the product design. The startup time from a low power mode is usually determined by the product hardware and software. Of most interest here is the latency associated with intermediate power modes which are present and activated regularly as a result of power management strategies. To some extent, the presence and operation of network functions may have some affect on the latency between modes. However, more often the requirements of a network may require product latency to be relatively short in order to maintain network functions (these requirements may restrict the "depth" of a sleep mode in order to achieve short reactivation times). In many cases the latency of the product is not affected by network considerations. The issue of product usability and latency are explored in some detail in Annex B. It is important to consider product usability and latency in the context of power management and energy saving options outlined in this section.

6.3 Reducing power required for network links

This section outlines options to reduce the power associated with maintaining relevant network functions in a product.

From the general description of a network in section 5, the first building block is data links between pairs of devices (for wireless connections, there can be broadcasts to all links simultaneously, but conceptually the connection to each device is a separate link). The power required to maintain a link is a function of the physical layer technology used (e.g. Ethernet, WiFi, Zigbee, Zwave, etc). Some of these have always had features to enable energy savings, and others are having them added. When devices are in a low power state (and for much of the time when they are in an active state), the amount of data being communicated is usually small compared to the capacity of the link, so providing mechanisms to save energy during periods of low utilization (data throughput) is critical. The primary methods to do this are to reduce the data carrying capacity of the link, and to introduce some latency. Both strategies can be used together.

The choice of how to accomplish the power saving is specific to each physical layer, as what is possible and worth doing is dependent on the physics of the technology, with consideration of the typical applications and what they can use or tolerate.

The immediate target of interest within this approach is the power required for the network interface hardware of the device (often a separate integrated circuit, but sometimes part of a larger chip that performs other functions as well). However, knowledge about speed and latency from the link can be used in some systems to enable savings in other parts of the system, by reducing clock rates, memory buffer sizes, or putting circuitry to sleep. Related to this, it is possible to throttle data rates or introduce latency on the link even if the link is operated in its basic configuration, but this can enable other hardware to save power.

Other approaches are to detect the distance the network link travels, and when it is substantially below the technology's rated distance, reduce transmission power.

Most network technologies enable "full-duplex" connectivity, in which data can be transmitted simultaneously in both directions. Reducing this to "half-duplex" in which the directions alternate with only one active at a time can be used to save power.

Most of these technologies require compliant hardware and software to be installed at both ends of the relevant link before energy savings can be achieved.

Examples of reducing link power are: Energy Efficient Ethernet (IEEE 802.3az), various WiFi features, ADSL2+, and the recently announced MOCA 2.0 and Bluetooth 4.0.

Amazingly, it is not yet known how much energy is consumed by network interface hardware globally, or in any country. Thus, one of the projects recommended by this study is to do such an assessment. While power requirements for any given network technology generally decline over time, it is also usual for speeds, operating hours, and total number of network links to rise, which both increase energy use. So, we can expect "link energy" to rise in the coming years, making this a continuing important topic to address. Another aspect to such a study could be to determine the penetration of the established technologies to reduce link power and examine options for their more rapid deployment within existing systems (where possible).

6.4 Changing product power state without cooperation of the network

This section outlines options to reduce energy consumption by changing the product into a lower power mode while maintaining normal network functions and presence in that low power mode.

The power used by a device is determined by its operating mode (and the functions being performed) — for example, on, sleep, standby or off — with smaller power differences within each operating mode depending on task activity and operational status. So, the largest source of energy savings available today is in ensuring that devices that are fully on but are not needed enter some sort of lower power state or sleep during such times. Key examples of this are PCs, set-top boxes, and game consoles; as more devices become "PC-like", the number of product types and total products in this category is likely to rise substantially.

One problem with these devices is that other devices often expect them to have continuous "presence" on the network, even during extended time periods (many minutes, hours, or even days) when there is no substantial activity required of the device. As noted in section 5.5, there are three basic layers to connectivity to the network for energy purposes. Today, some devices (eg PCs) can maintain the first level of network connectivity while asleep (or even off), but require the network generally and any application to know that they are asleep - so the network must be configured to act very differently if this is to work in practice. Internet networks and the vast majority of applications do not have the concept of a device being asleep in their design, so this approach has only limited utility and applicability and is unlikely to be of much value for general-purpose devices like PCs.

An alternative is to actively hide the fact that a device is asleep from the rest of the network and so be able to go to sleep without sacrificing connectivity to the network. The basic way to accomplish this is called "proxying", and there are a variety of technologies and products that do this for PCs and servers, some being internal to the device going to sleep, and others using another device on the local network to provide the proxying function for the device when it has gone to sleep.

Examples include the ECMA International standard on proxying ("ProxZzzy", Ecma-393), the "sleep proxy" function from Apple, Inc., the Sleep Server from UCSD, as well as various products for servers.

The technology options in the following section, where the network is actively involved in coordinating the power state of product on the network, requires that networks, protocols, and applications be aware of the power state of the product and act accordingly. In the long run, many devices will use some of each approach so they are not mutually exclusive. In the short run, it is difficult or impossible to change many protocols and applications, which makes the "hiding" approach particularly attractive. While proxying allows energy saving to occur in devices within networks as they exist today, some elements are somewhat contrived so the existing specifications are not as robust or universal as we might wish them to be in a perfect world.

6.5 Changing product power state in coordination with the network

This section outlines options to reduce energy consumption by changing the product into a lower power mode while indicating to the network that the product is in a low power mode.

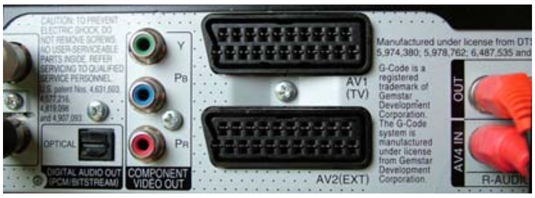
The core of this method to reduce energy use in a network context is to actively "expose" the device's power and functional state to the rest of the network so that protocols and applications can take it into account in helping to minimize energy use by allowing other devices to power down when not required. This is particularly attractive where one core device (eg computer or television) is linked to a number of others that principally or only serve the core device – the peripheral devices can go to sleep when the core device is not active or not being used.

A simple example of the successful implementation of this type of strategy is contemporary PCs and monitors. When a PC goes to sleep (or simply wants its display to go to sleep), it puts signals on the data link to the monitor indicating that fact – or simply drops the video link entirely. The monitor knows the PC is asleep (or is not providing data) so that it can put itself to sleep and save power. When the PC wakes (or wants to wake the display), it re-establishes an ordinary data link to the monitor causing the monitor to wake and resume active displaying. The PC can also detect the lack of a monitor being on at all, and so not bother sending it data if it knows the monitor is not “there”. In this case, the technology standards (specifically DPMS from VESA, and similar ones in other display connection standards) already exist to accomplish this outcome. This type of protocol is already widely used in computers and the energy savings are significant. This type of approach is fairly simple to implement for a data link between two devices, but often needs to be explicitly part of the technology standard to be acceptable for use in a range of products.

Another example is Wake On LAN (WOL). This is a capability of nearly all PCs that, when enabled, keeps the network link alive, but with no active participation on the link by the PC. Other devices on the local network can send a special packet (a so called “Magic Packet”) to wake up the system (or even turn it on from off if that is enabled), or in other cases, have it wake on certain types of “directed packets”. This usually requires other devices on the network to have advance knowledge that the device is asleep using the WOL protocol and so for it to be effective, these devices have to act differently based on this knowledge.

Probably the most important example of exposing power state — one not yet widely realized — is a more universal power control of devices like computers and audio/video equipment. Most televisions have a constellation of other devices connected to them such as DVD players, set-top boxes, digital video recorders, and audio amplifiers. In future, we are likely to see even more, such as security cameras, Internet servers, PCs, and remote speakers, visual displays and IP TV. At present, most of these devices need to be manually powered up by the user (with their own remote control) before use, and manually powered down afterwards. Often, the devices other than the TV, are in a cabinet or closet, not immediately visible, making it unobvious to the user that the device is on but not needed, and making it cumbersome to turn it on when it is needed. When one combines this with the fact that many people who use the TV and related systems are not the person who installed it and fully understands it, it is very easy for many of these devices to be remain on much of the time when they are not needed.

The ideal solution to all this is to limit the need to manually power a device up and down and link the power state of peripheral devices automatically to the TV display state — that is, have them wake up when they are needed, and go to sleep whenever they can. For example, if a DVD player is operating but the TV to which it is connected is powered down, it can stop sending the image to the TV and power itself down. Similarly, if the DVD is paused and the TV shifted to watching a different source (e.g. broadcast TV), then after a decent interval the DVD player should go to sleep (remembering the location of the pause for when it later wakes). When a TV is turned on, and the source is switched to the DVD player, this should cause the player to wake up to be available for use.



In between manually powering up and down individual devices and devices managing their own power state in response to need is explicit power commands sent across the network by one device to another. One example of this approach is the "Consumer Electronics Control" (CEC) protocol that is available under HDMI Version 1.4 (High-Definition Multimedia Interface). The CEC feature of HDMI allows networked devices to communicate with one another, thus allowing users to interact with a "system" rather than just one single device. One key element is the inclusion of a feature that allows command called "System Standby" to be broadcast from a master or so called "sink" device to all devices on the network. In most cases, the sink device would be the television, which is controlled by the end user, and other devices change state depending on whether they are required. One of the communication rules is that devices shall not transmit a message as a result of an internal event that did not occur as a result of user interaction with the source device (eg EPG update or programmed recording etc) to avoid devices being left powered unnecessarily. Some identification of devices on the network, their function and their relationship to the master device is required (HDMI LLC , 2010).

While the concept of this approach is valuable, at this stage it is only available within a network of fully digital products that are connected using HDMI interfaces. In addition, the ability to do this comprehensively relies on voluntary and vendor-specific extensions to the HDMI standard. The result is that full capability is only effectively accomplished when all components are from the same manufacturer. While HDMI is becoming more common in the AV product market (with the conversion to digital of free to air broadcasts in many countries), there is a large pool of legacy equipment that does not have an option for HDMI connection nor Version 1.4 firmware, so at this stage it has limited practical application even in this specific range of products. HDMI is also restricted to AV equipment so cannot be readily used other types of equipment (like computers). Standards development of the HDMI standard needs to occur to ensure that these commands are interoperable regardless of manufacturer, and the features should be made mandatory, not voluntary. However, this is only an interim step; the long-term future should be devices that manage their own state, once there is a standard that defines such behaviour, and facilities for devices to fully expose their functional and power state to the network.

This type of network related management strategy requires several components to work:

- two-way communication between all devices
- devices exposing their presence and identity to others on the local network
- devices exposing their power state to others on the local network
- devices exposing key aspects of functionality (e.g. what source(s) a TV is using) to others on the local network
- standard protocols to implement the above
- standard default behaviours and management strategies in response to changes in functionality of other devices, particularly delay timers.

These protocols would need to be designed with the Internet Protocol in mind, though versions of them on other common interconnects are also needed. Interoperability between different systems would be critical. The implementation of such systems would have to take into account common user expectations about how devices will (or should) operate so that they work consistently with their past experience. At present, many such connections are analogue and are not 2-way, and therefore lack the ability to transmit information such as identity and power state; this inevitably requires some (legacy) devices to be manually powered up for use. It is still possible to implement power-down strategies based on delay-timers from time of last use (which are already included in European standby regulations) where explicit knowledge about power state is not known, but this is not as effective (potentially much slow to enter low power modes). Dealing with a wide range of legacy equipment presents interesting issues: these will usually require a second set of rules for operation in mixed networks that provide the best balance between user convenience and energy savings.

The principle at the core of this approach is that devices manage their own power state based on all the knowledge they have, including information from other devices. An alternative approach is for one device to instruct other devices what to do, for example, a TV telling a DVD player to power down when it is no longer using it as a source. Based on past experience with the Internet, and with the fact that the device itself has the most knowledge and information relevant to such decision-making, it is likely that the distributed, autonomous-device approach, will be easier to implement and more successful in terms of being both functional for people and maximising energy savings.

Finally, we can consider people to be nodes on the network, so that the system knowing the presence status of people in a room or building can help systems save energy. For example, if no one is in a room, then the visual part of a TV display can be powered down (though people may be listening from a different room), and if no one is in a building at all, the audio can also be cut. Related to this, devices today expose their power state to people through operation (e.g. a TV display that is on or a microwave oven cooking show that the device is active) and usually through a power indicator. Devices also have power controls for people to manually change power state, or change the configuration of automatic settings. For maximum interoperability between people and their devices, standardization of this interface is needed; that is specified by IEEE 1621, which is focused on the Power Control User Interface. Lack of consistency and clarity in user interfaces wastes energy.

Devices in buildings will increasingly “export” their user interface to other devices. For example it is common today to be able to bring up the software control panel for a PC or wireless router via a PC link. Today, it is mostly electronic devices that can do this, but in the future, we should expect appliances and other devices to gain the same ability. The devices and displays will need an ability to discover each other, and to operate differently based on the power state of each, for both functional and energy-saving reasons.

The key to all this is to ensure that devices minimize the services they provide to others that are not used or needed, to avoid the energy required to generate and communicate those services, and to ensure that power management can operate optimally for functionality and energy use. It is likely that this protocol could be applied very widely to both traditional and non-tradition products that are connected.

Unfortunately, most of the protocol standards needed to implement this approach do not exist, though in some cases, existing protocols could be extended to include this type of management. In addition, there needs to be coordination between protocols in different domains to ensure that they are compatible and interoperable.

There will be other cases where exposing power state helps save energy, but these examples are the most urgent to address in the short term.

6.6 Scaling power in proportion task requirements

This approach can be used for many electronic products and is not restricted to use in products that are connected to networks. It is an approach that could be particularly important in network equipment as many are effectively required to remain in active mode virtually all of the time.

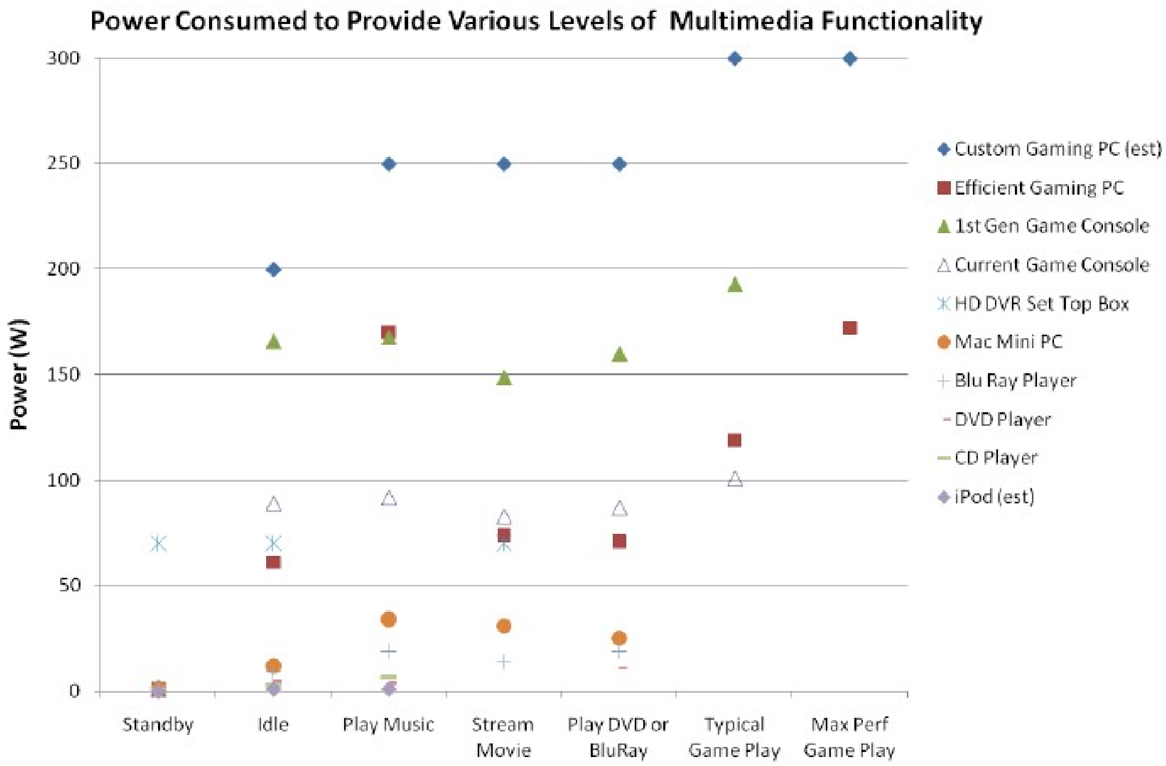
As we have seen, the power consumed by electronic equipment, particularly those that process information, is often a function of circuit design and power supply configuration. In many cases, the power consumed by such products is more or less fixed and processing load often has little or no effect on the power consumption of the product – effectively the power consumed is fairly constant with little or no impact from the volume of data processed. This is a function of electronic equipment and the laws of physics, and it means the concept of “efficiency” for electronic equipment is a difficult one to define, especially in cases of low utilisation. This contrasts markedly with “traditional” appliances and equipment where the energy consumed is usually in proportion (at least to some extent) to the “size” of the energy services delivered.

At face value, this means that there may not be many technical options to reduce power consumption during periods of lower throughput or demand for electronic equipment. This is of some concern, as we know that a lot of electronic equipment remains in active mode for long periods but that the actual processing load is light or even negligible.

However, observations and power measurements on a range of computers and other electronic equipment shows that there is a large potential to internally management power requirements during period were there are lower levels of functionality required. Some product types were able to reduce power by 70% or more in active mode where only lower level tasks were required by the user or in idle mode (on but no task being performed). Other machines used more or less the same power whether idle or undertaking heavy processing of data. These effects are illustrated in recent laboratory measurements conducted by Ecos Consulting in the USA (Calwell, 2010) as shown in Figure 5.

There are a number of ways these types of energy reductions can be achieved. Perhaps the most common and effective approach is to divide the main processor into a number of separate stand alone cores that can operate alone or in parallel with other cores. During periods where there is a heavy data processing load, all cores can operate in parallel to meet the processing load requirements. As the processing load reduces, unnecessary cores can be shut down, which mean that the loading on the remaining cores increases (but remains well within their capacity). During periods of light processing load, a single core can remain operational and perform all of the required active mode functions. This can result in significant energy reductions during periods of light load.

Figure 5: Measurements on a range of electronic equipment for similar tasks



Source: Calwell, 2010

Another technical approach is to shut down unnecessary components or functions within the product during periods of no utilisation of those particular functions. This can only occur where different parts of the equipment perform different functions. While this can be quite effective, it is highly dependent on the product type and design and the range of functions that it is required to perform.

This overall approach to internal energy management effectively breaks the shackles of a fixed power consumption for electronic consumption irrespective of processing load.

This approach would be extremely valuable for products like computers and especially network equipment, which are often left (or required to be) in active modes for very long periods with low levels of utilisation, especially when used in conjunction with options for reducing power required for network links (see Section 6.3).

As these types of approaches are likely to be achieved using proprietary designs, components and technologies, it is difficult to specify these type of requirements in technical standards. However, requirements can be set to specify different levels of scaling to occur under different levels of and types of processing load. These would have to be empirically determined through measurement on a range of different products to determine what is technically feasible.

6.7 Reducing services delivered

This approach can be used for a wide range of products and modes and is not restricted to use in products that are connected to networks.

It may sound like “cheating” to reduce the energy associated with delivering energy services by simply delivering a lower amount of service, but this can be effectively used, and is a component of the previous discussion about exposing power state, to reduce services that are not being consumed or required in any case.

Another example is frequency of an operation. For example, a device may update operating information from a network every few hours, but if it has been powered down for many days, it may be reasonable to only do this every few days, or even delay doing so at all until it wakes up again. For example, and Electronic Programming Guide on a digital television may be updated daily. However, if the television has not been used for a week, it may be reasonable to only update the EPG less frequently (say every 4 or 5 days) rather than daily until it is used more regularly again. In general, this capability will be part of an existing standard or protocol, or even only a characteristic of an application, so not need a new standard (though exposing of power state will help inform how systems do this).

This sort of behaviour can be controlled by the device itself so that the rest of the network is not aware of the change, or it can be implemented by connected devices when they see a low power mode exposed over the network.

Some devices may be able to disconnect from the network when in low power modes if it is compatible with their functional needs. Others may disconnect most of the time, but periodically reconnect to check for updates of some sort (eg tariff schedules for the next day). This is facilitated if it is possible to rapidly reconnect to the network on wake. It may be desirable for protocols and applications to have the concept of a device being off and not present on the network, but likely to reappear and so still present to some degree, even though the device cannot be powered up over the network. In general, sleeping devices will be expected to maintain network connectivity but off devices will not.

6.8 Other options

For network technologies in general, attention to the amount of "chatter" needed to maintain network operation should be examined, particularly to consider reducing the frequency of it during times of little or no activity, or when the network context facilitates it. Network protocols could also become cognisant of the power state of devices to change their operation beneficially (for example, reducing or eliminating use of cryptography for sleeping devices to make it easier for proxies to maintain presence, then resuming use of full security features on return to active modes).

Another option is for sleeping devices to reduce their power state when all network connections are lost.

6.9 Energy saving strategies used in existing networks

Many current network technologies employ methods to minimise energy use - the principal motivation for this has been for battery-powered end devices. Most of these take advantage of times when link utilization is low, and/or latency requirements are low.

6.9.1 Ethernet

Most network links are lightly utilized most of the time. However, traditionally, power required for a network link was proportional to the *capacity* of the link, not the *throughput*. Higher speeds cost more power (almost exponential with speed), so the result is relatively high power for the actual amount of typical data throughput.

The IEEE 802.3 Ethernet standard has long provided for different transmission rates. This was put into place for backwards compatibility with older devices that were unable to operate at higher rates (or wiring infrastructure incapable of supporting the higher rates). However, changing rates has required dropping the link and reconnecting, which takes at least 2 seconds (an eternity in most network circumstances). Recognizing all this, the IEEE standards committee in charge of Ethernet undertook to create Energy Efficient Ethernet (EEE, IEEE 802.3az) to enable Ethernet link energy to be scaled more proportionally to data utilization.

