Networked Standby: A Wake-up Call for 1W+

Hans-Paul Siderius, NL Agency

ABSTRACT

Ever more products are connected to a network and must retain their network connection even when not providing a main function for the user. The risk is that products will stay in idle or on-mode permanently only to preserve the network connection awaiting activation via the network. The energy consumption of networked products worldwide is estimated to be 850 TWh/year in 2020. This consumption can be avoided to a large extent by introducing networked standby, a condition where the product can be reactivated via a signal through the network, in combination with power management. Ultimately the power consumption in networked standby should be 1W+ (1 Watt plus), mirroring the 1 Watt goal of the IEA standby programme but allowing additional power for keeping the network connection alive.

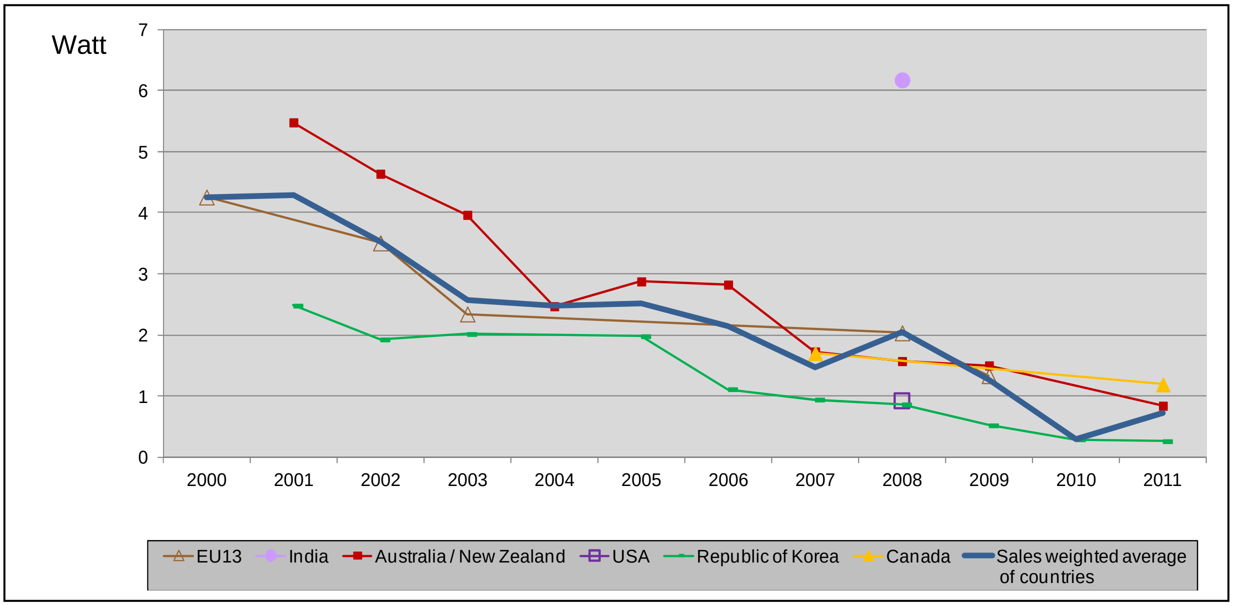
The paper discusses the concept of networked standby and the important parameters determining power consumption in networked standby. It further shows developments and illustrates the barriers preventing the 1W+ goal. The development of the EU Ecodesign regulation on networked standby is presented as example of introducing networked standby as a horizontal aspect in regulation.

Introduction

Standby power consumption has been subject to policies, including both voluntary and mandatory measures, for almost two decades, see Energy Efficient Strategies (2010, chapter 3). In the early nineties the voluntary ENERGY STAR © programme was the first major programme setting requirements on standby power for office equipment and some other products. The launch of the IEA 1 Watt target in 1999, endorsed by the G8 leaders in the 2005 Gleneagles Plan of Action (G8 Gleneagles, 2005), stimulated the uptake of (mandatory) measures to reduce standby power consumption in the European Union (EU), Australia, Korea, Japan, US and many other countries around the world. In general these policies have been successful, see Kim (2011), Almeida et al. (2011). As an example, figure 1 shows decreasing standby power consumption of televisions.