The original concept for EEE was to change the data rate, but do so in milliseconds rather than seconds. In the course of the standards process, an alternative was presented to maintain the high data rate, but put the link to sleep for periods of time when no data was ready to be transmitted. The key is that the link is maintained to be ready to return to normal capacity at short notice (measured in microseconds).

EEE has two key features as it applies to energy efficiency: the power to implement the physical layer of connectivity can be reduced by as much as 90%. However, for the energy savings to be achieved, the interface at both ends of the Ethernet cable have to support EEE. The standard is expected to be ratified in late 2010, and once it is, public policy can encourage or require rapid adoption of it for new products.

An EEE compliant interface will still function as a standard Ethernet connection when connected to an interface that does not support EEE (IEEE 802.3).

The existing Ethernet protocol (IEEE 802.3) will co-exist with EEE (IEEE 802.3az) for some years, at least until it is universally adopted by equipment suppliers. This progression may be hastened by its inclusion in voluntary and regulatory programs.

6.9.2 Wi-Fi

IEEE 802.11 has added a number of features to enable connected systems to o facilitate saving energy. Generally these require both the access point and the end device to both support the extra feature for them to engage; how frequently these are supported in current products is not well known. The approaches used include:

- reduce the frequency (in times per second) at which the two devices communicate to determine whether either has any data to be exchanged.
- allow the access point to filter out data that it knows or has been instructed that the end device can safely ignore.
- allow the access point to automatically respond to ARP requests on behalf of an end device.
- reduce routine coordination traffic between the two devices during times of low or no data traffic.

The specific techniques that are already included in IEEE 802.11 are:

- Power Save (PS-Poll) – IEEE 802.11-2007: A STA enters power save mode, and while in power save mode it listens to selected beacons.
- Automatic Power Save delivery (APSD) – IEEE 802.11-2007: The power save mechanism for Quality-of-Service (QoS) enabled STA and access points and allows per-stream power save.
- Fast BSS Transition – IEEE 802.11r-2008/ IEEE 802.11mb: A STA (station) can roam between 2 access points in a power efficient manner.
- IBSS Mode Power Save – IEEE 802.11-2007: Power Save mode for 2 STAs in IBSS (adhoc) mode, where STAs coordinate sleep duration and interval.

There are also a number of new power saving options proposed for IEEE 802.11:

- Proxy ARP – IEEE 802.11v, WiFi Alliance (WFA): The access point has the ability to proxy ARP frames for the STA.

- TIM Broadcast – IEEE 802.11v: Access point periodically transmits a TIM frame, to indicate traffic buffered for a STA.
- WNM Sleep Mode – IEEE 802.11v: WNM Sleep Mode is an extended STA power save mode.
- BSS Termination Notification – IEEE 802.11v: An access point notifies STAs that the access point will be powering-down.
- Traffic Filtering Service – IEEE 802.11v: Allows access point to send only traffic that matches STA-specified filters.
- Flexible Multicast System (FMS) – IEEE 802.11v: Access point sends multicast/broadcast frames allowing longer power save state for STA.

The above information is derived from Sood (2009).

7. Issues and elements needed to address network energy

7.1 Overview

So far, this report has explored a range of possible approaches to reducing different components of product energy consumption when the product is connected to a network. The possible approaches are diverse and in some cases complex.

While the genesis of this report is a concern about network standby (low power modes of products within networks), it only makes sense to address that topic with an integrated approach to two larger overlapping issues: low-power mode policy generally and coherent policy responses to energy issues in digital networks.

From a policy perspective, it is important to understand all of the possible elements and ensure that these are combined in sensible and logical manner. It is also critical that requirements do not conflict with each other, stifle innovation and development or impair product functionality; the user's perspective needs to be a primary concern.

Therefore an overriding consideration is that the product must adequately provide its primary functions (usability of the product) with any power management or energy saving features implemented.

There are a number of relevant issues with respect to networks and energy consumption. These can be categorised into three broad main areas:

- Power management:
    - Power management (edge devices) – ensuring products with network capability maximise their time spent in low power modes while still maintaining adequate functionality;
    - Power management (network equipment) – reducing, where possible, active mode power consumption during periods of low utilisation;
- Power levels:
    - Minimising power to operate network connections – reducing power required to maintain network links and an adequate network presence.
    - Minimum power levels in low power modes – while products are in low power modes, ensuring that the power levels are as low as possible;
- Implementation issues:
    - Network behaviour – ensuring that products are well-behaved with respect to how they interact with the network to ensure that other products are able to take maximum advantage of power management

and reductions in power levels and that protocols deal with poorly behaved equipment.

- o Context of equipment connected to networks – in many cases the operation of this equipment may have energy consequences on or control other energy using equipment and may also result in non energy benefits.
- o Usability of equipment – network equipment needs to deliver functions to the end user (or network) if and when they are required (usability).

Networked products include equipment that enable the network to operate (products whose main function is the network itself) and edge devices that are connected only to the local area network (LAN) or wide area network (WAN). The proliferation and range of technologies used for various networks have substantial implications for energy consumption, however they also pose specific and special challenges when developing policy approaches for standby power and an integrated policy approach. Without effective action on networked products, much of the projected benefits of standby policies will fail to materialise.

Unlike stand-alone devices and equipment, networked products can be affected by the behaviour of other products or operators on the network. Therefore much of the potential for energy savings comes from the ability of networks to allow products to go into low power modes for extended periods. Many networks carry large volumes of network traffic, which is an increasing burden to networks and their associated energy use. In addition, under current protocols, there is traffic that must be understood and responded to for devices to remain connected to the network; this confounds many efforts to implement effective power management, especially where product designs bundle essential network functions with the primary function.

The primary design paradigm for most networks is consistent, fast and reliable operation rather than the minimisation of the energy consumption of the network equipment. In the absence of energy management strategies, energy used by network connections is more or less fixed, independent of the volume of data transmitted. Products that operate principally on battery power are an exception, as long battery life is a key and valued type of functionality. The challenge is to develop hardware and software solutions that allow products to minimise their energy consumption without losing network or user functionality.

The energy consumption of any product is determined by the power consumption of each relevant mode used during normal use and the time spent in each mode. To reduce the energy consumption of a product, two possible approaches can be taken: a) reduce the power of each relevant mode, and b) shifting time spent in higher power modes to lower power modes. Both approaches can be effective.

Reducing the power levels in each mode is certainly effective and needs to be pursued, particularly where those modes are present for long periods. However, where there is a significant difference in product power consumption by mode (active mode versus low power modes), then being able to get products out of high power modes and into lower power modes as quickly as possible while retaining functionality can deliver substantial energy savings. Getting data-related products (eg network equipment and most other “information based” technology equipment such as computers) to scale their power requirements according to traffic and processing requirements is also another valuable energy saving strategy. Therefore internal power management within a product, whether or not it is connected to a network, is important in achieving energy savings. In many cases, the largest potential energy savings from power management are in these information based equipment types, most of which happen to be connected to networks. But the limitation on energy saving potential is not usually limited or constrained by network requirements in most cases (but poorly designed network systems can create problems).

This section examines each of the key elements that impact on energy consumption and the components that need to be in place before effective policies can be developed and implemented.

7.2 Primary function(s)

Where energy consumption in active mode is significant during normal use, energy policies may be warranted to ensure that this mode is as efficient as technically possible. For many types of electronic equipment, the energy consumption varies little with the energy service or throughput provided, so the concept of efficiency in these cases may need to be examined closely.

For many types of products, the power consumption in active modes is significantly higher than in low power modes. Therefore, in these cases significant energy savings can be achieved by minimising the time spent in active modes (and therefore maximising the time spent in low power modes). This applies to products that can be used on a continuous basis. As set out in Section 6, there are a number of ways of achieving such a mode shift to save energy, depending on the product design and the requirements of the product with respect to the network. This is mostly about reducing or turning off primary functions when they are not required.

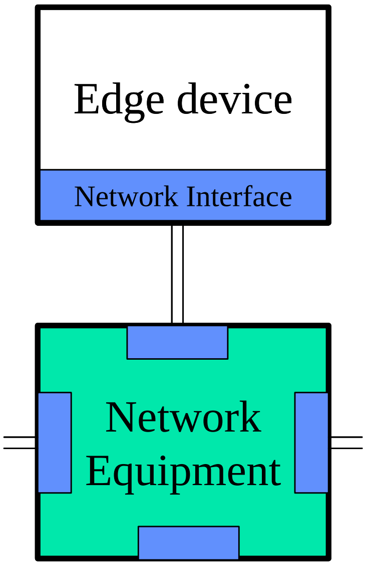
Section 6 also sets out examples of using internal power management in electronic equipment to reduce energy consumption in active mode during periods of low user demand or throughput (power scaling). These approaches usually involve specific internal designs and possible proprietary components and software, but nonetheless they can achieve substantial energy reductions.

7.3 Secondary functions

The power consumption of secondary functions (usually those associated with the concept of off, sleep or standby, but excluding network functions for the purposes of this discussion) is usually small. Where the power levels are not small, this is usually the result of poor design or lack of attention to detail in terms of components and their application, as most secondary functions (should) require only trivial amounts of power to operate. There are well documented procedures already implemented in some countries to set limits on the power consumption of these functions (usually defined in terms of power limits for specified modes).

There are a few cases where secondary functions can consume significant energy – examples are crank case heaters in air conditioners (which operate when the unit is not providing any heating or cooling function – the power may also be varied with weather conditions) and anti-freeze heaters for devices like water heaters (which are definitely linked to weather conditions). Where these secondary functions consume significant energy in particular regions, approaches to minimise this need to be considered. These issues are quite regional in nature and global solutions may be more difficult to develop.

7.4 Network functions



For edge devices connected to a network, network functions are secondary functions (but sometimes linked to primary functions). For network equipment, whose main function is the provision of the network links, network functions are the primary function.

For edge devices, the incremental power requirement for network functions is usually fairly small as a share of total power. As an example, a computer may have an active mode power of around 50W to 100W while the power required by the network interface to maintain a network connection could be of the order of 0.1W to 5W (depending on the interface and the connection speed). Of course, reducing the power consumed by the network interface is worthwhile, especially if the level of utilisation is low and the link speed is high. This is particularly important if the device moves out of active mode into a sleep mode during periods of low utilisation (a network interface power of 1 W in a total sleep mode of 4 W is substantial, for example, if it remains in this state for long periods).

Many products with network connections have to maintain full network connections, even in low power modes, to perform properly. Examples mentioned previously are printers, copiers and telephony products. In these cases, minimisation of power associated with network functions is important.

7.5 Network equipment

Network equipment, whose primary function is to provide the network itself, has limited scope to move out of active mode into low power modes – it generally has to remain on and available to all connected products. Packets of data have to be received and sent more or less immediately (with no latency, within the allowable network parameters). This type of product includes switches, hubs, routers, wireless access points and modems.

For network equipment, the provision and maintenance of adequate network links is the key function being provided. So ensuring that the power required to provide the required network link is as low as technically possible in network equipment is a critical approach to reduce energy consumption. This can be achieved through a number of technical standards that allow low power options to be implemented in specified circumstances. An additional approach is to introduce power scaling for the main function to allow parts of the equipment to be shut down during low utilisation.

7.6 Networks: direct and induced energy

In many cases equipment attached to networks (edge devices) will affect the energy consumption of other equipment (other edge devices) on the network, principally by preventing them from being in low-power modes when they otherwise could be. This issue does need to be a part of a broader policy on network connectivity and network design. However, the primary and secondary functions of equipment need to be understood when considering and regulating the energy consumption of such equipment.

One example is when one device periodically queries the status of a second device that wakes from sleep to respond to the query and the queries happen often enough to keep the second device mostly or entirely awake. A second example is when devices maintain a high speed link rate between them even when little traffic is being passed.

These examples demonstrate the two ways that networks increase energy use: direct and induced. Direct energy use is that from network interface hardware on edge devices, and the entire consumption of network equipment. This hardware is only necessary to enable operation of the network. Induced energy is when the rest of the product remains in a higher power state than it would otherwise be if the network connection was not present. A minor effect is increased computation to generate and receive basic network traffic, but the much larger one is devices that remain fully on for long periods in order to stay network-connected, instead of being asleep.

7.7 Power management and network functions

One of the key issues for edge devices on a network is that there is often poor implementation of energy management because of broader network requirements.

This occurs for a number of reasons. Firstly, the technical standards for energy management within a product have not dealt with network issues very effectively to date. Ideally, a product should be able to readily enter low power modes while still being able to respond to essential network traffic and wake up when required by the network (or the remote IT manager). Many of the existing protocols that allow internal management to be implemented effectively shut down network functions or severely limit their capability. Those protocols that do allow internal energy management to be activated while maintaining a network presence can be thwarted by extraneous traffic on the network that is generated by other devices that are poorly behaved. Energy management approaches are particularly difficult to implement for servers on networks.

A good example of this is the case of personal computers that operate in large corporate networks. Even though energy management in Windows is usually enabled in the operating system as shipped (as required by Energy Star), these features are usually removed by IT managers once the equipment is installed. Not only is energy management removed so that the products can't go to sleep when not in use, but many companies require that personal computers be left on overnight (every night) to allow management and software upgrades to be performed remotely. This has a massive energy cost.

The other reason why energy management is sometimes not implemented is that the required communication links are not available in the network to signal to other devices whether they are required or not. This is especially prevalent in home video products, where many of the interconnections are still analogue and there is not provision to indicate the state of each connected device.

So conceptually, many users have grown to think that products have to remain in active mode for network functions to remain active. However, some newer and more robust protocols now overcome many of the historical issues and allow energy management to be implemented internally while participating as required on the network.

7.8 Energy use estimates for network equipment

It is helpful to have a quantitative context for how networks affect energy use. Taking the U.S. as an example, over 70% of 2008 electricity use was in buildings (roughly evenly split between residential and commercial). Of electricity in buildings, about 290 TWh or 11%, was from devices in the "electronics" end use – those whose primary function is *information*. A recent estimate for 2008 is that network equipment alone accounts for about 18 TWh (Lanzisera and Nordman 2010), though all devices with a digital network connection exceed 150 TWh (this already more than half of electronics energy use and rising) (Nordman 2009). So, in rough terms in the USA, electronics are about 10% of buildings electricity, and network equipment about 1%, with networked devices accounting for over 5% and rising. So energy associated with networks is significant and rising. Development of policies for low energy networks will result in substantial energy savings as networks expand.

7.9 Non-energy benefits and secondary equipment

In some cases, a network related function may collect data operation for non energy benefits. Examples include: historical operation information to allow scheduled maintenance to be optimised and identification of parts that require replacement to avoid a catastrophic failure to prolong the life of the equipment or to ensure it ongoing efficient operation. Some networks functions may also perform vital ongoing tasks like maintaining indoor air quality, monitoring of environmental parameters, maintaining ambient and lighting levels for staff to remain productive and a range of safety related functions.

Another important element is that some edge devices on a network may control or even manage energy for of a wide range of other (much larger) devices. For example, a building power management system may control fans, pumps, air flow systems and other elements of building infrastructure. In some cases the primary function of this equipment may be to reduce the overall energy consumption of other equipment or even a whole building (e.g. daylighting, occupancy sensors, overnight fresh air flushing to cool building core, load shifting and peak load management). In this case the energy consumption of the equipment controlled may be many orders of magnitude larger than the controlling equipment that is connected to a network. This is not to say that such controlling equipment should use excessive power to perform a specified task – but the complete context of operation needs to be understood.

Peak load management (demand response) also falls into this category as the primary benefit is a reduction of peak load on the electricity system during critical supply events. Much of the energy use is simply shifted – the overall energy savings (if any) are generally small. These systems rely on networks as a mechanism to control equipment for short periods in response to infrequent and unpredictable events (typically dictated by the weather or equipment failure).

These types of benefits are not the primary concern of this report, however these benefits may be substantial in some cases. The main point is that the context and primary purpose of such equipment needs to be considered if the power consumption of the network related modes is to be regulated and implemented successfully.

8. Creating a path forward

8.1 Key elements required for effective policies

In order to develop effective policies to address energy in networks, it is important to consider the key elements that may be needed to underpin such a policy. Preparing such a checklist will help to identify which parts are already developed and are already suitable for implementation and which parts still require further work. This report has identified many of these critical elements and their current status. This section attempts to ascertain where resources are required to move forward.

Another critical element is information and understanding. This includes an understanding of how products use energy, what are reasonable power requirements for different functions and why the energy consumption of different products can be large when the energy service they perform is the same (or equivalent). Good information can help ensure that policy developments are competent and effective and push products towards the lowest energy options.

The key elements for effective policy are:

- Good network design;
- Implementation of effective product power management;
- Minimisation of energy for network functions;
- Setting limits for all low power mode functions.

These elements need to be implemented with an understanding of relevant issues and within the context of how real products are used within existing systems. The issue of legacy equipment in the context of networks would appear to be an important consideration if practical energy savings are to be achieved. Careful thought needs to be given to system design and transition arrangements when implementing new protocols and hardware solutions to reduce network related energy – new equipment needs to work in a practical way with older technology while achieving most of their energy savings potential, even when operating in non compliant or uncooperative networks. Ultimately, the objective is to reduce energy automatically as far as possible while maintaining adequate energy service.

The issue of energy efficiency when performing the primary function is not addressed in detail in this report. However, this can be included in the vertical approach to dealing with all product modes as set out in Section 8.6.

8.2 Guiding principles for good network design

Managing energy consequences of network connectivity requires an overall approach to technology and policy.

A proposed set of guiding principles was summarized at an IEA workshop in 2007 on Digital Networks. These “Guiding Principles” outline both network design and policy objective that could underpin future networks (Nordman et al. 2007) and are reproduced below (a smaller set of principles are included in the EU Code of Conduct on Broadband Equipment). The following text (sourced from IEA 2007) is a slight adaptation of the 2007 principles by the authors in order to update them, though a more thorough review and elaboration of these is warranted as a future project.

8.2.1 Network Connected Devices – Initial Hardware Objectives

- Network technologies should actively support power management and follow standard (international) power management principles and designs.
- Connection to a network should not impede a device from implementing its own power management activities.
- Networked 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.
- Network links should have the ability to modulate their own energy use in response to the amount of the service (level of function) required

8.2.2 Network Connected Devices – Initial EE Policy Objectives

- Governments should ensure that electronic devices enter low-power modes automatically after a reasonable period when not being used (power management).
- Governments should consider limits on energy consumption in low-power modes for networked products and develop technically feasible options.
- Governments should ensure that networked electronic devices minimise total energy consumption, with a priority placed on the establishment of industry-wide protocols for power management.
- Energy efficiency specifications should require specific particular hardware or software technologies only after careful consideration. Open source and non proprietary technologies are generally preferred.
- Requirements for networked products need to be generic and performance based.

Source: IEA Digital Networks Workshop, July 2007 (IEA 2007) (adapted by the authors).

8.3 Power management

A critical issue to reduce energy consumption of products within networks is the development and implementation of effective power management strategies and protocols. It is often difficult to define such requirements in a way that provides no loopholes and does not detract from functionality of the product during normal use. Power management has the potential to save substantial energy, and can compensate for (poor) user behaviour (which can be an important factor in the energy consumption of a product), and improve convenience and functionality. This issue is particularly important; as both poorly behaved users and poorly behaved network protocols can both thwart the implementation of otherwise effective power management strategies.

Part of this overall strategy should be to ensure that products automatically power manage themselves to the lowest possible power state at any point in time. To some extent, the implementation approach will depend on the equipment type and the type of network in which it operates.

Power management can be incorporated into efficiency policies in several different ways. For features or behaviours connected to network activity, these can be defined by technology standards, and the energy standards simply require adherence to these by reference. These may help the product in question power manage most effectively, as well as enable the devices it is connected to do the same. For internal power management in the absence of network information, this can be time-based measurements (eg stating that it should go to a particular low power mode within a specified time constraint), or, measure power over a period of time and put an energy limit on it that contemplates the device being in a low power mode most of the time.

As outlined in Section 7, energy management strategies fall into two broad categories:

a) Power management (edge devices) – ensuring products with network capability maximise their time spent in low power modes while still maintaining adequate functionality; and

b) Power management (network equipment) – reducing, where possible, active mode power consumption during periods of low utilisation.

There are a number of protocols that are already developed and operating to address issue (a) above. These are set out in Sections 6.4 and 6.5. However, many of these are not widely implemented and some have extremely specific configuration requirements to work properly (ie they do not work or perform poorly in networks with some non compliant products). One of the most important potential protocols, using network information to expose the state of all devices on the network to each other, is not yet developed. Understanding network functions and allowing them to be unlinked from active modes (where possible) is also an extremely important strategy that needs to be further reinforced. This area of energy management is one that requires detailed work and investigation.

While approaches under (b) will be critical in order to achieve energy reductions, especially in network equipment, these will generally be achieved through implementation of proprietary designs, components or software. This means that requirements cannot be specified through adherence to particular open source technical standards. However, it is still possible to set limits on power consumption of these products based on best available designs and technology on the market. To some extent this is a reactionary policy position, as requirements have to be based on existing market developments (or at least prospective developments). This is an area that lends itself more to voluntary requirements (market rewards for compliance) rather than mandatory approaches. It is very much an empirical approach to the issue, based on measurement.

8.4 Minimising power for network functions

This report has provided a good detail of technical information about network functions and their energy consumption. In the absence of other strategies, the power required to maintain of fully operational network link depends mainly on speed and is influenced little (if at all) by data throughput. Fortunately, there are already a number of technical standards that have been produced that aim to overcome these issues in a range of network types as set out in Section 6.3.

For wired systems using Ethernet protocols, the soon to be formally release “Energy Efficient Ethernet” (IEEE 802.3az) which applied to all wired network equipment using Ethernet protocols, primarily in local area networks (LANs). There are also a number of energy saving approaches being developed or proposed for various WiFi protocols (IEEE 802.11) within LANs although these have not been fully reviewed for this report. The area of WiFi is undergoing rapid evolution and new protocols to increase link speed are being developed on a regular basis. As with many areas related to networks, stability and speed appear to be the primary design objectives, with energy usually being well down on the priority list.

Some protocols also exist for energy reductions using ADSL2+ in wide area networks (WAN) that connect end use premises to internet gateways (typically in exchanges) as noted in Section 6.3. While this protocol is being widely implemented around the world (for speed reasons rather energy management features), there is some anecdotal evidence that the energy saving features are not implemented in many cases as the line drive power has to be held at the maximum output to minimise cross talk at high data rates (to support video streaming in particular) as the ADSL network reaches its data capacity limit in many areas. It is unclear what future role ADSL (which uses the copper network) will have in WAN networks if optical fibre networks replace these links over time. There are also a number of other protocols such as MOCA 2.0 and Bluetooth 4.0.Green Ethernet, which may have broader application, but these have not been reviewed in detail for this study.

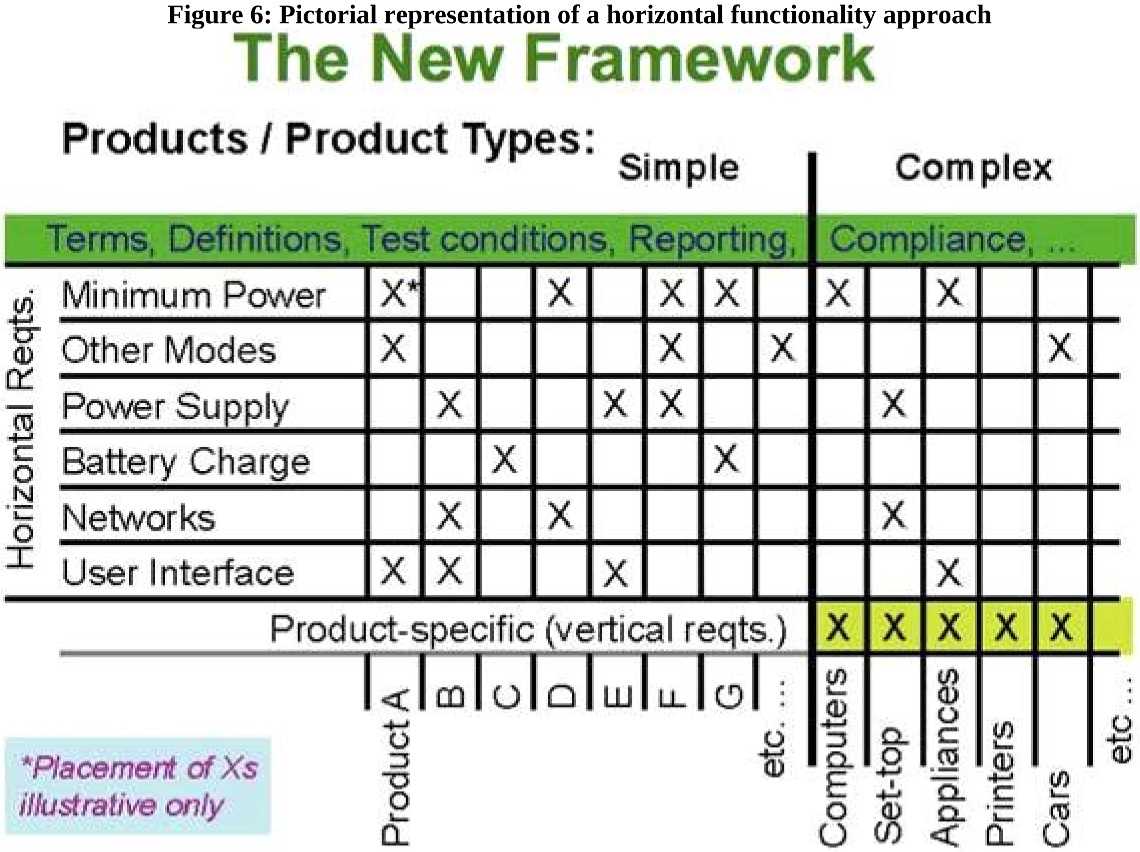
So while there appears to be a good deal of activity in the area of low energy protocols and technical standards to minimise energy associated with network functions, this certainly appears to be an area that warrants some closer investigation to establish which are the most promising approaches and where there are still gaps that could deliver further energy savings. The most promising approaches should be targeted for broad implementation.

8.5 Setting power limits for functions

Setting limits on the power in low power modes appears to be a critical element in any policy to reduce excessive standby power. The concept of horizontal functionality as a means for setting power allowances or budgets for low power mode functions appears to be the most versatile approach within any integrated approach. This approach is applicable to both networked products and stand alone products.

Horizontal functionality is where a maximum power level that potentially covers a wide range of product designs and product types is developed on the basis of the level of functionality offered by each individual product, potentially across the range of different low power modes that may be present. Conceptually, it is a system of providing a power budget or allowance for the provision of a specified level or type of functionality (or combination of functions) that are active in the product in the particular mode. This approach has already been successfully used in a number of programs.

Figure 6: Pictorial representation of a horizontal functionality approach



One key advantage of such a broad approach is that it recognizes that products are differentiated where different functions are available and activated in low power modes, both within and between product types. This enables policies to fairly and reasonably reward such functionality; otherwise, more functional products would be burdened by much more difficult — or impossible to meet — limits than less functional ones, and less functional products would have limits that are too lenient. Thus, this approach is ultimate easier and fairer for manufacturers, and will lead to more energy savings while allowing the inclusion of features and functions that users want. Of course some functions can be offered no adders and a cap on the total power budget can be set.

8.6 Including low power modes in vertical requirements

Many products that use significant amounts of energy will already be included in energy programs of some sort. Traditionally, such programs tend to focus on the primary energy service provided and efficiency criteria are then established (based on the amount of energy service provided per unit of input energy). Increasingly, due to the growing prevalence of electronics in all sorts of appliances and equipment, most of these products will also consume some energy while they are NOT performing their primary function.

One of the problems with the issue of "standby" (low power modes) is that small amounts of energy are used by a large (and increasing) number of products. So in any comprehensive policy to address excessive standby power should also deal with these modes in major appliances and equipment, even where they may already have program coverage for active mode.

There are two possible approaches to dealing with such products – the so called "horizontal approach" (outlined in some detail in the previous section) and a "vertical approach", where low power modes are combined with energy consumed in active mode(s) to give a total energy consumption for a defined duty cycle. The pros and cons of these approaches are set out in some detail in Sections 3.6.4 and 3.7.

In the vertical approach, the energy consumption in all relevant low power modes is summed with on mode energy consumption, calculated for a defined usage profile that is intended to be typical of normal use patterns. This allows energy in low power modes to be considered as part of the total energy consumption of the product. An advantage is that it keeps energy consumed in low power modes in perspective with total energy consumption for the product, as the low power mode energy as a share of total energy varies dramatically by product. It allows manufacturers some flexibility on how they achieve overall energy consumption targets – through a combination of improvements to active and/or low power modes. This is particularly useful when the time spent in different low power modes is a function of the design/implementation in a product, not inherent in the product type (laser printers are a prime example of this).

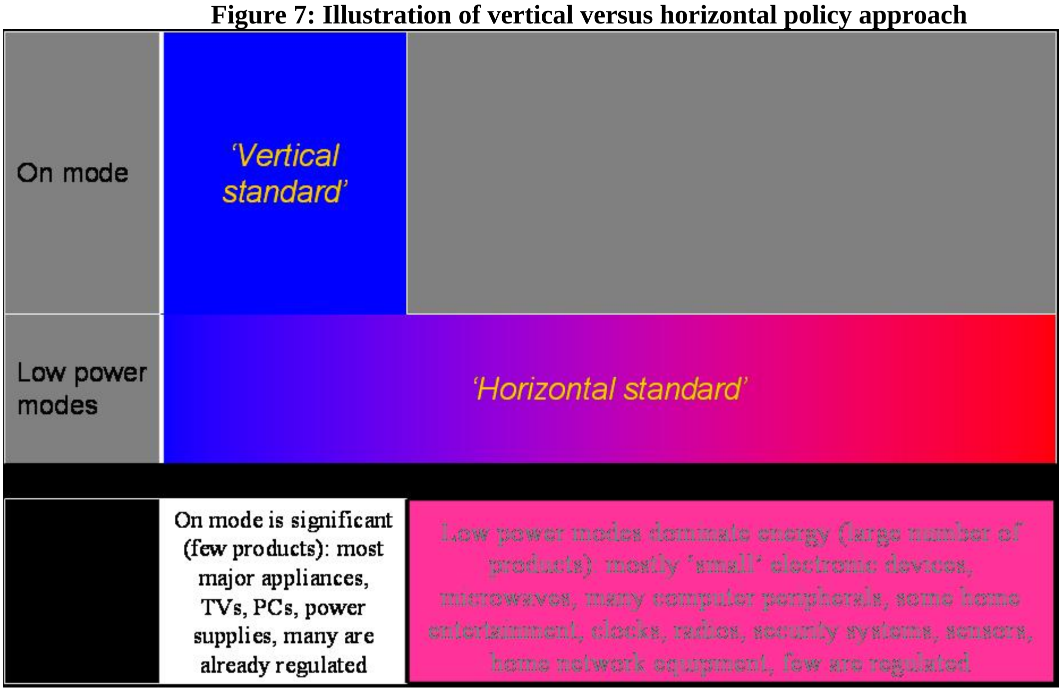
A vertical approach to include the energy consumption of low power modes into the total energy consumption of a number of products has already been successfully implemented (eg in Australia & New Zealand (Harrington 2005), USA (Meier & Siderius 2006) and Japan (EECJ, 2008)). Duty-cycle based specifications which sum energy in different modes are increasingly used by the Energy Star program (e.g. imaging equipment).

A vertical approach has the benefit of assessing total energy consumption across all modes in a consistent and integral fashion. However, care is required to ensure that all relevant low power modes (and their share of use) during normal usage patterns are included in the defined duty cycle. The other issue to be considered is that the duty cycle needs to be reflective of normal use in order to get a realistic "vertical" energy consumption estimate. It is important for vertical approaches (duty cycles) to recognise and reward energy management features when they are implemented over a specified duty cycle. However, these energy savings need achieved for a wide range of possible usage patterns (not just one duty cycle that may be specified in a test procedure) – savings that only occur for one usage pattern is venturing into the area of circumvention of test procedures (see Annex C).

A related issue is that for some products, usage patterns vary substantially within a country (different types of users) or across countries (in the case of regional schemes). This may also be problematic for manufacturers of internationally traded goods and for governments who may wish to see harmonised test and performance requirements. It is always important to separately measure and report the energy consumption in each mode under the test procedure, as this can allow usage patterns to vary by country without the need for retesting, and for individual purchasers to understand how the product's characteristics apply to their own usage context.

A vertical approach is particularly recommended where secondary functions consume substantial amounts of energy (which may not be related to standby functions). The most concrete example of this type of product is air conditioners that may have crank case heaters that operate when the product is not performing any heating or cooling function.

Figure 7: Illustration of vertical versus horizontal policy approach



Source: Harrington et al, 2007

One issue mitigating against the use of vertical approaches is so called regulatory inertia, where existing mandatory requirements apply. In many cases, making changes to existing regulatory rules can be difficult and may take a long time. The inclusion of low power mode energy may change total energy and therefore label rankings, program eligibility and even MEPS levels, so there may be some resistance to modification of the program to include this energy element. An option to overcome this is to leave existing active mode (efficiency) requirements untouched and to apply horizontal requirements to low power modes independently (as set out in the previous section).

In terms of policy application, it is possible (and probably makes some sense) to exclude products from horizontal requirements where they are already covered by vertical requirements. However, while manufacturers may regard it as less than ideal, a product could in practice be independently subjected to both vertical (active mode and low power modes for a specified duty cycle) and horizontal requirements for low power modes. This means that low power modes would be effectively covered in two different ways. There may be some cases where there is some internal conflict in these cases, but this is not very likely.

Whether low power modes for products are included in vertical requirements or are subjected to horizontal requirements (or both) is ultimately a matter of regional preference, which needs to take into account existing requirements and the mixture of products to be covered by each and existing requirements. The most important point is that all products should also be covered by at least some requirements for low power modes, irrespective of whether those products that are covered by efficiency requirements for active modes.

8.7 Alternative approaches

While the approaches outlined above will serve us well for the majority of products, the best policy for some product types could be through a different or unique approach, and these should be fairly considered. A good example of this is the concept of “service provider pays” for set-top box energy (this applies to any customer premises equipment—CPE). This approach can overcome the split incentive of who is responsible for equipment costs and energy costs (the company owns the equipment and the user pays for the energy), which often drives product energy consumption in perverse ways.

Addressing energy use of set-top boxes has been difficult and unwieldy from the very beginning of policy action on them. This is due to the peculiar nature of the STB market, the closed nature of many of the STB systems, and the important role of connectivity (and security) for them. An alternative approach is to have no direct energy regulation of STB at all. This would alleviate a significant burden for policy makers and manufacturers to negotiate and implement regulations on them. In exchange, service providers (SP) would become responsible for the energy use of their products installed in the homes of end users, subtracting the cost of the electricity they use from the monthly SP bill.

Set-top boxes (and some other types of CPE) are unique in having the following attributes: the SP specifies the box, the SP controls their firmware (and updates it), the SP can keep the box active (through excessive downloads or other activity), the STB can track its operating patterns and store this, and finally, the SP has a continuing financial relationship with the customer. With all these ingredients in place, the SP can reasonably be expected to be responsible for the STB energy use. With this approach in place, at any time they can replace the hardware, improve the software, or do other things to reduce the STB energy consumption, and all of the net financial benefit accrues to the SP. It seems likely that this approach would be less burdensome and save more energy than alternatives of trying to regulate specific modes for these types of products and the associated problems with security for pay TV systems.

8.8 Integrating these key elements

The previous sections have set out a number of elements that could be used to deal with a range of energy issues within networks. In isolation, many of these could be reasonably effective in reducing energy. However, in order to maximise their effectiveness, they need to be integrated into a single coherent policy framework with the following elements:

- Ensuring that power management strategies and protocols to reduce energy consumption of products within networks are developed and available;
- Implementing the widespread use of these power management protocols in new products in global markets;
- Designing networks to facilitate low power operation of devices within and connected to networks, taking into the account the presence of legacy equipment for some time;
- Minimising power requirements of network interfaces and functions through widespread implementation of relevant technical standards for low energy networks;
- Setting limits on power consumption for products using a horizontal functionality approach taking into account power consumption for relevant modes and functions;
- Ensure that any policies and programs consider the context of equipment use in terms of non-energy effectives, secondary equipment and usability.
- Where relevant, use vertical approaches or other alternative or complementary measures;
- Ensure that there are test procedures to accurately measure the power consumption of products in order to support such a framework;

- Clear separation of test procedures, calculation methods, and power/energy limits.

To effectively and comprehensively incorporate consideration of network connectivity into product energy policy will require an evolution of thinking in general terms. While a new framework is also helpful for setting requirements for stand-alone products, it is essential to deal to products connected to networks. The new framework is evolutionary, not revolutionary, in that it builds on the many successful parts of today's energy policies. Many of the elements have already been used in existing policies.

A core element of this policy will be to complement existing policies that specify energy efficiency requirements for primary functions by allowing either vertical standards (product-specific) to be developed or independent generic horizontal standards applied to products to be applied in parallel with existing requirements.

9. Recommended projects and work plan

9.1 Strategy to build knowledge and information

This report has undertaken initial investigations into the issue of energy and networks. While there are a range of technical standards and other mechanisms already in the market which can reduce energy consumption of equipment connected to networks, there are some areas where knowledge and information are lacking and some areas where technical standards are still under development or even yet to be developed. At this stage, policy approaches with respect to networks are also rather underdeveloped.

This section summarises the foundation elements that are already in existence and that provide a basis for the development of a new policy framework to deal with energy and networks. It also identifies gaps and omissions which are likely to hinder the development of a coherent policy framework in the medium term.

In order to redress these perceived (or actual) gaps, a range of proposed projects have been developed by the authors to improve knowledge and understanding of issues surrounding energy and networks. As the issue of energy and networks is a complex subject, good information is essential in order to identify those areas where resources are required to facilitate the development and implementation of technical standards and to inform the creation of sound policy approaches to support low energy options within networks.

9.2 Existing foundations for policy development

This study has been able to provide some initial analysis on the key issue with respect to energy and networks. This section identifies the key elements that are already in existence and that can be used as a foundation for existing energy policy development. While some of these may require further work in terms of minor developments or ongoing maintenance, in general terms these elements can already be used as a basis for selected policy measures.

Key foundations that are already in existence are listed in the following sub-sections.

9.2.1 Power management strategies in networks

This issue in investigated in some depth in Section 6. This is quite a complex area and is one where there are some options that have been developed, but overall many of the options are quite technology and platform specific. As outlined in Section 6 the key approaches to energy management are:

a) Minimising power required for network links;

b) Minimising product power without the cooperation of the network;

c) Minimising product power with the cooperation of the network;

d) Internal power scaling of electronic equipment in proportion to processing load.

A number of power management protocols are already in existence and can be used in networks as set out below.

Network links: A significant problem for wired networks is that there is a strong trend towards high speeds (and speed costs power) and there have been no energy reduction strategies available. However, the recent development and imminent finalisation of IEEE P802.3az Energy Efficient Ethernet should provide a solid platform for moving forward for networks that are based on Ethernet connections and that use the Internet Protocol Suite. This standard will be ready for widespread implementation once it is ratified in late 2010.

Minimising power without the cooperation of the network: In terms of power management without the cooperation of the network, there are a number of technical standards that have already been developed and are in place that can be used to achieve these objectives (essentially using “proxy” based approaches). Some use proprietary software and/or hardware and some are platform specific (often these have to be fully integrated into operating systems to be effective) so have some limits to their widespread implementation, but can be effective nonetheless.

Minimising power coordinated within the network: This is potentially a major contributor to energy reductions in future networks. A number of examples are in existence for specific cases such as Wake-on-LAN and DPMS for data links between computers and monitors. However, these are quite technology specific and of limited application in most large scale networks. A promising protocol is HDMI Version 1.4a, which allows audio visual products on the network to coordination their power state based on the status of the “sink” (or master) device. This will provide an important platform from which to expand these type of protocols into other network types.

Power scaling: This clearly an important area for future energy savings. But the nature of this type of requirement does not lend itself to technical specifications. Requirements can be set but these have to be based on empirical measurement approaches.

9.2.2 Requirements for horizontal functionality

The recommended approach in this report is to expand the concept of horizontal functionality, which takes into account power consumption for relevant modes and functions, to include equipment with network capabilities. Setting limits on power consumption for products using a horizontal functionality approach is a key foundation for a global approach to addressing excessive standby energy consumption. The concept is already well developed in a number of program elements within Energy Star and European Codes of Conduct. While expansion of this approach to cover most electronic equipment and networks still needs to be done, this should be relatively straight forward.

9.2.3 Energy test method

IEC62301 Edition is about to be released as an FDIS and publication is expected late in 2010. This specifies a comprehensive test method for measurement of low power modes. Its ongoing maintenance is undertaken by IEC TC59 Maintenance Team 9. It should be used as the foundation for all power measurements for network equipment and low power modes and can be readily adapted to cover active modes of most electronic equipment.

9.3 Missing pieces – developing resource priorities

One of the primary objectives of this study is to identify gaps in terms of existing requirements and make preliminary assessment of where resources may be required to ensure that an integrated approach to energy and networks can be developed over time.

The following sub-sections provide a qualitative assessment of the gaps in each of the key areas required for an integrated strategy. These assessments have been subsequently used to develop the scope of a range of project proposals as part of an overall work plan, as detailed later in this section. Many of these elements complement and build on the existing strategies and technical standards documented in the previous section.

9.3.1 Power management strategies in networks

Network links: The approaches in wireless and other wired networks (other than Ethernet) are less certain as there are a number of approaches currently used. There may be potential for unifying these approaches in the future to provide a more universal platform within technical standards, so some review of these standards that cover networks is warranted (in particular wireless and wired AV networks).

Minimising power without the cooperation of the network: So while there are a range of technical options in existence, there appears to be no clear front runner in terms of generic open source approaches. A review of technical standards would provide in depth of pros and cons for each of the systems and allow an assessment of whether a more generic approach can be developed. However, this is not likely to be the most important part of a network energy management platform due to the specific requirements of this approach.

Minimising power coordinated within the network: The most promising approach appears to be a protocol that exposes function and power state to the network and sets up a range of internal protocols to allow the power state (and mode) of all products in the network to be coordinated and minimised. No such system exists for computer (IP) networks, although an approach using the SNMP communication protocol under the Internet Protocol Suite should be possible and could potentially be effective. This concept is possible to achieve using “Consumer Electronics Control” feature of HDMI Version 1.4a for digital AV networks, though needs work to specify how this should be done in a required and standardised way.

Power scaling: The problem arises as, in the absence of other strategies, power consumption of most electronic equipment that is based on data processing, does not vary much (if at all) with processing activity or data throughput. However, it would appear that there are a range of technical options to overcome these inherent problems through the implementation of specialised internal power management strategies. Unfortunately, virtually of these are likely to be proprietary in nature so do not lend themselves to specification in technical standards. The way forward for this particular topic is an empirical measurement type approach for different product types. This involves rewarding suppliers for achieving measured power scaling in their product designs (without caring how these are achieved in practice). This type of approach is already used extensive in programs like Energy Star and can be expanded to cover a broader range of equipment types.

9.3.2 Well designed networks

In the long term, networks will have to be designed to facilitate low power operation of devices within and connected to networks. This will require some understanding of the energy management strategies that are likely to be developed under the previous section and ensure that networks themselves are designed to provide the communication required while facilitating energy management of individual devices. One issue that will also be an important consideration is taking into the account the presence of legacy equipment. This would appear to be a critical issue within computer networks and some investigation into elements within the Internet Protocol Suite to ensure that these facilities are enshrined in future versions would appear to be an important ongoing task.

9.3.3 Developing requirements for horizontal functionality

While the concept is well understood, the first practical element in progressing this approach is mapping all common functions into modes for the most common and ubiquitous product types on the market. Further detailed technical investigations and measurements on real products would then be required to quantify the power budget required for different functional elements in a wide range of products. The impact of (poor) product design and configuration would need to be considered when developing proposals for power budgets for various functions (e.g. power supply configuration). An important consideration is who would be responsible for the development and ongoing maintenance of such an approach if it was to be undertaken as a global framework. There is no doubt that technology change is very rapid in all products and any approach to redress excessive standby would, at least in the short term, have to keep on top of the most recent product designs and technology changes.