However, in the meantime the standby problem has proliferated both regarding the number of products that have one or more standby modes and the type of standby modes. Whereas 20 years ago televisions and office equipment were the main products with standby, nowadays many more products are equipped with a standby function, see Energy Efficient Strategies (2006), Meier et al. (2008). Furthermore, ever more products are becoming networked products meaning that they must retain their network connection even when not providing a main function for the user. While the alternative, the product being permanently in on or idle mode, would be even worse from an energy consumption perspective, networked standby might annul the savings achieved by current standby policies.

Figure 1. Standby power consumption of televisions



Source: 4E Mapping & Benchmarking (2012)

A recent study on energy consumption of networked equipment estimated the worldwide consumption to be 424 TWh/year in 2008, increasing to 849 TWh/year in 2020 (Mudgal, Lyons & de Prado Trigo, 2011). The savings were estimated at between 20% (conservative estimate) and 65% (exploiting the full technical potential of todays technology), i.e. between 170 and 551 TWh/year in 2020. By comparison, the IEA estimated that simple, non networked standby in electrical appliances and equipment accounts for between 200 and 400 TWh/year (IEA, 2009). Thus the consequences of networked standby for increasing energy consumption is in the same range as that of (simple) standby. Therefore the emergence of networked standby can be seen as a wake-up call for a global 1W+ action to counteract this increasing consumption without hampering the full deployment of networked standby.

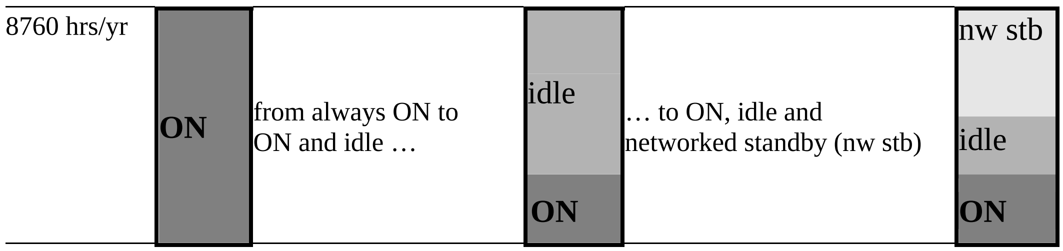
This paper is divided into two main parts: the first describes the concept of networked standby, the important parameters determining power consumption in networked standby and issues for different product groups. The second turns to the policy side suggesting a horizontal 1W+ goal for networked standby in the spirit of the IEA 1 W goal for standby. The paper concentrates on the product aspects of networked standby. Note however that the development of standard protocols that allow products to go into a low power mode with networked standby is a necessary condition; see Mudgal, Mehmel & Faninger (2011) for an overview on standards for networked standby. As an example of introducing networked standby in product regulation, the development of the EU Ecodesign regulation on networked standby is presented. The paper closes with conclusions and recommendations.

Networked Standby: The Concept

Networked Standby: Definition

IEC 62301 Ed. 2 (2011) distinguishes 3 types of low power modes: Off mode(s), Standby mode(s) and Network mode(s). The definition of Standby mode(s) refers to the functions, amongst others, to facilitate the activation of other modes (including activation or deactivation of active mode) by remote switch (including remote control), internal sensor, timer. The definition of Network mode(s) refers to modes where at least one network function, e.g. network integrity communication, is activated. Combining ‘network’ and ‘standby’, networked standby is the condition where at least one network function is activated to facilitate the activation of other modes[1]. Networked standby allows the reactivation of the product via a network signal, meaning the product need not be in active or idle mode to receive, process and act upon a network signal (trigger), see figure 2.