9.3.4 Energy test method

Test procedures to accurately measure the power consumption of products is a key foundation of such a framework. As indicated previously, in a broad measurement context, IEC62301 Edition 2 should provide a sound approach to physical measurements of products for all relevant modes. One area where IEC62301 may need to be extended in the future is to cover DC powered products.

Testing of complex products with network connections requires a range of common content requirements for setup and configuration to be included in reference documentation. Many of the required elements already exist within Energy Star and European Codes of Conduct, so it may be possible to codify these into a global reference document for testing in networks. Once developed and the content is stable, this could by formalised within a standards group like IEC, ISO or IEEE in the medium term.

It is important that a repository for critical definitions be developed and maintained, Such a repository can be readily cited by governments and regulators and should be kept up to date and relevant in a way that facilitates current and future energy policy development. Care is also required to avoid “locking up” key regulatory definitions in international standards that can take 5 years to modify.

It is important to maintain a clear separation of test procedures and any post testing requirements such as usage patterns and power/energy limits. If any of these latter elements are included or embedded in test procedures, the test procedure is then rendered largely useless and will be shunned internationally.

9.3.5 Other issues for consideration

In terms of policy and program implementation, it is important to consider the context of equipment use in terms of non-energy effectives, secondary equipment and usability. These issues are generally well understood and experienced policy analysts should be able to deal with most issues on a case by case basis. However, some of these issues require some research and documentation.

Combining proposed new policy approaches with existing efficiency program requirements is an important issue. The proposals for horizontal functionality have been developed in a way that can complement existing requirements so should create minimal issues in terms of practical implementation.

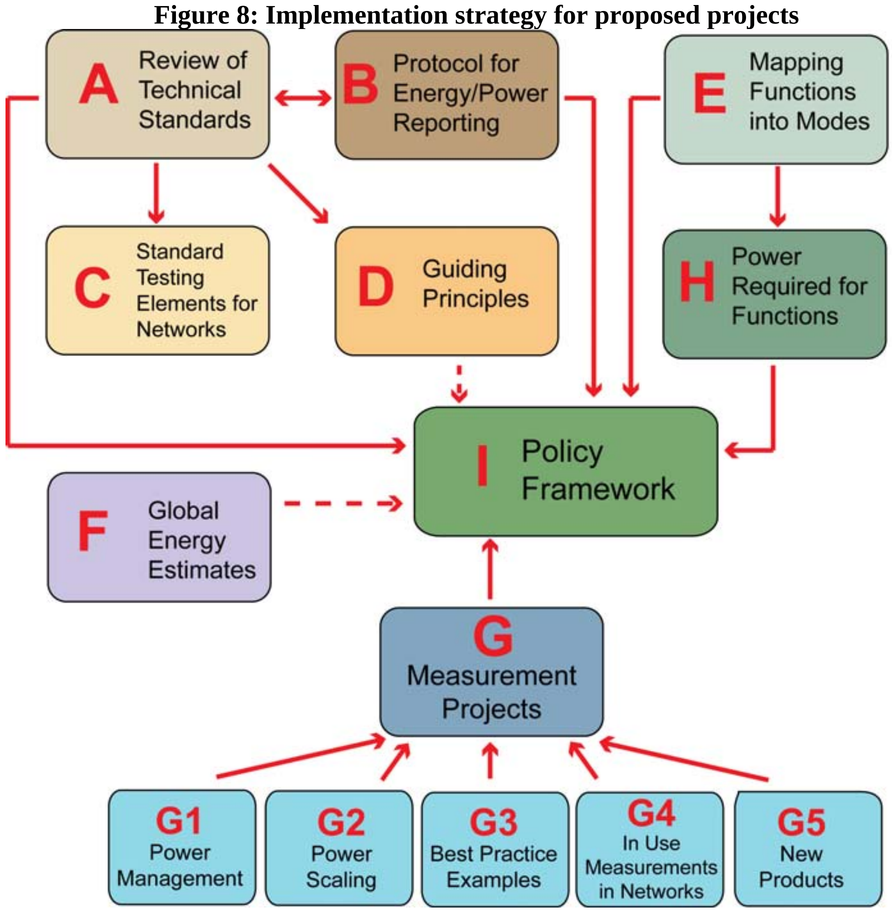
Another area of some concern is the rapid evolution of a number of so called “home networks” for a wide range of electronic equipment (including AV, computers and appliances). These are being heavily promoted as the latest and greatest development in high end developments in developed countries and are likely to proliferate rapidly once the technology is more developed and established. Many of these are being done in-house within individual companies or regional manufacturer groups. One concern is that these systems may not end up as open source specifications, which potentially limits their interoperability. Another major concern is that energy management requirements are unlikely to be integrated into these systems (at least in the first instance), which could have adverse energy impacts and undermine other work on networks. Some examples of work under way are within the IEC/ISO Joint Working Group 25 on home networks and the CHAIN appliance network standard being developed by CECED in Europe. It is hoped that some engagement with CECED on the development of the CHAIN standard can be made once the process moves under IEC TC59 or CENELEC TC59X WG 7 in the future. A watching brief on the development of these systems is warranted. Some engagement in the relevant standards development process many also be valuable after further investigation.

9.4 Summary of recommended projects

The proposed projects set out in the remainder of this section aim to fill many of the information gaps identified in the previous section. While each proposed project is nominally separate and could be conducted independently, there may be some subject overlap in some areas, so careful coordination and project management will be required. These projects need to address stakeholder concerns and should be undertaken in a time frame that facilitates the timely development of relevant policies to address energy in networks.

A suggest priority for each of the proposed projects is listed in Table 8. Proposed projects that rely on outputs from previous projects are noted in the implementation strategy as depicted in Figure 8 below. Most of these projects are supporting the eventual development of an integrated policy framework (Project I) which can then be used as the basis for both voluntary and regulatory programs.

Figure 8: Implementation strategy for proposed projects



It is recommended that all outputs from proposed projects undertaken be made publicly available through summary reports, technical documents and website updates. Efforts will also be required to communicate the outputs to all the relevant stakeholders, such as energy policy professionals, product manufacturers and standards organisations in an attempt to create a global consensus on the most effective technical and policy approaches to address these issues. A body will need to be responsible for coordinating and resourcing this work, possible as a joint project under APP and the 4E Standby Annex.

Table 8 summarises a range of projects which are recommended by the authors in order to improve knowledge and understanding of energy in networks and to provide a sound basis for the development of effective energy policies.

The remainder of this section sets out a wide range of proposed projects that will lead to the development of low energy networks and a policy framework to deal with low power modes and equipment connected to networks.

9.5 Overall project coordination: Developing a roadmap for technology and policy development for low energy networks and low-power modes

As there are number of proposed projects, it is important that these are managed in a coordinated manner to make sure all projects are complementary and contribute towards the common objective for low energy networks and minimal energy in low power modes. It is also critical that the outputs for these projects are used to inform the development of a sound policy framework.

This project, developing a roadmap for technology and policy development for low energy networks and low-power modes, will coordinate all of the proposed projects set out in the remainder of this section and build on the analysis in this report by considering the outcomes and results of these projects. This project will facilitate and manage the development of a coherent and comprehensive roadmap for technology and policy developments that can ultimately deliver low energy networks and specify coherent requirements for low-power modes.

A comprehensive policy to cover networks and low-power mode policy needs to define horizontal requirements, power management and network connectivity. The proposed projects to cover these topics will provide the basis for a comprehensive strategy to undertake the relevant research and collect information to allow sound policy approaches to be developed.

Other parts of an integrated roadmap will be oriented to technology development. In some areas there is likely to be a need to initiate or accelerate development of technical standards to facilitate low energy in networks. For example, there is a need to accelerate development and implementation of technology standards for device behaviour with respect to network/data connectivity and energy management; this would create consistent default behaviour of such devices, and ensure that they automatically wake up when they need to, and always go to sleep whenever they can.

Table 8: Summary of recommended research and development projects

Project	Title	Priority	Objective
Co-ordinate	Developing a roadmap for technology and policy development for low energy networks and low-power modes	High	Coordination of all projects to ensure they are complementary and contribute towards the common objective of low energy networks
A	Review of technical standards relevant to networks and energy	High	Examine energy elements in network protocols: identify opportunities and gaps with respect to energy issues to support the development of new energy policies for networks
B	Standard protocol for energy/power reporting	High	Develop or extent existing protocols to allow querying network-connected devices for standard energy information, possibly based on the Simple Network Management Protocol (SNMP).
C	Standard testing elements for networks	Med	Develop the test procedure content (setup and configuration) to measure modes where network functions are present
D	Implementation of guiding principles for good network design	Low	Identify the key elements that need to be included into network architecture and operating principles to achieve universal low energy networks in the long term
E	Mapping functions into modes for common products	Med	Document the most common product designs currently on the market and identify typical configurations and groupings with respect to functions by mode
F	Global network energy	Med	Make global estimates of energy use of equipment connected to networks (edge devices) and their network links, as well as the energy associated with network equipment
G	Measurement projects		Undertake quantitative measurements on real products with a network function to quantify differences in design and impact of behavioural elements on existing products
G1	Power management in four product types	High	Quantify the energy savings from effective (or ineffective) power management where products are moved into lower power modes
G2	Power scaling in active mode	Med	Document power scaling techniques in active mode for network equipment
G3	Exceptional best practice examples	Med	Quantify the power characteristics of exceptional low energy products from around the world in a standardised reporting format
G4	In use measurements of products with network connections	Med	Undertake field measurements of selected equipment during normal use (in the commercial or residential sector) to assess their actual energy consumption and impact of different energy management approaches, usage patterns and other factors to be quantified
G5	Measurements of new products with network connections	Med	Measure a reasonably large number of new products offered for sale in retail outlets in order to establish key energy characteristics of products with a network function (where feasible)
H	Power required for functions	High	Liaison with "function providers" (suppliers of technology, hardware (chips) and software) in order to document best practice approaches to minimise energy for a range of common secondary functions found in products, especially network functions
I	Policy framework for low energy networks	Med	Develop a policy structure for a range of standard power "adders" for different types of functionality, for both network functions and other functions and develop relevant specification for power management
Other	International battery charger test method		Not a core objective, but a battery charging test method is a critical complementary requirement to other policies

Priority: High = Higher priority short term, Med = Medium term, Low = Lower priority/longer term

Another important area is further development and implementation of energy-friendly network protocols; this is particularly to support network connectivity proxies, that maintain connectivity for a sleeping higher-power product.

A critical area of coordination is to ensure that main network protocols allow, support and even require power management (where appropriate) and that the related power management protocols are synchronously developed to facilitate these requirements. Accomplishing this and other activities will be done by technology standards organizations; the role of energy policy is to bring to them the need for the work, and policy carrots or sticks to motivate these organizations to initiate and conclude these activities.

One of the additional areas under a coordinated strategy (not listed as a specific project at this stage) is user interface standards to enable better communication between devices and the people who use them (it is likely that some of these might be mandatory, with others voluntary but recommended; Energy Star does this today for power controls). Another additional topic area is issues related to batteries, both in test procedures and specification content (again, building on what already exists in this area).

It is critical that a watching brief be maintained on relevant developments. In some cases these may warrant further work to keep abreast of new work (such as technical developments in network designs) or to facilitate developments in specific areas such as power management.

9.6 Project A: Review of technical standards relevant to networks and energy

This study has found that there are a large number of technical standards in place that detail with networks. Some of these have elements that deal with energy consumption and power management. However, some critical mainstream protocols do not appear to support adequate power management strategies. This project would undertake a review of technical standards for networks of interest and identify elements that could support new energy policies around networks and energy (with a first task to identify the relevant technical standards) as well as any energy gaps. Technical standards with potential for energy reductions may be of interest because they:

- Already exist and could be more widely implemented and therefore be required or rewarded by policy
- Have key energy features that are optional parts of existing standards and merit being required or rewarded by policy
- Need to be developed to add or improve features that result in energy saving
- Don't yet exist and need to be developed from the ground up.

The technical standards for networks to be reviewed would cover the full range of the OSI layers. The approach would be to identify key standards to:

- For standards with power management or energy saving features

  - are these widely implemented? (if not, why not)
  - if not, what could be done to speed implementation?
- For standards without power management or energy saving features
  - are such features technically possible?
  - what would be required to develop them?
  - what would be required to make them work?
  - which organisations would need to be engaged to make this happen?

Many devices in buildings might benefit from highly efficient standard low-data-rate network technology. One proposal to accomplish this is “Internet Ø”, deserves detailed investigation for its potential (see: cba.mit.edu/projects/I0/).

This project is seen as a fundamental area of research to identify existing technical standards that can be more widely implemented and to direct resources into areas that could have improved energy outcomes within networks. It is envisaged that this would be a desk study conducted over a relatively short period. Implementation of any recommendations with respect to further development of energy issues in network protocols would be considered as separate projects, if warranted.

9.7 Project B: Standard protocol for energy/power reporting

Section 6.5 documented a number of possible approaches in which the power of different products on a network could be coordinated by exposing information on their function, power and status to the network. A key need to enable this to happen in the future is a universal standard for Internet-connected devices for exposing this data is a standardised manner. Such a protocol is the equivalent of asking any device (be it a PC, printer or refrigerator) for information such as “who are you”, “how much power are you using now”, “what is your main function” and “how much energy did you use yesterday?”. What is needed is a single way to ask any device connected to the Internet the same question, and to be able to get a standard answer to it. This will allow further coordination of power states to be done in a cooperative way on networks based on the state and functions in other related devices.

There are already standard protocols for querying network-connected devices for standard information, so the best approach is likely to be to simply extend an existing protocol rather than define one new from the ground up. A good candidate for this is SNMP, the Simple Network Management Protocol. Like most core Internet protocols, it is defined by the Internet Engineering Task Force (IETF, see ietf.org). A similar approach has already been implemented in HDMI Version 1.4a, but at this stage this is limited to only HDMI compatible products which will always be quite limited. The proposal would aim to have a more universal protocol that could be implemented across any network platform.

There is already interest in such a standard in the IETF, and it is critical that this process be engaged as quickly as possible. In fact, the IETF is considering creating a working group solely to tackle energy management and it is critical that the energy community have adequate representation in this process (which it has lacked to date). The outcome is critical infrastructure for enabling new energy measurement capabilities over IP networks, and large potential energy savings through coordinated power management strategies. It is essential to have experts from the energy efficiency community engage in this process to ensure that any proposals are feasible and can feed into efficiency policy.

This project would benefit from the research undertaken for Project A, although rapid engagement in the relevant processes is critical, so work should be commenced immediately.

9.8 Project C: Standard testing elements for networks

While there are adequate measurement procedures in place for low power modes in the form of IEC62301 (via the forthcoming Edition 2), there are a number of complementary procedures that need to be developed to deal with network connections for a wide range of product types.

It is recommended that standard content to deal with network connections and related functions be developed. This can then be referenced or incorporated into the relevant test procedures which need to measure modes with a network function. This content would need to be generic to allow it to be referenced by generic test procedures (like IEC62301) (which could be the basis of a measurement test method for horizontal requirements) as well as product-specific test procedures. The content could be incorporated by copying or by reference to a network specific setup and testing procedure.

This proposed project would develop the test procedure content (setup and configuration) to measure modes where network functions are present. The test procedure content would specify how many network connections to make, their speed, physical configuration and characteristics, cable characteristics, use of ports, software configuration, enabling/disabling of features, data rates, data content and so forth for a range of connection types. An important element of this project would be the development of terminology and definitions associated with energy testing for equipment connected to network. Some of these testing and terminology elements are already specified in Energy Star and European Codes of Conducts, so these documents should be used as a starting point as the basis for an international specification. These would all interface with IEC62301 as the base energy test method but provide complementary specialised setup information for use with that standard for products with network connections where required. Some of these issues are documented in Annex C.6.

The ultimate location for these new testing requirements does not need to be decided in the first instance. The most important point is that the procedures are openly developed with extensive international consultation. Once the technical details are settled, consideration could then be given to the placement of this text into IEC or IEEE standards (for example). It is not advisable to place requirements that are rapidly evolving into international standards (during the initial phase). Once the technical details are agreed and settled, it can then be included into international standards.

This project should build on the research undertaken for Project A.

9.9 Project D: Guiding principles – implementation in major network protocols

Section 8.2 sets out a range of guiding principles for good network design. These ensure that products use the minimum energy possible while operating effectively.

The project would build on the work in Project A (a review of energy elements of major network protocols) and identify the key elements that need to be included into network architecture and operating principles. By their nature, the implementation of these guiding principles will be fairly general in nature, but will provide a good reference framework for the revision and upgrading of all network protocols over time.

9.10 Project E: Mapping functions into modes for common products

Section 4.3 defined a mode as a state which has a number of functions present and activated. Section 4.5 then set out a conceptual framework for the categorisation of functions into various types.

This project is an investigation into the common functions that are present for various modes in a wide range of common product types. The objective would be to document the most common product designs currently on the market and to identify typical configurations and groupings with respect to functions. This study is effectively desk research project that would look at product literature, manuals and other documentation in order to determine the likely functions present and active in a model in different modes.

This study will further assist in refining the categorisation of various functions and to identify new and possibly future functions in products. This study will help to identify the most important functions in products and will provide a sound basis for undertaking quantitative measurements in a laboratory on selected products which can be used to quantitatively assess the power requirements of various functions (Project G). It will also provide a framework for further research into power used for various functions (Project H).

9.11 Project F: Global network energy

One reason that network issues have been neglected to date is a lack of solid energy estimates of equipment connected to networks and the consequences of different types of network connectivity. This project would make global estimates of energy use of equipment connected to networks (edge devices) and their network links, as well as the energy associated with network equipment (these two overlap so the potential ‘double counting’ would be identified).

Important elements to be covered by the study are:

- Estimate stocks of networked products
- Estimates of global network energy use for major economies.
- Preliminary estimates of network induced energy

This study should build on the data collected and analysed in the IEA report on Gadgets/Gigawatts report and the recent LBNL report on energy use of network equipment in the US. The study should also provide preliminary estimates of the energy saving potential from the measures proposed in this report: energy management, reduced network link energy and horizontal requirements for low power modes.

9.12 Project G: Measurement projects

A series of quantitative measurements on real products with a network function (mostly in a laboratory, but including some field measurements) are proposed in order to quantify a number of important design and behavioural elements in existing products. To some extent, the measurements are intended to identify differences in power levels at a functional level and will allow some preliminary investigations to be undertaken to explain the source of these differences for equivalent functions, and how different implementation approaches can reduce energy consumption. This type of data provides a strong quantitative basis for developing meaningful policy proposals.

Each of the following projects can be treated as stand alone investigations, although there may be some overlap between them.

9.12.1 Project G1: Detailed exploration of overall power management in four product types

This project aims to quantify the energy savings that can accrue from effective (or ineffective) power management in products where products are moved into lower power modes whenever possible. Particular attention will be paid to the functions that are active in network connected products and whether measured products are able to achieve the ideal low power mode power levels while maintaining adequate functionality (network integrity, data exchange and/or reactivation).

The project will examine existing product power management implementation in four product categories with worst to best case power management implementation to be examined and documented for five products in each product category. The measurements will include observations on product quality of service and usability (latency etc.) for each of the available modes on the product. As far as possible, the measurements should deconstruct how energy savings are achieved through power management in the best case in each product genre and record any obstacles or limitations in their implementation.

The proposed product categories to be examined are: Games Consoles, Complex Set Top Boxes, PCs, and VoIP phones. Testing should be deployed internationally to ensure that a typical product range in each region is examined.

9.12.2 Project G2: Investigation of power scaling in active mode for electronic equipment

As set out in Section 6.6, scaling power requirements in electronic products in proportion to processing load or data transmission while remaining in active mode are technically possible. However, these are done in many different ways and are highly dependent on product design and configuration. Many low energy approaches use proprietary software and hardware to achieve active mode power scaling, so are not suitable for specification in technical standards. However, examples of very low energy variants do exist, especially in the mobile world. Mobile networks are particularly interesting because battery life is a primary diver of product design, so the imperative for low energy configurations is fundamental and has shaped product development for many years. Documentation of the power reductions that can be achieved in practice in real products is critical to inform policy development and to develop possible empirical requirements.

This study will focus on products that are generally required to remain in active mode because of the nature of their primary functions: this is mostly applicable to network equipment and some other specialised equipment types. In network equipment, power reductions may also be due to implementation of power reduction strategies within their network links, which should also be investigated and quantified as far as possible.

This project aims to examine a range of existing product power scaling techniques in active mode of network equipment with worst to best case power scaling to be examined and documented. The measurements will include observations on product quality of service and usability with different levels of scaling implemented. As far as possible, the measurements should deconstruct how energy savings are achieved through internal power management and reduction of link power in the best case in each product and record any obstacles or limitations in their implementation.

While the proposed product categories are yet to be finalised, an initial list could include switches, routers, ADSL2+ modems and wireless access points.

9.12.3 Project G3: Exceptional best practice examples

Occasionally there are examples of exceptional product design with respect to low power and low energy. These type of products are likely to combine low energy hardware with advanced software and power management techniques which could allow a high degree of scalability of power in proportion to processing load and the minimisation of energy consumption for a given duty cycle. The characteristics are to be identified through laboratory measurements and standardised assessment approaches.

This project encourages technical experts to identify and undertake laboratory measurements of the power characteristics of exceptional low energy products in a standardised reporting format from around the world. The product categories are completely open. The acquisition and testing of product will be ad hoc. Innovative suppliers should be encouraged to offer their lowest energy products for assessment. This could be organised in the form of a low level competition.

It is proposed that the results of the technical assessments be prepared and made publicly available. This will provide a valuable catalogue of data that can be used to inform policy makers in all regions.

9.12.4 Project G4: In use measurements of products with network connections

This project proposal is different to previous project elements in that it involves measurements of real products which are being used within real networks. The objective of this study is to undertake field measurements of selected equipment during normal use (in the commercial or residential sector) to assess their actual energy consumption. This will enable the documentation of usage patterns and other factors that affect energy consumption to be quantified. Ideally a number of different systems should be measured in parallel to allow quantification of a range of power management approaches, low energy network links, active mode scaling and other energy reduction techniques. This will provide practical assessments of energy saving potential and will also allow the identification of any practical implementation issues for products that have low energy configurations.

9.12.5 Project G5: Measurements of new products with network connections

This project differs from the previous project in that it aims to cover a reasonably large number of measurements on new products offered for sale in retail outlets (c.f. a test laboratory or a work establishment). This is merely an extension of the so called "basket of products" approach to quantifying standby trends at a country level, except that it will specifically target "electronic data based" products with network connections. As these measurements are carried out in a limited amount of time and in non-laboratory conditions (i.e. in retail outlets), the information that can be gathered is more qualitative in nature. However, measurements on a large number of products can be collected in a relatively short period.

While conceptually this is a straight forward task, some initial investigations will be required to determine what practical and useful measurements can actually be performed in the field within a limited time period (about 10 minutes per product). There will be need to specify a range of standard configurations and possibly supply some sort of standard network connection during measurements. Products that appear to be exceptional in their energy and performance could be acquired for more detailed investigations in a test laboratory.

9.13 Project H: Investigation of power required for functions

There are a limited number of functions that are required in appliances and equipment. Many of these are secondary functions (ancillary to the primary function of the product), including many network functions in edge devices.

This project will be research based and will involve close liaison with "function providers" (suppliers of technology, hardware (chips) and software) in order to document best practice approaches to minimise energy for a range of common secondary functions found in products, with particular attention paid to network functions. Investigations into network functions may require investigations of approaches across a number of OSI layers and may include advanced internal power management techniques. This research project could be complemented by selected measurements on products that are known to have leading edge technology already implemented.

This standard should build on the research undertaken for Project E.

9.14 Project I: Practical policy framework for low energy networks

Building on the results of Projects E, G and H, this project would further develop a framework and technical content for a set of requirements based on horizontal functionality. This could be used in voluntary and mandatory program specifications. The core would be a structure for a range of standard power "adders" for different types of functionality, for both network functions and other functions. This is more than just a listing of functions, as some network functions may be qualified by number or speed, or some other characteristic (e.g. whether a port is in use or not during the test).

A second part of the project would be to create the numeric values to populate the table. These would draw heavily on previous projects, which will provide a map of functions, clear information on power requirements for these functions in real products and information on what may be technically possible in terms of power requirements. Adders are likely to need review from time to time as technologies improve and new approaches to reduce energy are developed. Note that for individual product specifications (or for generic horizontal specifications) the standard adder value can be used or for specific products that are deemed not to require specific functions, this can be set to zero (for example, there might be a power adder for a colour display, but a vacuum cleaner specification for low-power modes might set this to zero on the grounds that a vacuum cleaner does not need such a display while asleep or off). This project could identify both "acceptable" levels of power consumption as well as "best practice" levels within the table of functional adders. Caps to the total power permitted (irrespective of how many functions are present) can be specified as part of the overall approach.

A third part of this project would be to specify power management requirements for products. Again, this would cover both stand alone products and products connected to networks. This would draw on Projects A, B, D and G, which will provide documentation on existing power management protocols and how these can be implemented in a practical sense. Requirements for network equipment (and other equipment that is required to remain in active mode) will need to be based on empirical measurements rather than via reference to technical standards.

9.15 Other projects: international battery charger test method

This test procedure is not core to the objectives of this report, but a number of products do have battery charging requirements, so a test method to determine overall charge efficiency and so called maintenance power requirements where they exist (e.g. float charge) is a critical underlying requirement and a complementary test procedure to adequately cover all modes of all products.

A battery test procedure is already in place for both Energy Star and in the state of California, so this is an obvious starting point for an agreed international approach to this testing element.

REFERENCES

AEA/Intertek 2010, A study of the energy consumption of domestic products in actual household use, an end use measurement project of 1200 homes being undertaken by AEA Technology and Intertek on behalf of DEFRA, Department of Energy and Climate Change and Energy Saving Trust.

Bennech 2006. Personal communication, Peter Bennech, August 2006, Swedish Energy Agency (STEM).

Bush 2001, US Presidential Executive Order 13221 – 13221: Energy Efficient Standby Power Devices, 2 August 2001, George W. Bush, see http://www1.eere.energy.gov/femp/regulations/eo13221.html

Calwell 2010, Arthur H. Rosenfeld Symposium & Reception, University of California, Davis, 9 March 2010. Presentation by Chris Calwell of Ecos Consulting. See http://eec.ucdavis.edu/uploadedmedia/symposiumreception.pdf

CEC 2007a, Comparison of Savings from the CEC and NTIA DTA Standards. California Energy Commission. See

http://www.energy.ca.gov/appliances/2007rulemaking2/documents/DTA_JUSTIFICATION.PDF

CEC 2007b, 2007 Energy Commission Business meeting, including Adoption of Proposed Repeal. The California Energy Commission, Transcript of 10 October 2007. http://www.energy.ca.gov/business_meetings/2007_transcripts/2007-10-10_TRANSCRIPT.PDF

E3 2006. Order out of Chaos – summary paper for the international standby power conference, Canberra, Australia, 6-7 November 2006. Paper available from www.energyrating.gov.au under E3 events.

ECCJ 2008, Top Runner Program – Developing the world's best energy efficient appliances, Energy Conservation Centre, Japan website, see http://www.eccj.or.jp/top_runner/index.html (English)

ECEEE 2010, Is efficient sufficient?, report prepared by ECOS Consulting for ECEEE, 22 March 2010. See http://www.eceee.org/sufficiency/

Ecos 2006. Final Field Research Report. Prepared by Ecos Consulting on contract to the California Energy Commission under PIER contract # 500-04-030, 31 October 2006.

EES 2006a, 2005 Intrusive Residential Standby Survey Report. Report 2006/02. Prepared by Energy Efficient Strategies on contract to the Equipment Energy Efficiency Committee, Australia. Copy available from www.energyrating.gov.au in the electronic library.

EES 2006b, Standby Power - Current Status. Report 2006/02. Prepared by Energy Efficient Strategies on contract to the Equipment Energy Efficiency Committee, Australia. Copy available from www.energyrating.gov.au in the electronic library.

EES 2008, Consultation Regulatory Impact Statement for the Revision to the Energy Labelling Algorithms and Revised MEPS levels and Other Requirements for Air Conditioners, prepared by Energy Efficient Strategies for E3 Committee, Report 2008/09. Copy available from www.energyrating.gov.au in the electronic library.

European Commission 2005, Commission Directive 1275/2008, The Eco-design Directive for Energy-using Products, Official Journal of the European Union. The EuP Directive came into force in August 2007.

European Commission 2008a, Code of Conduct on Energy Consumption of Broadband Communication Equipment, Version 3, 18 November 2008. http://re.jrc.ec.europa.eu/energyefficiency/

European Commission 2008b, Code of Conduct on Energy Consumption of Digital TV Services, Version 7, 18 November 2008. http://re.jrc.ec.europa.eu/energyefficiency/ Note that Version 8 was released on 15 July 2009.

European Commission 2008c, Commission Regulation (EC) No 1275/2008, 17 December 2008, Official Journal of the European Union.

European Commission 2010, 2010 Best Practices for the EU Code of Conduct on Data Centres, Joint Research Centre, Ispra, Version 2, see http://re.jrc.ec.europa.eu/energyefficiency/html/standby_initiative_data_centers.htm

Fraunhofer 2006, Draft Definition Document for Standby and Off-mode Losses (Lot 6, Task 1). Initial report dated 30 August 2006 under the European Commission Eco-design Directive contract. Available from www.ecostandby.org

Fraunhofer 2007, Preparatory Study Lot 6 "standby and off-mode losses" – report on task 1 (definition), task 2 (market data) and task 3 (consumer behaviour and local infrastructure). Interim reports dated 10 January 2007 under the European Commission Eco-design Directive contract. Available from www.ecostandby.org

Fraunhofer 2009, EuP Preparatory Studies: Lot 26: Networked Standby Losses: First Stakeholder Document, Fraunhofer Institute for Reliability and Microintegration IZM (with BIO Intelligence Service), European Commission report TREN/D3/91-2007/Lot 26, Preparatory Studies for Eco-design Requirements of EuP, 16 September 2009. Available from www.ecostandby.org

Fraunhofer 2010a, EuP Preparatory Studies: Lot 26: Networked Standby Losses: Draft Report Task 1 – Definition, Fraunhofer Institute for Reliability and Microintegration IZM (with BIO Intelligence Service), European Commission report TREN/D3/91-2007/Lot 26, Preparatory Studies for Eco-design Requirements of EuP, February 2010. Available from www.ecostandby.org

Fraunhofer 2010b, EuP Preparatory Studies: Lot 26: Networked Standby Losses: Draft Report Task 2 – Economic and Market Analysis, Fraunhofer Institute for Reliability and Microintegration IZM (with BIO Intelligence Service), European Commission report TREN/D3/91-2007/Lot 26, Preparatory Studies for Eco-design Requirements of EuP, February 2010. Available from www.ecostandby.org

Fraunhofer 2010c, EuP Preparatory Studies: Lot 26: Networked Standby Losses: Draft Report Task 3 – Consumer Behaviour and Local Infrastructure, Fraunhofer Institute for Reliability and Microintegration IZM (with BIO Intelligence Service), European Commission report TREN/D3/91-2007/Lot 26, Preparatory Studies for Eco-design Requirements of EuP, February 2010. Available from www.ecostandby.org

Gunaratne et al 2005, Managing Energy Consumption Costs in Desktop PCs and LAN Switches with Proxying, Split TCP Connections, and Scaling of Link Speed, International Journal of Network Management, Vol. 15, No. 5, pp. 297-310, September/October 2005. Paper by C. Gunaratne, K. Christensen, and B. Nordman. See http://www.csee.usf.edu/~christen/energy/pubs.html

Harrington 2005. Standby Requirements for Wet Products. Presented to NAEEEC/Industry Whitegoods Workshop, August 2005, Sydney. Copy available from www.energyrating.gov.au under E3 events.

Harrington 2006, Trends in television energy use: where it is and where its going. Paper by Lloyd Harrington, Keith Jones, Bob Harrison. Presented to ACEEE Summer Study, Asilomar, California, August 2006.

Harrington et al 2007, Standby Energy: building a coherent international policy framework – moving to the next level, European Council for an Energy Efficient Economy Summer Study, June 2007. Paper by Lloyd Harrington, Jack Brown, Shane Holt, Alan Meier, Bruce Nordman, Mark Ellis. See www.eceee.org

Harrington et al 2008, "Standby Power: Building a Coherent International Policy Framework", ACEEE Summer Study on Energy Efficiency in Buildings, 2008. Paper by Lloyd Harrington, Hans-Paul Siderius, Mark Ellis. See www.aceee.org

HDMI LLC 2010, HDMI Networked Products and Consumer Electronics Control (CEC) Protocols for the Network Standby Mode and Other Features, HDMI Version 1.4a, 4 March , 2010, See http://www.hdmi.org/manufacturer/specification.aspx

IEA Digital Networks Workshop, July 2007.

See http://www.iea.org/work/workshopdetail.asp?WS_ID=285

IEA 2001, Things that go blip in the night – standby power and how to limit it, International Energy Agency, see http://www.iea.org/publications/free_new_Desc.asp?PUBS_ID=1110

IEA 2008, Implementing Agreement on Efficient Electrical End-Use Equipment (4E): Programme of Work, January 2008. http://www.iea-4e.org/

IEA 2009, 4E Standby Annex: Programme of Work, October 2009. http://standby.iea-4e.org/

IEA 2009a, Gadgets and Gigawatts -- Policies for Energy Efficient Electronics, International Energy Agency, May 2009. See http://www.iea.org/w/bookshop/add.aspx?id=361

KEMCO 2005, Standby Korea 2010 – Korea's 1 watt plan, Korea Energy Management Corporation and the Ministry of Knowledge Economy (available in English and Korean).

KEMCO 2010, Korea's Energy Standards and Labeling Program – Market Transformation, Ministry of Knowledge Economy and Korea Energy Management Corporation. See http://www.kemco.or.kr/new_eng/pg02/pg02100101.asp (Korean and English)

Lanzisera and Nordman 2010, Network Equipment Energy Use and Savings Potential in Buildings, paper by Steven Lanzisera and Bruce Nordman, ACEEE Summer Study in Buildings, Asilomar, August 2010.

Meier & Siderius 2006, Regulating Standby. Paper by Dr Alan Meier and Hans-Paul Siderius. Presented to ACEEE Summer Study, Asilomar, California, August 2006.

Meier et al 2007, Buildings as Networks: Danger, Opportunity and Guiding Principles for Energy Efficiency, September 2007. International Workshop on Energy Efficient Set-top Boxes and Digital Networks, July 2007. Paper by Meier Meier, Alan, Bruce Nordman, and Mark Ellis, See http://www.iea.org/Textbase/work/workshopdetail.asp?WS_ID=285

Meier et al 2008, Low-Power Mode Energy Consumption in California Homes, Report by Alan Meier, Bruce Nordman, John Busch, Christopher Payne, Richard Brown, Gregory Homan, Maria Sanchez, and Carrie Webber, Report CEC-500-2008-035. See: http://www.energy.ca.gov/publications/displayOneReport.php?pubNum=CEC-500-2008-035

Nordman 2004, Developing and Testing Low Power Mode Measurement Methods, CEC-500-04-057, September 2004. Paper by Bruce Nordman. See: http://www.energy.ca.gov/pier/project_reports/500-04-057.html

Nordman 2006. The Way Forward: A New Standby Framework. Paper presented to the international standby power conference, Canberra, Australia, 6-7 November 2006. http://www.energyrating.gov.au/forums-2006-standby.html

Nordman and Christensen, 2007, "Improving the Energy Efficiency of Ethernet-Connected Devices: A Proposal for Proxying," White Paper, Version 1.0, Ethernet Alliance, October 2007. Paper by , Bruce Nordamn and Ken Christensen http://ethernetalliance.org/library/white-papers.html

Nordman 2007, Energy Consumption of Networks, paper presented to International Workshop on Energy Efficient Set-top Boxes and Digital Networks, 6 July 2007. Bruce Nordman, Lawrence Berkeley National Laboratory. http://www.iea.org/work/workshopdetail.asp?WS_ID=285

Nordman et al 2007, Draft Principles for Energy Efficient Digital Networks and Network-connected Devices, International Workshop on Energy Efficient Set-top Boxes and Digital Networks, International Energy Agency, July 6, 2007. Paper by Bruce Nordman, Alan Meier, Mark Ellis. See http://www.iea.org/Textbase/work/workshopdetail.asp?WS_ID=285

Nordman et al 2009, Bruce, Hans-Paul Siderius, Lloyd Harrington, Mark Ellis, and Alan Meier, Network connectivity and low-power mode energy consumption, Energy Efficient Domestic Appliances and Lighting, 2009. Paper by Bruce Nordman, Hans-Paul Siderius, Lloyd Harrington, Mark Ellis, and Alan Meier. See www.eedal.eu

Nordman 2009, What the Real World Tells Us about Saving Energy in Electronics, 1st Symposium on Energy Efficient Electronic Systems (E3S), CITRIS / UC Berkeley, June 11, 2009. See http://www.citris-uc.org/events/E3S

NTIA 2007, DTV Converter Box Coupon Program, Information Sheet for Manufacturers, National Telecommunications and Information Administration, March 2007. See http://www.ntia.doc.gov/dtvcoupon/DTVretailers.pdf

REMODECE 2008, Residential Monitoring to Decrease Energy Use and Carbon Emissions in Europe, project supported by Intelligent Energy for Europe (contract no. EIE/05/124/S12.419657). See http://www.isr.uc.pt/~remodece/

Sood 2009, Presentation on IEEE 802.11 Wireless LAN (WiFi), by Kapil Sood, Intel given as part of a Plenary Tutorial presentation to IEEE 802.3, titled "Energy Efficiency and Regulation", 13 July 2009, San Francisco, see http://ieee802.org/Tutorials.shtml (Tutorial #2)

Standby Data 2007, Basket of Products: A means of regularly measuring new product releases to track global standby power trends. Discussion paper prepared by Energy Efficient Strategies on contract to the Equipment Energy Efficiency Committee, Australia. Copy available from www.energyrating.gov.au/standbydata/

U.S. EPA, ENERGY STAR® Program Requirements for Imaging Equipment, Version 1.0, 2006.

http://www.energystar.gov/ia/partners/product_specs/program_reqs/Prog_Req.pdf

U.S. EPA, ENERGY STAR® Program Requirements for Computers, Version 4.0, 2006.
http://www.energystar.gov/ia/partners/product_specs/program_reqs/Computer_Spec_Final.pdf

U.S. EPA, ENERGY STAR® Program Requirements for Set-top Boxes, Version 2.0, 2008,
http://www.energystar.gov/ia/partners/prod_development/revisions/downloads/settop_boxes/Set-top_Boxes_Spec.pdf

Wikipedia – many of the standard terms and definitions used in this report are based on or derived from information on Wikipedia and other public domain sources. See http://www.wikipedia.org/

TECHNICAL STANDARDS

The technical standards are referenced in this report. The standards should be individually examined in order to ascertain the technical details specified.

CEA-2013-A (ANSI), Digital STB Background Power Consumption, July 2007, available from http://www.ce.org/Standards/browseByCommittee_2785.asp

CEA-2022 (ANSI), Digital STB Active Power Consumption Measurement, August 2007, available from http://www.ce.org/Standards/browseByCommittee_3373.asp

ECMA-393, proxZZZy for sleeping hosts, Edition 1, February 2010 See http://www.ecma-international.org/publications/files/ECMA-ST/ECMA-393.pdf

IEC 62301, 2005, Household electrical appliances - Measurement of standby power, Edition 1, June 2005, International Electrotechnical Commission, Geneva. See www.iec.ch

IEC 62301, 2009, Household electrical appliances - Measurement of standby power, Edition 2, Committee Draft for Voting IEC 59/540/CDV, 28 August 2009, International Electrotechnical Commission, Geneva. See www.iec.ch

IEEE, P802 Network standards – this is split into many sub-standards. See http://www.ieee802.org/ for details.

IEEE 802, Standard for Information technology -- Telecommunications and information exchange between systems -- Local and metropolitan area networks

IEEE 802-2001 (R2007) IEEE Standard for Local and Metropolitan Area Networks: Overview and Architecture

IEEE 802a-2003 (R2007) IEEE Standard for Local and Metropolitan Area Networks: Overview and Architecture - Amendment 1: Ethertypes for Prototype and Vendor - Specific Protocol Development

IEEE 802b-2004 (R2007) IEEE Standard for Local and Metropolitan Area Networks: Overview and Architecture - Amendment 2: Registration of Object Identifiers

Disbanded standards and specialised groups are not listed below:

IEEE 802.1: Bridging & Management

IEEE 802.2: Logical Link Control (inactive)

IEEE 802.3: CSMA/CD (Ethernet) Access Method

IEEE 802.11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications (includes protocols for a/b/g/n)

IEEE 802.15: Wireless Personal Area Networks (5 sub-parts)

IEEE 802.16: Broadband Wireless MANs (WiMAX)

IEEE 802.17: Resilient Packet Rings

IEEE 802.20: Mobile Broadband Wireless Access

IEEE 802.21: Media Independent Handoff

IEEE 802.22: Wireless Regional Area Network

IEEE P802.3az Energy Efficient Ethernet Task Force website, http://www.ieee802.org/3/az/index.html

IEEE 1394 - Standard for a High-Performance Serial Bus (also called Firewire)

IEEE 1621 - Power Management Controls - User Interface Standard

ISO7498, 1989, Information processing systems -- Open Systems Interconnection -- Basic Reference Model, International Standards Organisation, Geneva

Annex A: Convening bodies

A.1: APP Alignment of Standby Power Approaches Project

The Asia-Pacific Partnership on Clean Development and Climate (known as APP) is an innovative new effort to accelerate the development and deployment of clean energy technologies. Current Partners are Australia, Canada, China, India, Japan, Korea and the USA.

While each of the Partners has different natural resource endowments, and sustainable development and energy strategies, Partners are already working together and will continue to work to achieve common goals. By building on the foundation of existing bilateral and multilateral initiatives, the Partners will enhance cooperation to meet both our increased energy needs and associated challenges, including those related to air pollution, energy security, and greenhouse gas intensities.

The Partners will collaborate to promote and create an enabling environment for the development, diffusion, deployment and transfer of existing and emerging cost-effective, cleaner technologies and practices, through concrete and substantial cooperation so as to achieve practical results. The Partners will also cooperate on the development, diffusion, deployment and transfer of longer-term transformational energy technologies that will promote economic growth while enabling significant reductions in greenhouse gas intensities. In addition, the Partners will share experiences in developing and implementing our national sustainable development and energy strategies, and explore opportunities to reduce the greenhouse gas intensities of our economies.

The Building and Appliances Task Force (BATF) is one of 8 specialised task forces within APP. BATF recognise that reducing our use of energy for buildings and appliances decreases the demand for primary energy and is a key means to deliver better economic performance, increase energy security and reduce greenhouse gas and air pollutant emissions. Partner countries have recognized for some time the importance of cooperating on energy efficiency for buildings and appliances, and have already taken a range of bilateral and other collaborative actions in this area. As the Partners represent a majority of the world's manufacturing capacity for a diverse range of appliances, we have the potential to drive significant regional and global improvements in energy efficiency in this sector. The Partners will demonstrate technologies, enhance and exchange skills relating to energy efficiency auditing, share experiences and policies on best practices with regard to standards and codes, as well as labelling schemes for buildings, building materials and appliances.

BATF objectives are to:

- Use cooperative mechanisms to support the further uptake of increasingly more energy efficient appliances, recognizing that extensive cooperative action is already occurring between Partner countries.
- Promote best practice and demonstrate technologies and building design principles to increase energy efficiency in building materials and in new and existing buildings.
- Support the integration of appropriate mechanisms to increase the uptake of energy efficient buildings and appliances into broader national efforts that support sustainable development, increase energy security and reduce environmental impacts.
- Systematically identify and respond to the range of barriers that limit the implementation of end-use energy efficiency practices and technologies.

The APP project number BATF PR-022006 *Alignment of national standby power approaches* was approved in 2006 by the BATF. The project is being co-lead by Australia and Korea.

APP Partner countries recognize that excessive standby power continues to be a concern in their respective marketplaces. This recognition has spawned a variety of policy responses but where no two Partners approach this issue with the same policy mix. Even Australia and Korea, which have the most similar schemes, operate without coordination surrounding targeted appliance types, performance levels and implementation dates. This lack of coordination could create trade issues for multi-national suppliers subject to multiple national schemes.

The project seeks to report progress in each Partner country using the IEA voluntary 1 Watt target as a comparative benchmark. The project will initially focus on reporting the success of “early adopter” product suppliers and, over time, move to report those companies and products that have not reduced passive standby power to 1 Watt. The project is about regular measurement and public reporting seeking to inform the marketplace in Partner countries. It will not dictate to Partners what policy tools to use, rather it will measure and compare over the next decade the effectiveness of those policies chosen in each Partner marketplace.

The key objectives of the project are:

- *Energy Reduction and Greenhouse Abatement*: To reduce the standby energy consumed by products over the next decade without compromising the functionality of the appliance by using the following elements.
- *Common target*: To agree to adopt the IEA passive standby power target – 1 Watt by 2010 – as the aspirational (voluntary) goal of this project.
- *Common policies*: To consider the use of agreed policies that are practical and cost effective to address standby power.

- *Common Products*: To measure the effectiveness of agreed standby policies by regularly collecting low power mode data of an agreed "basket of products".
- *Common Test Method*: To encourage the use, understanding and acceptance of the definitions and methodologies set out in IEC 62301 in all partners.
- *Global alignment*: To develop this APP project in a manner that is complementary and comparable to other projects by countries outside of the APP group.

More information can be found at http://www.asiapacificpartnership.org/

Some APP related projects are described in Section G.6 and can be found on http://www.energyrating.gov.au/standbydata/index.html

A.2: 4E and the Standby Annex

The International Energy Agency (IEA) is an intergovernmental organisation which acts as energy policy advisor to 28 member countries in their effort to ensure reliable, affordable and clean energy for their citizens. As energy markets have changed, so has the IEA. Its mandate has broadened to incorporate the "Three E's" of balanced energy policy making: energy security, economic development and environmental protection. Current work focuses on climate change policies, market reform, energy technology collaboration and outreach to the rest of the world.

To facilitate international cooperation and collaboration on in specialised areas, the IEA has developed a framework for Energy Technology Agreements, which are also known as Implementing Agreements. The IEA describes implementing agreements as follows:

Ensuring energy security and addressing climate change issues in a cost-effective way are the main challenges of energy policies and in the longer term will be solved only through technology cooperation. To encourage collaborative efforts to meet these energy challenges, the IEA created a legal contract – Implementing Agreement – and a system of standard rules and regulations. This allows interested member and non-member governments or other organisations to pool resources and to foster the research, development and deployment of particular technologies.

IEA implementing agreements are organised into eight groups as follows:

- End-Use / Buildings
- Cross-Cutting Agreements
- End-Use / Electricity
- Fossil Fuels
- Fusion Power
- End-Use / Industry

- Renewable Energy
- End-Use / Transport

As of early 2010 there were 42 implementing agreements in force.

The IEA Implementing on Efficiency Electrical End-Use Equipment (4E) was formed in March 2008 in order to provide a forum for countries and other stakeholders to:

- share expertise and develop their understanding of end-use equipment and policies; and
- facilitate coordination of international approaches in the area of efficient end-use equipment.

Participating members agree that this objective will be met through:

- collecting and sharing information on end-use equipment technologies and programmes; and
- pooling resources for agreed projects and tasks.

The Interim Executive Committee of 4E agreed in principle to establish four research projects (Annexes):

i) Mapping and Benchmarking;

ii) Standby Power;

iii) Set-Top Boxes;

iv) Motor Systems.

Recent proposals for new annexes on LED lighting and compliance are being considered. More information can be found on http://www.iea-4e.org/

This report falls under the responsibility of the Standby Power Annex. The overall goal of the Standby Power Annex is:

To monitor and report the extent of, and changes in, energy consumption by electrical appliances in low-power modes (standby power); and support the development of policies which seek to minimise excessive energy consumption by products in standby power modes.

The 4E Standby Annex seeks to assist policy makers in development, implementation and measurement of policy action for standby power through:

I. Enhancing market knowledge: The Annex will enhance the ability of individual countries to gather, analyse, and share market data on standby power, thus, improving the overall knowledge base for decision making and enabling valid international comparisons so the rate of improvement or deterioration in standby power use can be quantified within and between countries against the backdrop of the policies employed.

II. Enabling improved policy application: The Annex will assist in the development of tools for the application of horizontal approaches to standby which offer the most robust policy approach to tackling low power energy use across a wide range of products - enabling ongoing policy implementation without rapid redundancy and the possibility of coordination of policy approaches between countries.

III. Integration and co-ordination: Building and developing the work undertaken by groups like the Asia Pacific Economic Cooperation (APEC), the Asia Pacific Partnership on Clean Development and Climate (APP) and the European EcoDesign Directive.

The 4E Standby Annex encompasses the following key areas:

A. Data related activities: Undertake data collection, data collation and analysis, information dissemination through publication of reports, organisation of workshops and seminars, provision of information to other organisations, groups and conferences;

B. Evaluation of policies: Undertake studies to assess standby power polices in force and proposed, document different approaches and assess their relevance in different market structures;

C. Horizontal policy approach: Undertake technical work which will assist in the development of a horizontal policy approach to tackle standby power for the growing number of products on the market;

D. Network products: While networking is technically a sub-element within a generalised horizontal approach to standby, it is an area of growing importance and concern, due to the number of products within this element and the magnitude of the energy related issues within networks. This task will examine the technical issues involved in network products and the potential for policies to enable effective power management.

The website for the 4E Standby Annex is http://standby.iea-4e.org/

A.3: Network Standby Task in the Standby Annex

Network standby is a key area of interest to Standby Annex members. 4E Annex areas of specific investigation on Network standby include:

- Undertake a technical review of international and industry standards and protocols for network products and identify key shortcomings in terms of power management within networks.
- Investigate a possible range of network functional allowances which could be used in a horizontal approach to standby power (draft initial levels).

This report is the first step in exploring some of these technical issues surrounding network products.

Since 'standby' was recognized as an energy efficiency issue, a growing number of countries have established policies that reduce low power mode energy consumption. However, most of these policies, e.g. the EU Ecodesign regulation on standby and off modes, only target simple low power modes. Meanwhile, a rapidly increasing number of products have greater numbers and increasingly complex low power modes. The complexity arises from the fact that many products are already or will be in future connected to a network and will maintain a connection to the network when the product is not performing one of its main functions. Most standby definitions and levels do not take this complexity into account. As a result, only a few policies cover network-connected modes, and not in a consistent or comprehensive way.

Annex B: User related requirements

B.1: Introduction of the issue of product usability

This section provides further background to the issue raised in Section 6.2.

From a high level perspective, the primary objective of energy efficiency policy is to minimise the total energy consumption of products while delivering adequate (or the required minimum) energy service. The traditional approach to this has been to set limits on the active mode energy consumption of products (usually defined in terms of energy efficiency). As previously discussed, there are technical limits to energy efficiency (although these limits are continually changing as technology improves). This approach works well for products where the energy service is well defined and of a finite size (eg kg of clothes to be washed) or for products that operate continuously (eg refrigerators).

The total energy consumption of a product is a function of the average power in each possible mode and the time spent in that mode. For products that operate (or could operate) for very long hours, an effective energy reduction strategy is power management — getting products into the lowest possible mode while maintaining satisfactory service. This is particularly important for those products which operate for long hours but which have low levels of utilisation (e.g. computers, most network equipment) or which can be accidentally (or intentionally) left on for very long hours (audio visual equipment). This issue is investigated in great detail in Section 6.

B.2: Latency

When considering the effects of power management on a product's energy consumption, it is important to understand how this may affect the usability of the product — how the user perceives changes in performance introduced by power management. A key issues is latency.

In simple terms, latency is the time that it takes for a product to start up and be ready for use, or the time that a product takes to change state and respond to a user request or provide a function. It can also be defined as the delay time “beyond what is considered to be a reasonable delay” from the users perspective. What is acceptable depends on the product and the user context.

From a network perspective, latency can mean the time that it takes for a packet of data to be transmitted from one node to another. In some cases it can mean the time that it takes from when a packet is sent until confirmation that it has been received (ie the round-trip time for communication). The latency of a network when in full active mode is not the key area of interest in this report. However, the latency to establish a full active network connection from a low power mode is of interest (network start-up latency).

Latency is quite critical as it affects the usability of the product. For some products, users expect some start-up time and this is considered normal and acceptable. For example, users expect to wait for a minute or so before being able to use a computer from start-up (cold boot) and they normally expect to wait 5 to 15 seconds before a picture is available on a television once it is switched on. However, if a computer is in sleep mode (eg during lunch), a delay of 5 or 10 seconds may be at the limit of acceptability.

For some types of products, very low latency is essential to ensure usability of a product. The most obvious example is equipment used for voice telecommunications — whether standard telephone network (PSTN or ISDN) or VOIP — in these cases the system has to be available for use when required almost instantly (within a second or so) and the time delay during use has to be close to zero. Failure to deliver this consistently renders the system unusable.

Latency is usually a function of the product design. The startup time from a low power mode is usually determined by the product hardware and software. Of most interest here is the latency associated with intermediate power modes which are present and activated regularly as a result of power management strategies.

This Annex focuses on the latency issues associated with changes in mode (eg from low power modes to active mode) rather than the latency associated with normal use in active mode (which is a function of the product design and usability).

B.3: Issues that affect latency

When power management is activated in a product, certain functions are modified or shut down to save power. The latency effect depends on which functions are affected and how quickly they can be reactivated.

A good example of power management and the affect of latency is a photocopier or a laser printer. When these products are not in active use (which is normally much of the time), they usually enter energy saving modes (these have various names). The most common strategy is to turn off heaters that are required when an image is being formed on the printing drum. Even when in a low power state, some systems turn their heaters on from time to time to maintain a minimum drum temperature. The energy needed to maintain the drum at temperature is substantial so it is important to reduce this during non-use times as much as possible. However, this also means that when a printing job is received, there is some delay while the heater is activated and the drum is heated up to its operating temperature. Most of these types of products maintain a fully active network interface even in low power modes so print jobs can be received and processed at any time from sleep mode. The latency of the product is dictated by the physical properties of the imaging equipment and not the network connection.

In the case of computers, the product can enter various states ranging from full power active to idle to sleep to off. The latency from each state to full active mode typically increases as the power level of the low power mode decreases. The limiting factor for the latency is also not network related in this case. A wide range of proprietary designs are being developed to reduce latency from off and from sleep while achieving low power levels in those modes.

Some products can be affected by network related issues with respect to latency. Once case is where a computer is in sleep mode but maintains some sort of network presence (either through a proxy, or via a wake on LAN type function) – in this case the product latency during wake up has to be short enough to ensure that the network connection is maintained satisfactorily.

Another network-related latency is from changing Ethernet link rate. PCs are commonly (although not universally) capable of dropping the data rate of their Ethernet link when asleep from 1 Gbps to either 100 Mbps or 10 Mbps. This saves power (as much as several watts) and unsurprisingly, systems have low traffic levels when they are asleep (typically waiting for a Wake on LAN signal). The latency in each direction is about 2 seconds. When going to sleep, this never introduces user issues since the product is not in use. When waking up, today's systems use a similar amount of time for the rest of the hardware to become ready for use, so that so long as the link rate change is occurring at the same time, it does not add to this latency. Energy Efficient Ethernet (IEEE P802.3az, see IEEE, 2010), when widely available on the market, will have a different sort of latency that occurs many times every second, but is measured in dozens of microseconds so is not an issue from the user's perspective.

Products with a voice-related function (eg VOIP telephones) need to maintain a network connection to receive calls and must have very short latency during use to be usable. The challenge for these products is to reduce energy consumption to the lowest level possible while maintaining a continuous network connection and short latency for any transition to full active mode.

A disturbing example of the relationship between latency and energy consumption has been noted in some hard drive video recorders (also called PVRs or DVD recorders), which are commonly used with household televisions. These products are already covered by several standby related regulations (such as Europe, Korea, Canada and California) and therefore are generally shipped with a low power standby as the default configuration. While this mode is usually less than 1W, products can take as long as 1 to 2 minutes to boot up; this is hardware and software related as there is typically no digital network connection present. However, many of these products also have a sleep (quick start) option (instead of the default low power standby mode). In this mode the power is much higher (5W to 10W) but the startup time is much shorter - 5 to 10 seconds. Given that these products probably spend 90% or more of their life in a low power (non active) mode, the overall energy penalty for such a fast start option is substantial over the product life.

This is a good illustration of how the technical requirements of regulations can be thwarted with user programmable software settings to increase user convenience (but which also increases power). Hence latency and usability are important considerations when setting limits on power consumption in different modes and for different functions. Meeting a technical limit on power consumption is of no value if users never put the products into those modes.

As a general rule, the time taken to establish a network connection (or other network related issues) is not usually a limiting factor with respect to latency and usability of most products. But it can be an issue of usability where power management is activated.

B.4: User interfaces

Saving energy in those devices where interaction with people is an important component (most electronic products) requires several steps. One is the technical ability of the product to accomplish its desired function at lower energy cost. Another is for the user to actually use the product in a way which uses the energy saving features. In some cases this requires communication between the device and the user so that the user understands what the device is doing, and the device understands the users preferences. This is mediated by the "user interface" of the product.

One barrier to use of power management in electronics is confusion about power states. This first arose for things like PCs and printers, but as more devices get more possible power modes, will extend to many electronic devices. There is a standard which addresses this topic, IEEE 1621. It covers an overall concept for power states (three basic states: on, sleep, and off, with sub-states within these possible), the sleep metaphor, as well as terminology, symbols, and colours associated with different power states.

While power control is important, other user interfaces relevant to low-power modes and networks also need attention, such as battery charging, and wireless power transfer.

Annex C: Test procedure issues

C.1: International test method for standby power – IEC 62301

IEC Technical Committee TC59, which covers the performance of household appliances, first examined the issue of standby power in 1999. After a brief investigation, it was agreed that there was a lot of interest and activity in the area of standby power and that a new international test method was warranted. TC59 created Working Group 9 to prepare an international test method on standby power in 2001. Edition 1 of IEC 62301 was published in 2005.

Since its publication, the standard IEC 62301 has been used extensively in many countries around the world. Experience in the use of the standard led to a range of proposals to refine the technical measurement approaches set out in the standard. While the underlying approaches in IEC 62301 were considered robust, the proposals introduced a number of evolutionary improvements to the test method, most notably the use of high speed sampling over longer periods to better document the behaviour of the product and to more accurately measure its power consumption.

Edition 1 was primarily a method of test for determination of power consumption in any relevant low power mode. However, it did not define these low power modes; usually, external standards or regulations that reference IEC 62301 define these modes. However, within the standard a definition of "standby mode" was included as follows to assist in defining the scope and application of the standard:

lowest power consumption mode which cannot be switched off (influenced) by the user and that may persist for an indefinite time when an appliance is connected to the main electricity supply and used in accordance with the manufacturer's instructions

Effectively, this definition of "standby mode" ("minimum power mode") was an internal definition within the standard, but it did create some confusion in the energy policy world. In 2006 IEC TC59 directed WG9 to review the definition of standby (mode) in order to clarify the difference between standby mode and off mode. TC59 also turned Working Group 9 into a Maintenance Team (MT9) (which is effectively a permanent working group which is responsible for maintaining a published standard).

C.2: IEC 62301 Edition 2

In response to the instructions from TC59 regarding modes, MT9 prepared a range of new definitions with respect to product modes for inclusion in Edition 2. The main new definitions of interest are:

- Mode: a state that has a particular set of functions activated (and may include no function)
- Function: a predetermined operation undertaken by the energy using product

- Active Modes (primary function), Low Power Modes and Disconnected Mode.
- Low Power Modes include: Off modes, Standby Modes and Network Modes.
- Off Modes: no standby mode, network mode or active mode function activated and where the primary function is not activated.
- Standby Modes: one or more defined user oriented or protective functions activated.
- Network Modes: at least one network function is activated but the primary function is not activated.
- Product Mode: the set of functions activated for a specified configuration for a particular product.

Standby Mode has one or more of the following user oriented functions activated (Clause 3.6, IEC62301, 2010):

- *To facilitate the activation of other modes (including activation or deactivation of active mode) by remote switch (including remote control), internal sensor, timer;*
- *Continuous function: information or status displays including clocks;*
- *Continuous function: sensor-based functions*.

Under the standard, low power modes (i.e. Off modes, Standby Modes and Network Modes) are considered to be broad mode categories or families of modes and numerous specific product modes can exist within each of these categories for a particular product. Each product mode that exists falls into one of these mode categories. A product may have many functions available for use, but only those functions that are activated (operating) determine the relevant mode. Functions that do not fall into the categories defined for Standby Mode or Network Mode do not affect the product mode classification when activated.

It is important to note that under this series of definitions in the new standard that:

- There may be several separate product modes on a single product that are classified into the same low power mode category (eg there could be several Off Modes and/or several Standby Modes).
- Product modes that are classified in the same mode category may have different functions activated so may not be directly comparable (on the same product or on different products) in terms of their functionality.
- Some products have one or more functions activated in one or several relevant low power mode categories.
- The previously defined "lowest power mode" has been deleted from Edition 2.

One area of improved understanding in Edition 2 is that many low power modes may not be persistent or continuous. The main cases are transitional modes (short duration), single modes with cyclical behaviour and sequences of different modes in a pattern.

Some low power modes are transitional (where a product automatically changes state) so, where present, need to be reported as a temporary mode with an associated energy and duration. However, their importance in terms of total energy consumption is often secondary. An example of this type of mode is a shutdown sequence for a product at the end of its normal usage or a start-up sequence. Another example is transitions to and from sleep modes.

Some products have single modes that exhibit “cyclical” behaviour – this type of product is quite common and is well covered by the first edition and the new standard. Common examples of this type of behaviour are heaters that may come on periodically to maintain a certain condition (eg ready for use) or a regular pulse charging of a capacitor or other electronic device that appears as a short, regular power spike. The important point is that for such a mode to be considered as persistent, the functions activated in that mode have to remain the same.

Another product configuration that is becoming more common is a stable and persistent sequence of modes that occurs automatically. A common example of this is a product that remains in sleep mode most of the time but wakes itself up once a day for a short period to obtain information on tariffs or programs (eg through a broadcast signal or network connection). In this case two different modes with different functions activated are present – so strictly speaking neither mode is “persistent” (indefinite). These product modes occur in a regular and predictable sequence, so this falls within the normal operation now envisaged by the standard. The average power in each of the modes is determined in accordance with the standard with the sequence separately documented. This provides sufficient information to determine the total energy of the product.

Edition 2 of IEC 62301 is progressing and has passed the Committee Draft for Voting (CDV) Stage, having already been through two Committee Drafts in 2007 and 2008. The committee draft for voting (CDV), issued in late 2009, attracted a large number of technical comments from a number of European countries, partly in response to the mandate given to CENELEC by the European Commission as part of the standby regulation (European Commission 2008c). The majority of the comments submitted and the changes made to the CDV in this FDIS were either editorial in nature or were considered refinements of the technical requirements (i.e. they clarify the requirements but do not change the overall direction of the standard). However, there are two requirements in the FDIS that could be considered as significant technical changes.

- Changes to the uncertainty requirements: Very detailed investigations showed that “difficult” loads (with very low power factor and very high crest factor) cannot be measured with the limits on measurement uncertainty in Edition 1, even with sophisticated laboratory instruments. The FDIS includes a proposal to increase the permitted uncertainty in accordance with a new term (Maximum Current Ratio), which is a function of the permitted crest factor of the meter, the actual crest factor of the load and the power factor of the load. The uncertainty is only increased once these effects become quite large. The other significant change is the alteration of the threshold from a relative uncertainty of 2% to an absolute uncertainty: this has been altered from 0.5 W (and 10 mW) to 1.0 W (and 20 mW).

- Stability criteria: MT9 undertook considerable analysis on a number of different types of loads and concluded that it would be extremely prudent to have some checks for stability for all measurement methodologies in the standard. These have been included in the measurement section of the FDIS.

Other changes in Edition 2 include:

- Updated guidance on product configuration, instrumentation and calculation of measurement uncertainty.
- Inclusion of specific test conditions where power consumption is affected by ambient illumination.

A Final Draft International Standard (FDIS) of Edition 2 is expected in mid 2010 and publication is expected by late 2010 if the FDIS passes.

C.3: Measurement approach for specified modes

Within any voluntary or mandatory scheme it is necessary to clearly set out the technical requirements for the relevant mode (or collection of functions) and to then be able to reliably measure the power associated with that configuration on a particular product. This process requires a number of steps as described below. Many of these are already embodied in regulations or program specifications, although the overall procedure is sometimes not clearly outlined.

The first step is to establish a test procedure. This can be a generic one for measurement, such as IEC 62301, or product-specific (and for this, either added to an existing procedure for measuring active power, or created just for low power measurement). It is likely that some content is needed to specify functions and to provide names for the mode, but this can be contained in a specification if not enough content to merit a test procedure. For this and the rest of the process, “common content” should be drawn on as much as possible so that consistency is attained across product types and across countries. Examples of such content include terminology, test conditions, and procedural instructions (other common content is used in specifications and regulations). This is particularly important for complex functions like network connections.

A test is carried out for each identified mode. Note that even within a product type there may be differences in what modes exist (e.g. some printers lack an off mode; some products that commonly have a sleep mode don’t always have one). In such cases, the next higher mode available will generally substitute for the “missing” mode. For example, when testing the off power for a printer with no off mode, its sleep mode will be used instead, and have several “extra” functions such as maintaining network connectivity.

Reporting of results from the test will include for each mode the power level, required functions (from the test procedure and specifications), and extra functions present.

The reporting also needs to include characteristics of the product such as performance, capacity, and other factors that might influence allowances for energy use in active or low-power modes.

The next step is to calculate an allowance or allowances that the product is to meet. These may depend on product characteristics and may also depend on the required or extra functions. Thus, the allowance might not be known before the test is done (since the extra functions that exist are made apparent during the test). Functional adders for required functions might be implicit in the base power allocated, or might be added to it (the latter helpful if the adder is variable, e.g. depending on the number and type of network connections). Functional adders for extra functions are a separate list from the required list and might have different quantities. Any adder can be zero if indicated by technology and policy. Adder definitions should be consistent across all products, and as much as possible, adder values should also be consistent or zero.

If the metric(s) are not simply modal power levels, then calculations need to be done on the measured results, e.g. to annualise the measurements (this parallel to but different from annualising the allowance).

Finally, the measurements and allowances can be compared to each other to see if the product meets the energy/power requirements of the specification.

C.4: Testing low power modes

A test procedure based on functions must list all required functions for a particular mode, annotated in some cases with standard conditions such as expected network speeds, traffic levels, etc. A function may be explicitly noted as required, required only implicitly (e.g. that the product should wake on network activity), or be explicitly required by a specification for which the test is being done. Some modes could list "prohibited" functions (whether any prohibitions are needed is not yet known). For many products, there may be a need for some configuration of the product prior to testing to accomplish particular modes (or reflect the intention of the test). Details of this configuration (and the as-shipped conditions as well) need to be carefully reported. An example would be to enable Wi-Fi connectivity during sleep mode (which might be disabled as the default).

As products increasingly alter their energy-using behaviour in response to environmental conditions, these will need to be specified, and established for tests for these products. Examples include products that adjust display brightness based on light sensors, that change behaviour depending on assessment of room occupancy, or have fans that are thermostatically controlled (and so affected by the ambient room temperature).

Thus, the procedure that a test laboratory should follow is:

- Begin with a product as shipped
- Review a list of required functions from the test procedure (and specification when applicable) for each mode of interest

- Modify the configuration and setup as per required functions
- Measure power for each relevant mode (combination of functions)
- Report actual functions present in each mode (and level of activity if relevant).

Beginning with a product as-shipped is important to have an unambiguous test procedure, and as many people may never change many or any of the settings. The order of testing can be important; for example, some products enter a different mode when entering their off mode via an automatic power-down feature than they do when done with a manual power control. For testing with this scheme, the forthcoming second edition of IEC 62301 (2010) is sound and does not need particular alteration, other than being supplemented with additional reporting, and possibly standard terminology to refer to particular types of functions. Some additional guidance will be required for network functions – this should build on work already done by Energy Star and the European Codes of Conduct. This work is set out in Project C (see Section 9.8).

One can imagine a product "cheating", as by making strategic use of stored battery power to distort a test result. In other contexts, products have had intelligence to detect tell-tale signatures of a test procedure and alter their behaviour. There needs to be general language prohibiting this, as well as vigilance to try to detect any such behaviour.

C.5: Functions required and functions present

The functional approach is a critical development, but needs one additional feature to reach its full potential, which clarifies a core duality of functions. In casual language this can be described as "what you *want* versus what you *get*". It is easily explained in the context of a test (and a test procedure). A specific test of a particular project will identify a number of specific modes to be evaluated. For each mode, there will be a list of functions that must be present in the product during the test. Since a product may have many more functions than distinct modes (and even more combinations of functions than modes), many collections of functions will not have an exact incarnation in the product being tested with only those functions present.

For example, a microwave oven being tested is only required to have its keypad enabled in its ready mode to be available for immediate use; the display is not required to be on as it will wake when a key is pressed. The oven happens to keep the display on continuously, and also displays the current time, and so has a clock function. Thus, the keypad active function is required, and the clock and display functions are "extra".

So, depending on the product design, functions of direct interest may be always bundled with other functions of indirect or no interest. This example may seem trivial, but the principle is important: each measurement of a mode has two sets of functions: those required, and those actually present when tested (the latter is always the same as or a superset of the former). Any measurement or regulation needs to be clear which is being addressed.

An example closer to the core of this paper is the presence of network connectivity as a function. Some products have network connectivity in all low-power modes; that is, so long as it is connected to power, you always get that connectivity, with the functionality and energy use that implies. In some products you may not have any network functionality in low power modes. A common design is network connectivity in sleep, but not in off.

C.6: Testing products with network connections

This section outlines possible states that a network interface can be in during operation or testing. It is particularly important to ensure that the product network interface is configured correctly when measurements are performed. Further work in this area is set out in Project C (see Section 9.8).

The following discussion refers to a single network connection which is present on a product. In practice, products may have multiple network connections with the same or different physical layers. The relevant configuration must be applied to each interface separately. A network interface can be in one of several states as follows:

Disabled

The first possibility is that a device has the capability to be network connected but the feature is disabled through configuration. In principle, all electronics associated with the connection might be removed from power, though in practice, some power may be expended by the interface or related electronics (including power supply losses). Thus, even a disabled capability may require some power. In the language of functions, a disabled interface only exists.

Absent - Wired

For a wired network (e.g. Ethernet), there are several possible paths to no data connection to another device:

- the interface is enabled but no cable connected;
- a cable is connected with no device at the other end; or
- a device is at the other end but not enabled or turned on.

These cases of absent connection are not likely a central focus of standards developers and product designers (who quite naturally focus on designing interfaces and products to actually be in use). Nevertheless, these non-functional conditions are common in practice, particularly for products that have network connections only intermittently, are portable (e.g. notebooks PCs), or have multiple network connections (and so may have several commonly inactive even if most of the time at least one is active). An absent connection implies that it is available, not disabled.

Absent - Wireless

For wireless networks, no cable is involved, but that does not mean the end of complications. With an enabled wireless interface, it may find or not find one or more other devices (particularly access points) to connect to, and may be able to make a connection to it or not depending on physical conditions and security limitations. Some types of wireless interfaces expend more power trying to establish a connection than they do to maintain a connection. Since wireless devices commonly can move (as can objects causing interference), there is an inherent dynamism in wireless connections not present in wired ones. As with wired, an absent connection is available.

Linked

The purpose of any wired or wireless interface, is to actually establish a link to other devices. Links may be capable of several different operational modes that affect the amount of power required, including different throughput capabilities. Examples include Ethernet, which supports speeds that vary by four orders of magnitude, and the various "flavours" of Wi-Fi. Other factors are the length of the data link, and the ability of a link to go to sleep for short periods of time when utilization is low. The ability of the device being tested to enter these speeds or modes can depend on the capabilities of the device to which it is connected. Signal strength and interference can also be important and can dictate the connection speed. A linked connection is active, regardless of how much useful data is flowing across the link (even none).

Full Connectivity

A link alone can be accomplished with fairly limited communication, but maintaining a device connected to the network in a more general sense involves much more. Examples include network infrastructure activity, as well as maintaining presence in an application sense. This requires some additional power (energy) over just maintaining a link — sometimes much more. Today this is associated more with active consumption for mains-powered devices like PCs.

Special Modes

There are special modes in certain networks that provide for sending a wake-up signal but not ordinary connectivity. Wake-On-LAN is the most widely known of these. The EU Code of Conduct for Broadband references a DSL state in which the interfaces are only looking for wake-up signal. Some sensor network technologies use a "wakeup radio" signal (that can be listened to at very low power) that is separate from the one used to actually transmit data. Other modes useful when a device is relatively inactive are those that introduce latencies in communication, based on knowledge that these are acceptable in the usage context. These modes can be useful and may be a way to leverage significant savings. Thus, they need to be accommodated and recognized by test procedures.

C.7 Circumvention of test procedures and normal use

Having accurate and repeatable test procedures is a fundamental foundation to any energy policy. When a product is being measured, it is important that the power levels recorded are representative of the product's power consumption during normal use.

Given the prevalence of electronic controls, there is a possibility that products could contain circumvention devices that may give a power reading that is unrepresentative in some circumstances.

A circumvention device is: "*any control device, software, component or part that alters the energy characteristics during any test procedure, resulting in measurements that are unrepresentative of the product's true characteristics during normal use*".

The issue of circumvention is essentially software controls that are intended to deceive a test laboratory during a test in order to obtain a power consumption value that is too low. Circumvention is easiest where a very strict and structured sequence of events and conditions occurs during a test procedure. The chances of this occurring are diminished if the conditions during test are more reflective of normal use. If network connections are active and user interaction occurs (at least to some degree in a random and unstructured way) circumvention is much more difficult.

The issue of user software and setup preferences is not strictly a circumvention issue. But it is important that the product during a test measurement be configured in accordance with the instructions for use provided by the manufacturer. An example of an issue previous discussed may be boot-up speed from standby mode. Products may be shipped from the factory with a low power option activated (with a long boot time), which would normally be the default condition for testing. However, if the instructions for use encourage people to activate the rapid start option through software settings (with higher power requirements), then this may be a more legitimate mode to be tested (irrespective of the default software settings as shipped). There is a case for measuring both modes in this case. How this data is used is a matter for program implementation – it could use a weighted average of what is known to be selected by users during normal use or it could take a more conservative (aggressive) approach and use the highest power configuration through users software settings in that mode. This illustrates why it is important to measure those product configurations that are most commonly used during normal use.

Annex D: Additional information – functions and modes

This Annex sets out additional information to complement Section 4.

D.1: Notes on the scope of products to be considered

There are an increasing number of products that use “alternative” methods of power supply. Their number and total energy consumption is reaching the point where energy policy needs to address them, and do so in a fair and equitable manner vis-à-vis their AC-powered counterparts. For this report, only standard DC distribution technologies are considered.

DC-powered products are an emerging part of the market but policy in this area is less well developed. Standard DC technologies include Power over Ethernet (PoE, 48V), Universal Serial Bus (USB, 5V), eMerge (24V and 380V), and that in automobiles (12V), as well one in development through IEEE called UPAMD (Universal Power Adapter for Mobile Devices). Also emerging is wireless powering (particularly charging) at close distance, or even across rooms. In the future, products may be also commonly configured to be connected directly to a central DC supply (eg a single large central DC supply which is distributed within a building in parallel with main power).

Dealing with these new and emerging (primarily DC) power sources provides a range of new challenges as power can be shared and flow among a number of devices. This adds complexity to measurement and energy allocation amongst interconnected products. Many of these devices are low power (due to the power constraints of the technology) and/or mobile, so tend to have a low overall energy impact, but an increasing number are higher power and stationary. An integrated and standardised approach to deal with these products will ultimately be required. Some of these issues could the subject of new content for future editions of IEC 62301 (standby power measurement procedures).

Components that are effectively part of a product (often supplied with it) but where there is some sort of connection between these components are not considered to be a network. Examples of things that are not considered to be discrete products are remote controls, control panels (wired or wireless), handsets for cordless phones, and keyboards/mice for a PC. These components are peripheral devices that operate as part of the product itself; they are not separate products, even though they may communicate using wireless technologies. Many are battery powered.

Some future clarification will be required for:

- Products intended only for use in cars (though these may be easily covered through standard DC source policy)

- Battery-only products (which need separate batteries that are charged externally or products which use non-rechargeable batteries)

D.2: Low power mode categories

Modes can be broadly categorised into active modes, low power modes and disconnected (from mains power, but it may still be connected to a network). Each of these mode categories is discussed below.

Active

An active mode of a product is where one or more primary functions are operating (or activated) — a period of time where the product is performing its intended job or task.

Some products, like computers, can operate in active mode at different levels of output, ranging from full output (maximum activity level) to idle (where the product is immediately ready to be active but is doing nothing useful — waiting for user activity to which it responds).

For products with a network connection, it is usual for the network function to be operational when the product is in active mode (except where this is actively shut down or disconnected by the user or where the network is not available). Increasingly, products have multiple network technologies and pathways available.

Low power

Low power modes occur when no primary function is operating. There are many possible low power modes, and the functions present in any particular mode depend on the particular product design and configuration. Some products which have network functions in active mode have no network functions available in low power modes. However, some products can have some network functions active in one or more low power modes (ranging from a low level network connectivity to a full network presence – e.g. printers).

The broad low power mode categories, where the primary function is not active, can be grouped as follows (adapted from IEC62301 Edition 2 FDIS):

- Off mode – where the product is connected to a mains power source and where there are no standby mode functions present;
- Standby mode – where the product is connected to a mains power source and where at least one or more of the following user oriented or protective functions are present and available:
    - o Function to facilitate the activation of other modes (including activation or deactivation of active mode) by remote switch (including remote control), internal sensor, timer;
    - o Continuous function: information or status displays including clocks;
    - o Continuous function: sensor-based functions

- Network (standby) mode – where the product is connected to a mains power source and at least one network function is activated.

Many of these functions can be present in active modes as well.

Disconnected

This mode is not usually of much interest, as by definition the product is using no mains power when disconnected from all power sources. However, some portable devices with network connections can still operate on a network while operating on internal battery power (such as notebook computers and mobile phones), so network functions will remain active in these cases. With mobile devices, great attention is usually paid to the power required within the product to operate such network connections, as battery life is limited and this is a key parameter of interest to users.

These devices will subsequently require recharging when reconnected to mains power – the overall charging efficiency of battery systems is not a concern of this report.

D.3: Notes on function classification and categories

There are various ways to organize a list of functions. This section lists common functions that cover the majority of those of interest for low power modes in user-oriented products. The first group covers functions that are clearly related to network connectivity. The other types of communication are part of the network context if one sees people and other non-electronic parts of the environment as nodes on the conceptual network. This is a useful abstraction, but one we can put aside for the moment as we focus strictly on electronic network connections. Displays need to be considered for network connectivity as devices will in future be “exporting” their user interface to other devices, either entirely or in addition to their conventional user interface. This can be seen today for many printers and network access points, that provide interfaces through applications or web browsers. Time tracking can be necessary for some network functions that happen periodically, though time tracking can also be useful for devices for other reasons. Finally, an increasing number of devices can be powered by low-voltage DC, which can be provided by devices that are networked to each other for communications in addition to power supply. There can be interactions functionally between the provision of power and functions of these connected devices, so it is useful to consider the power supplying function in the network connectivity context.

Communication – between devices

These types of functions can be communication within a product (eg via wired control pad or remote control – strictly not a network under the definitions in this report) or communication with other products (network type functions). These network type functions include data links and analogue type systems as well as multi-node (digital) networks.

Communication – with people and the environment

These functions relate to interaction of products with users (humans) or the environment. The type of functions include:

- “outputs”: displays, audio functions, visual indicators (power, temperatures, tariffs, other information);
- “inputs”: audio (voice activation), touch, user Input (keys/switches/buttons), environmental sensors – some of these functions can be remote (eg via mobile phone or Internet).

Sensors that monitor environmental or physical parameters (usually inputs) can be considered as communication between the environment and the product. These include parameters such as temperature, ambient light, audio, motion (occupancy) sensors, atmospheric pressure, fluid/gas motion or flow. These can be used to provide feedback to a product so that it can perform a primary or secondary function correctly. There is no sharp delineation between some of these environmental sensors and human-related functions, so they are grouped together for the purposes of this report.

Power related

There is a wide range of power-related functions such as EMC filters, surge protection functions, battery charging functions (internal or external), power transformation and distribution (AC/DC and voltage supply for internal purposes).

Time related

Time related functions can be broken down into 3 broad categories:

- Timers (tracking relative time) – this includes timers that enable repeating a cycle of operation as well as count down timers for a one off operation (eg delay start of primary function).
- Clock - keeping absolute time (and often the date as well).
- Schedule – activating a function at a specified time (and date). These can be one off or regular events and can range from simple to complex devices.

In practical terms, clock functions are required scheduling functions.

Other functions

There is a group of other functions (many of which are not listed here) which do not logically fit in these main categories. These include memory related functions (which are extremely common but not obvious), quick wake up (from sleep), fast turn-on (from off), various safety and protection functions such as electrical protection (residual current devices, also called Ground Fault Circuit Interrupter or Arc Fault Circuit Interrupters or Earth Leakage Circuit Breakers), flood protection devices (and back siphonage), child locks, movement safety cutouts (eg irons which are switch off with no movement for a specified period). Many of these functions are secondary and may require some power budget.

D.4: Notes on the naming of modes

At one point in time, devices were generally of simple design and had two basic states: on or off. Some products had different forms of on, reflecting different functional states for their primary function. Starting several decades ago, products started to get functionality within their "off" states which resulted in some power consumption, and since there is some association (at least conceptually) between "off" and zero power consumption, this new condition was called "standby", to emphasize that the product was still consuming some power (also because the most common early secondary function was a remote control – the product was "standing by", ready to be turned on). This is reflected in safety standards that specify that the "on/off" power symbol (with a full circle and line inside) be used only for devices with a zero (hard) off state, and in others, the "standby" symbol be used (with a circle broken by the vertical bar). While standby started to mean off, it was soon also used to mean sleep (in Microsoft Windows), and on (ready for copiers), and for up to three different low-power modes in testing of TVs. IEC62301 had "standby mode" defined as the minimum power mode of the device in the first edition, and in the second edition, it includes a general category of modes that covers any product mode with at least one user oriented function but no network function (and no active function). These are just a few of the historical uses of the word standby. More recently, an draft of IEC62542 has put forward a constellation of terms for low power modes centred around the word standby.

This is all in the context of many existing product terminologies in test procedures, specifications, and user interfaces, in addition to those found in electronics technologies.

D.5: Modes relevant to this report

This report is focuses on the energy consumption of products (appliances and equipment) that are connected to networks. In order to maximise energy savings potential of these types of products, it is necessary to consider the following broad modes (derived from IEC62301 Edition 2 FDIS):

- Standby and off modes: the low power modes where a product may have a network function available but where this function is not activated. The primary focus will be on whether the network functions have an impact on power consumption and whether the presence of a network capability (even when it is not activated) should affect the treatment of the product under different policy approaches. This includes sleep mode for many network products.
- Network standby modes: the low power modes where at least one network function is activated but where the primary function is not activated. The primary focus will be on the type and number of network functions activated in network mode and the power consumption levels that may be required in order to maintain different levels of functionality.

- Active modes: where one or more network functions are activated and where the primary function is activated. The primary focus will be on which network functions require a link to the primary function and how network functionality can be maintained (where necessary) when the primary function may not be required (and where this can be shut down). To some degree this is about the issue of power management within a network context and how the network can help or hinder this objective. Network connections also add power to the active mode power levels, to power the network interface hardware itself, and sometimes induced in other parts of the product.

The underlying policy principle is to ensure that the minimum power is consumed while maintaining the required level of functionality (in all modes).

The power consumption (or energy efficiency) in active mode of products is not the primary focus of this study. However, much of the energy saving potential in active mode will come from internal power management of other functions (in addition to network functions). Where the energy consumption of such a product is significant, then this may need to be considered on its own merits for a policy response. However, the interdependence between active mode and network functions is critical.

The active mode of a product is also of some importance where a vertical policy approach is considered: where low power modes and active modes are combined within in a specified duty cycle to calculate a total task based energy consumption. For a vertical approach to be effective, it must be able to recognise and reward power management functions where these are present and implemented, or require them to be implemented in order to meet a specification.

Note that while we are principally concerned with modes of the entire product, there are also modes of operation of individual components, such as network links. To some extent, these can change independently of the mode of the whole product. Most efficiency policies sensibly avoid specifying internal technology implementation decisions, but networks provide an exception to this. The reason is that the behaviour of one device on the network can affect the energy consumption of the connected devices, so that some calling out of specific technologies to be present (or absent) is warranted.

D.6: Functions and power/energy

If a product has no functions in a low power mode, then it has no good reason to be using any power. Actually, most products (but not all) have a mechanism to turn them on, usually just a power switch, so this is an implicit function in all devices that have an off mode. How much electricity a device uses is dependent on the functions active in that mode, and the minimum reasonable that a device could plausibly use to provide that function. In real products, the actual power used depends a lot on the product design and power supply implementation for that function. It is a truism that "functions cost power".

For regulations, the key objective is to establish power limits that are reasonable within the context of what the device is doing in a particular mode, which is dependent on the functions provided. As power limits become more stringent, it becomes increasingly important to accurately match any power limits to the technical requirements of the specific functions present. Many standards and regulations have begun to use “adders” for extra functionality as a way to accomplish this. An alternative is to use mode naming as a way to distinguish among different functionalities, but this does not provide the ability to make necessary distinctions between particular products with different functionality, which is required for good policy (e.g. Ethernet and WiFi are two ways to provide network connectivity, but both 100 Mbps Ethernet and 1 Gpbs Ethernet with Energy Efficient Ethernet require significantly less power than a persistent WiFi connection does).

The key then is to have power values (“adders”) for extra low power mode energy use corresponding to each named function, and ideally use these same values across all products. Policy makers may decide to “zero out” some adders for some modes; for example, network connection adders could be set to zero for off modes, even if they are left as-is for sleep modes. This does not preclude a manufacturer form including network connectivity in off mode, but they don’t gain any additional allowance for doing so. It is also possible to put total caps on power budgets when adders are used – in this case you cannot exceed a specified maximum total power level, irrespective of how many functions are active.

An early use of multiple adders is in the Energy Star imaging specification for non-laser type devices. This provides a table of adders for several types of data and network connectivity as well as a few other attributes. It further had different adders for interfaces in use from those where the interface was not in use.

Annex E: Approaches to setting limits on modes

E.1: Active modes

Active modes of many products are regulated for energy efficiency and sometimes with absolute limits on energy consumption (irrespective of size or energy service). Governments have historically focussed on efficiency as the most effective means of delivering energy reductions (although in a carbon constrained world, absolute limits in energy are gaining increasing attention – see ECEEE 2010). Energy efficiency is defined as the unit of energy service per unit of input energy. To assess energy efficiency requires an objective measure of the energy service provided. For traditional appliances and equipment, this is fairly readily defined (eg litres of cooled space for a refrigerator, kJ of cooling or heating output for an air conditioner or heater, watts of shaft power for a motor, output capacity for a power supply or transformer, kg of clothes washed for a clothes washer).

For many electronic products in the ICT and home entertainment areas (a key focus for this report), saving energy requires a different approach. For example, a computer typically uses comparable power when fully loaded with computations as when it is idle and effectively doing nothing for the user (although this does not have to be the case as we explore later). Very little of the annual energy use of a typical PC is associated with active computation; the vast majority is required just for the PC to be present and available. So the concept of "energy efficiency" for many electronic products does not apply; evaluating energy savings opportunities requires different approaches.

A wide range of products are regulated on their active mode energy efficiency. These tend to be products which use a lot of energy individually, are widespread (have high or increasing penetration or ownership) and where there are a range of technical options to reduce energy or improve efficiency. While active mode efficiency is not a key focus of this report, the implementation of effective power management strategies is a key focus of this report (especially for bringing devices out of active modes and into low power modes and to implement power reduction strategies while maintaining functionality).

E.2: Low power modes

Low power modes occur when a primary function is not activated. When in these modes, products may have one or many functions activated (or in some cases, no functions activated). The types of functions are set out in some detail in IEC62301 (refer Annex C.1 for more details).

For simple stand-alone products with only one or two functions present in low power modes, setting limits is fairly straightforward. This approach has been used successfully in regulating low power modes in Europe and Korea (refer to Annex F for more details). The approach most commonly adopted is a flat power allowance (maximum permitted value) in the relevant mode.

For complex products, especially those with network connections and numerous other potential functions, a uniform power allowance is more problematic, as the functionality present in low power modes can vary significantly among products. A sound approach needs to consider the level of functionality present (with consideration of necessary the functions are) and the power that may be acceptable to provide such functions.

In a purely technical sense, the best technological design implementations of many common functions present in low power modes require almost negligible amounts of incremental power to operate.

Unlike active modes, the concept of “energy efficiency” of low power modes has little practical meaning. Some further discussion on energy associated with networks in particular is provided in Section 5 and Annex C.

E.3: Regulating low power modes

A test method is a critical prerequisite for any voluntary and mandatory energy program that sets power limits on the energy use of products in low-power modes.

Program requirements can address “any mode with X characteristics and not Y characteristics” and can require that a product “shall have such a mode with a power level of ≤ x watts” or “shall have all low power modes require ≤ x watts” (special consideration is needed to consider the possibility that a product being tested has no mode of the type being specified, so how those products are treated needs to be specified). This is best understood in the context of policy collections of horizontal and vertical efficiency standards (see Section 8.6). A vertical standard is one specific to a single product type (or collection of like ones). A horizontal standard is one that covers a particular function, set of functions, or characteristic across many or all product types (e.g. power supplies, low power mode consumption, network characteristics, battery characteristics, user interfaces, etc.) (see Section 8.5).

There are two basic methods of setting thresholds on consumption: modal (power) and annual (energy). The modal approach specifies one or more low-power modes that are measured and establishes individual limits for each mode. The annual approach (or any convenient period of time) sums up the consumption of all modes deemed significant, with an operating pattern that is seen as representative of typical consumption and limits only the sum, not the components. The annual total often also includes active consumption and is sometimes referred to as a ‘duty cycle’ or ‘typical energy consumption’ approach. Both of these have their advantages and for the foreseeable future, both will have good uses for specific product types. The functional approach with adders applies equally well to both.

For a particular mode, a regulation can specify a base power level with additional allowances (“adders”) provided for functions beyond the assumed base for the mode. Adders have been widely used in the Energy Star imaging and set-top box specifications, and the Code of Conduct Digital TV Services. More recently it has been used in the Energy Star computer specification, and the Code of Conduct on Broadband Equipment.

Some view such adders as a way for manufacturers of products that shouldn’t qualify for a limit or label to do so by loading up with many spurious functions. This could work if the adder values are too large, but if they are set to the minimum level required for the functionality (and no more) this problem does not arise. A regulator can place a limit on which allowances are valid for a particular mode, and how many can be used (This doesn’t preclude a manufacturer from including additional functions, but there will not be additional power for doing so; if there are many such functions, their power levels have to be very low to compensate. Also, in setting adders economies of scale need to be considered, i.e. an adder being additional (on top of other adders) might be lower than a single adder.).

Most efficiency test procedures and policies are limited to AC-powered products. However, there are many reasons to include low-power DC products in these as they can have efficiency (and other) advantages and should be allowed to compete on an even basis with those powered by traditional AC sources.

Annex F: OSI - Detailed network description

F.1: OSI model

A foundation of modern networks is the "OSI Model" — Open Systems Interconnection — from the International Organization for Standardization (a thorough summary of this can be found on Wikipedia). A key feature of networks is the ability to communicate arbitrarily among many nodes on the network (this is distinct from a data link which only enables exchange between two adjacent devices). OSI networks are always digital, and today are usually based on the Internet Protocol (IP).

Layer 1 - Physical

Moving bits from one place to another, whether via electricity, radio waves, light, etc. (often called the "medium"). This is also called PHY.

Layer 2 - Data link

Making sense of these bits, imposing "frames" on the data, to have it sent in useful chunks and sequences. Can have features like error detection, correction, and even retransmission.

Layers 1 and 2 tend to have much more coupling and interdependency with each other than they do with higher layers.

Layer 3 - Network

Moving groups of bytes (a datagram or packet) from one point on the network to some other point on the network. This involves a completely different addressing scheme (Internet Address, IPv4 or v6) than at layer 2. The average packet on the Internet at large makes around 15-20 "hops" across data links between source and destination. This is "IP", the Internet Protocol.

Layer 4 - Transport

Providing "pipes" to send data between nodes on the network, that may include more error checking both within packets and to retransmit lost packets (and detect duplicates). Most common are TCP and UDP.

Layers 3 and 4 in the Internet today are closely linked to each other, much more so than to adjacent layers higher or lower. There are other protocols at layers 3 and 4, but they are mostly for network operations rather than application purposes.

Layers 5-7 – Application

Often these layers (Session, Presentation, and Application) are collapsed into one, and how many an individual application has is application-dependent. Some of these protocols are application-specific (eg FTP). Others were designed for one purpose, eg HTTP, but then widely reused for others.

Application protocols often use languages in the data they transmit. An example of this is HTML, which describes web pages.

Layer 8 –User Interface

The user interface of an application is not formally in the OSI model, but often referenced as Layer 8. This leads to the notion of people being "nodes" on the network, which is useful conceptually and for policy.

F.2: Physical layer data and network interfaces

The following is not an exhaustive list, but highlights some of the most important technologies for exchanging data.

Wired

-Analog: Line level audio, Video (Component, Composite, etc.), Phone (POTS)

-Data: RS-232, USB, HDMI, DSL

-Network: Ethernet, MOCA, IEEE 1394 (Firewire), Bluetooth

Optical

-Passive Optical Networks

Wireless

-WiFi, WiMax, Bluetooth, Mobile phone

Annex G: Other relevant activities with respect to networks

G.1: Energy Star

As noted in Section 3.4, Energy Star has many specifications which cover products connected to networks. Energy Star continually revises existing specifications and creates new ones for different product types. Increasingly these cover products with network functions.

At present, at least eight specifications deal with network connectivity in some way, as do two specifications under development (data centre storage and small network equipment). The most common requirement is (during the test procedure) to require that the product be tested with at least some network connectivity engaged (assuming it has any at all), to ensure the product performs well in that circumstance and can enter the requisite low-power modes. In some cases, the speed of the network connection is specified, since that can affect the power required.

Five of the specifications (AV, Game Console, PC, Set-top Box, and Imaging) provide extra power allowances for network connectivity in sleep. Four specifications (AV, Small Network Equipment, Server, and Set-top Box) provide an extra allowance for network connectivity when the device is fully on. In both cases these are usually an incremental power allowance per port active during the test. The imaging and server specifications take the speed of the link into account in the power level determination.

G.2: European EcoDesign Lot 6: Standby and Off-mode Losses

This study was commissioned under the Eco-Design Directive of the European Commission (European Commission 2005). The lead contractors were Fraunhofer IZM and BIO Intelligence Service. The study was conducted in 2007 (Fraunhofer 2007) and formed the basis of the European Regulation on Standby Power (European Commission 2008c).

This study set out many of the original concepts and terminology that is now used in low power mode energy policy. It primarily examined off mode and standby mode.

The study defined network standby mode as including remote network reactivation and/or network integrity communication. This is a very narrow view of network standby in that only limited network functionality is anticipated. Requirements for these modes were not specified and the study recommended that further work be done on this issue. Consequently, these modes were excluded from the European Standby Regulation. This further work is now being progressed in Lot 26 (see next section).

G.3: EcoDesign Lot 26: Networked Standby Losses

This study was commissioned under the Eco-Design Directive of the European Commission (European Commission 2005). The lead contractors are Fraunhofer IZM and BIO Intelligence Service (the same as with Lot 6). The study commenced in 2009 and is expected to conclude in late 2010. Task 1 to 3 reports were released in February 2010 (Fraunhofer 2010a, 2010b and 2010c) and can be found at http://www.ecostandby.org/.

This study builds on the work undertaken in the Lot 6 study on Standby and Off-mode Losses and is to address Networked Standby Losses.

In this study networked standby mode has been defined as a condition during which the equipment is directly or indirectly connected to the mains power source and provides the following functions:

- Reactivation via network; this function means analysing the incoming signals on one or more communication paths external to the equipment in order to initiate the reactivation of the equipment.
- Network integrity communication; this function applies additionally for more complex network types and means maintaining the external communication paths.
- Reactivation, information and status display; this means that standby functions according to EC 1275/2008 (European standby regulation – see European Commission 2008c) may also be provided during networked standby mode.

There is some ongoing liaison between the Lot 26 contractors and the 4E Standby Annex.

G.4: European Codes of Conduct

The European Commission has facilitated a number of voluntary Codes of Conduct with industry in order to achieve voluntary improvements of energy efficiency. These started in the 1990's and originally covered televisions and home entertainment equipment and some whitegoods. There are a number of current Codes of Conduct of some interest that already (or could potentially) set requirements for low power modes and some network related elements. The main ones of interest are:

- Code of Conduct for Digital TV Services (European Commission 2008a)
- Code of Conduct on Energy Consumption of Broadband Communication Equipment (European Commission 2008b)
- Code of Conduct on Efficiency of External Power Supplies
- Code of Conduct for Data Centres (European Commission 2010)

The Codes of Conduct are managed for the European Commission by the Joint Research Centre – Institute for Energy. More information on these Codes of Conduct can be found on http://re.jrc.ec.europa.eu/energyefficiency/

G.5: DIGITALEUROPE

DIGITALEUROPE is the European industry association for ICT and CE manufacturers. They have a deep interest in issues related to low power mode requirements and network related issues and have made numerous submissions to various Eco-Design studies.

According to their own literature, DIGITALEUROPE is the pre-eminent advocacy group of the European digital economy acting on behalf of the information technology, consumer electronics and telecommunications sectors. They are dedicated to improving the business environment, and to promoting industry's contribution to economic growth and social progress in the European Union.

DIGITALEUROPE ensures industry participation in the development and implementation of EU policies. DIGITALEUROPE's members include 58 leading corporations and 40 national trade associations from all the Member States of EU. In particular it:

"*seeks to participate in the development and implementation of EU policies by helping European governments and institutions to understand future technology trends and how digital technologies can contribute effectively to sustain economic performance in Europe*."

More details be obtained from: http://www.digitaleurope.org/

G.6: APP Basket of Products and other projects

The aim of this project is to compile a representative "basket of products" for which standby power levels can be measured and tracked in any country around the world. This basket can be measured by interested parties to compare trends in standby power within that country and across countries. Many of these products will be global commodities with small differences in standby power levels (some may be due to voltage and frequency effects). However, some products may be subject to regional differences as a result of local standby programs or other influences. For other products which are more regional in nature in terms of their design or configuration, there may be larger differences in standby power levels between countries.

The purpose of these standby measurements on a common set of products is to allow national and international comparison of these like products across different countries and regions. Such measurement will heighten the awareness of stakeholders of the magnitude of standby power and will provide a focal point to highlight differences across regions. Such measurement will demonstrate the effectiveness of the policy mix used in individual countries and promote products that meet the standby power challenge.

Because information is collected at an individual product level, differences between brands and models can also be examined. The information can be used to encourage manufacturers which supply products with good standby attributes and can be used to put pressure on manufacturers which supply products with poor standby attributes to make rapid improvements.

Eventually, the data collected will also provide trends in standby power by product type over time so that the rate of improvement or deterioration can be quantified within and between markets as well as by product type and even brand.

Such improved information at a product level will assist national governments to formulate specific responses to the issue of standby power. It will eventually allow specific manufacturers to be identified if they continue to supply products with poor standby attributes in selected markets. Such information is important for monitoring the market and for measuring program effectiveness.

Measurements have already been taken in Australia, Canada, China, India, Korea, New Zealand and the USA. Initial measurements were also undertaken in the Czech Republic and Hungary, but these countries have now been included in the SELINA project (see next section). Comparative country data can be found at http://www.energyrating.gov.au/standbydata/app/

A regular standby newsletter called “Load Down” is also released.

More information is on http://www.energyrating.gov.au/standbydata/index.html

G.7: SELINA Measurement Program

The SELINA project (Standby and Off-Mode Energy Losses In New Appliances) is a project that ran from 2007 to 2010 to measure the low power characteristics in retail outlets around Europe.

The main objective of this project is the market characterization of the standby and off-mode electricity consumption of new appliances in the market. This information will be collected by measurements in shops, and by gathering manufacturers data, in each low power mode of operation.

A key goal of the proposed actions is to identify effective market transformation policies targeted at all the key stakeholders involved in the manufacture, sales and operation of appliances with standby and off-mode losses. The project will also identify policy recommendations to EU – in line with EuP, European Commission Codes of Conduct and Energy Star activities – as well as provide support to national officials, manufacturers and the experts related to the standby consumption should be a result of the project.

More information can be found on the website http://www.selina-project.eu/

G.8: U.S. Department of Energy

The Energy Independence and Security Act (2007) in the United States requires its Department of Energy to evaluate Standby and Off mode in mandatory regulations on a variety of products. No regulations so far include measurement of modes with network connectivity but as the scope of products covered expands and as more products gain network connectivity, this can be expected to change.

Annex H: Impact of power supplies and product design on low power modes

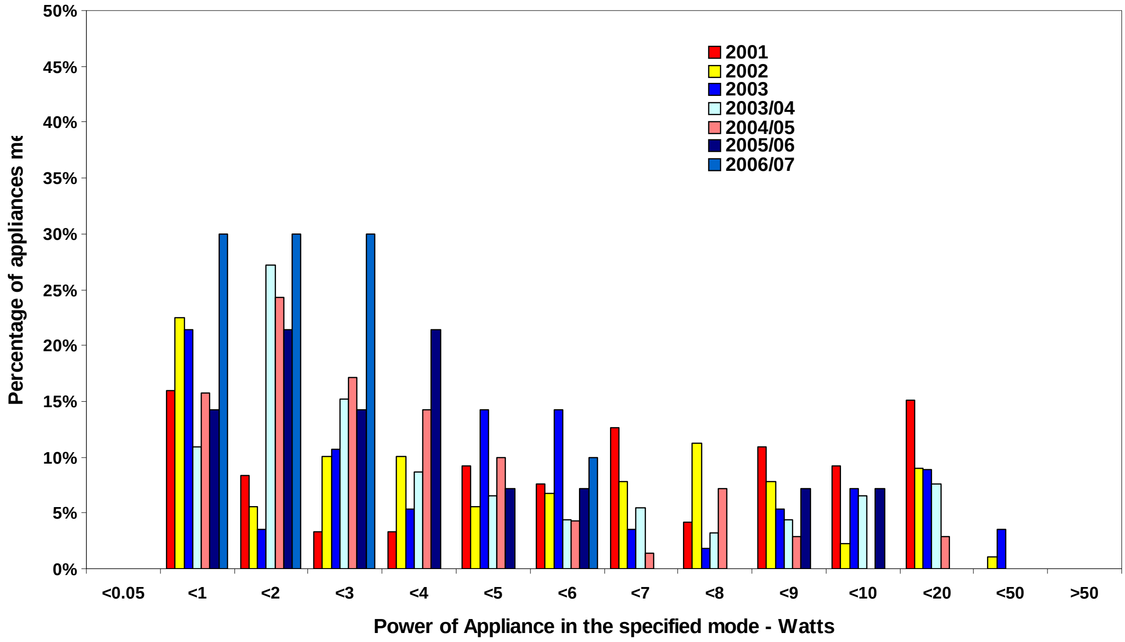
Power supply design and other aspects of product configuration can have a significant impact on the power levels in various low power modes. In more complex products, there are an increasing number of functions present, especially in low power modes. Many of these functions make the product more usable by increasing convenience or by providing additional user oriented features. Many of the most common secondary functions such as remote controls, timers, program/memory functions and sensing functions fundamentally have fairly low DC input power requirements as these are usually very simple electronic circuits. The same applies to network functions that may be present in any mode. The minimum power requirements for each of the most common function types is yet to be investigated in detail (see research Project H in Section 9.13), but anecdotally, data indicates that the basic power requirements for many of these functions is usually quite small.

A good example is the infra red sensor for a remote control that is ubiquitous in audio visual equipment and some major appliances (e.g. air conditioners). A small integrated circuit is commonly used to provide this function. The infra red receiver on the appliance has to remain in a state that is ready receive a signal at any moment ("standing by"), even though the total transmission time is probably less than a second a day (each event takes only a few milliseconds to process). So the power required to keep the sensor active is the primary concern.

The case infra red sensor on televisions is a good example – prior to the advent of digital tuners, the only function offered by televisions in standby mode was activation by remote control. A large number of measurements in standby mode have been taken over many years on new televisions offered for sale in retail outlets. Some of the results over a 7 year period are shown in Figure 9. The measurements show that there is a massive range in the distribution of the measured power of new products in this mode – ranging from as low as 0.1 W to as much as 40 W in a few instances, with the weighted average of around 3 W in later years. In the last few years products have also appeared on the market that offer the full functionality of a remote control but that have a measured power consumption in standby mode of around 0.02 W (20 mW), which is close to the reading resolution and uncertainty of typical laboratory power measurement equipment.

How did we end up with products that effectively offer exactly the same function (activation by remote control) but have a measured input power to provide this function that varies by a factor of 2000 from highest to lowest? The answer to this question is yet to be answered through some detailed technical investigations. We know that the function of a remote control infra red sensor will be supplied by standard circuits and while the input power requirement for these may vary, in general terms is likely to be very small (at most 100mW or so). So the likely cause for the drastic differences in standby power for these particular televisions is likely to be due to other aspects of product design.

Figure 9: Distribution of measured power in standby mode – CRT televisions



We know that in some product designs EMC filters are left connected to the mains even when the product is in standby mode or off mode. However, this only accounts for around 0.3W to 0.5W of input power. One cause for some of these disparities in input power are likely to be due to power supply design and configuration. It is well known that an AC to DC power supply will have no load losses that are to some extent a function of the rated output power of the power supply. If a 100W (or a 500W) power supply is used to supply an input load of 0.1W to an infra-red sensor, then the likely total input power for the product is likely to be quite poor (at least several watts). At such low power levels, large power supplies have a fixed no power loss (of the order of a watt or so) and fairly low power conversion efficiency (could be as low as 20%). So supplying a 0.1 W function could require a 2W input power. Until recently, suppliers had no interest or incentive to minimise power in these modes.

There may be other reasons why some products have very high input power in standby mode. In some designs parts of the product circuit may be left energised even when the product is put into so called standby mode by the user – this seems to be most prevalent in products like set top boxes, although it may occur in some televisions as well. In one case, a lab found that the only perceptible difference in a complex set top box (that was consuming 35W) when changed from active mode to standby mode was that the LED on the front changed from green to red (there was no measurable change in power consumption).

The design philosophy required to overcome many of these issues is the separation of power supplies for the primary function and the low power mode functions. The input power for secondary functions will typically be of the order of a watt (or even a few mW) while the primary function may have an input power of 100W or even 500W or 1000W (depending on the product). In these cases, power supply optimisation could have a huge impact. For example, if a network interface card in a computer requires 0.5W to maintain a network presence but this is being supplied from a 500W power supply, the overall power level it presents to the mains may look fairly poor (depending on what else is running and how the power supply is configured).

In practice millions of consumer electronics products and appliances should be using a separate low power supply to operate internal secondary and network functions at high efficiency when active functions are not needed – the main power supply (to supply the primary function) can then be pulled off line in low power modes. Super efficient small power supplies are now readily available to enable product designs to minimise power losses when secondary functions are activated in low power modes. The use of multiple power supplies to supply different parts of the product (and different functions) presents no technical barrier when power supplies are internal to the product, other than some attention to detail in product design to optimise power in all modes.

Another interesting development is the increasing use of external power supplies to power many electronic products. External power supplies are usually sourced from third party suppliers and provide a convenient and low cost way of powering products for a wide range of markets with different plug configurations, mains power voltages and frequencies. The vast majority of external power supplies are manufactured in China (more than 1 billion per year). Generally, external power supplies are specified on the basis of their rated or maximum output which is designed to meet the power requirements of the supplied product in its highest operating mode. This of course means that when the product is in a lower power mode, the external power supply will be well below its rated output. External power supplies are necessarily sized to supply the maximum possible power requirement of the product (plus some margin and allowances for operation at different input voltages). At low power levels the no load losses of the external power supply (which are generally a function of maximum rated power output) tend to dominate the power consumption. So even though a product may require only 0.1W or less in a low power mode to activate a particular function, the external power supply (which may be rated for 50W or 100W output) may have a no load power loss that is significantly higher (say 0.5W or 1W and a conversion efficiency of as low as 25%).

While it is technically possible to design external power supplies with dual power outputs for high and low power states, the range of potential different power input requirements in different modes for different products means that such configurations may have to be custom designed in the short term, until some sort of standardised interface and/or design specifications are developed for both external power supplies and end use products. This is an area where some standardisation work may be warranted. Another alternative is for an external power supply to have multiple internal power supplies which automatically optimise themselves in accordance with the load power requirement. The larger internal power supplies are pulled into operation as the load increases and smaller ones are pulled into operation as the load decreases. The optimum configuration would depend on the likely in power requirements for the product being supplied (i.e. just a couple of power levels or a continuum of power levels up to the rated output).