Figure 2. Networked standby partly replacing idle and on modes



Networked standby allows the product to be in a mode with a lower power consumption thereby saving energy. One condition is that for the product a mode with networked standby is available and activated, another is that the product is switched into that mode when this is appropriate, e.g. when the product is not providing a main function (power management), including when other products do not need it’s services.

From the definition of networked standby we can see that the following aspects are important: the networked product, the type of network and the type of network signal to trigger the reactivation. As indicated in the introduction this article focuses on the product aspects, it does not discuss the developments needed in network protocols; see e.g. Energy Efficient Strategies (2010).

Power Consumption in Networked Standby

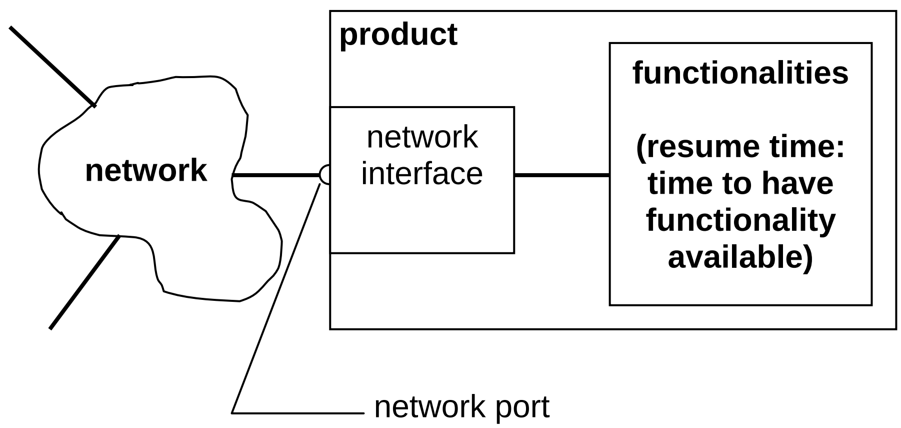
From an energy efficiency perspective the question is how networked standby can contribute to an overall total energy consumption of the product that is as low as possible. In general the solution is to have in networked standby as few parts of the product powered as possible, and at the same time ensure that the product can be reactivated as quickly as possible to resume the required functions. For the (total) energy consumption of a networked product also the time spent in various modes is important. To achieve this we want the product to have a short delay time and a short resume time. The delay time is the period of inactivity after which the product is powered down, the resume time is the time that it takes for the product to wake up and have functionality available. In order for a short delay time to be acceptable for the user the resume time must be short[2]. This is why older versions of power management for personal computers failed and were disabled; for these products even a long delay time was not acceptable because the resume time was too long or the reactivation as such failed, making a reboot of the computer necessary. A short(er) resume time might increase the power consumption in

[1] Note that for computers and monitors the term ‘sleep mode’ is used to indicate (networked) standby.
[2] Where delay time is counted in (tens of) minutes, resume time is mostly expressed in seconds.

networked standby because more parts of the product need to be powered in order to react quickly. Therefore the power consumption in networked standby on one hand and the resume time and delay time on the other hand need to be balanced. It can be beneficial to allow more power in networked standby in order to decrease resume time and thereby enabling (in practice) a shorter delay time, resulting in lower energy consumption in on/idle mode of the product and in a lower total energy consumption.

Power consumption related to resume time can be distinguished into (see figure 3) the power consumption and resume time for the network interface and the power consumption and resume time for the functionality that is to be reactivated.

Figure 3. Network interface and functionalities



The network interface keeps the network connection alive and receives and processes the trigger (wake-up signal) via the network. Power consumption depends on the hardware, the type of network connection and the type of wake-up signal. Regarding the type of network connection, in general a wireless connection needs more power than a wired connection. Regarding the trigger, three types can be distinguished (Nissen 2011, p. 1-9), see table 1. The table shows that processing the wake-up signal can require some power but the effect on resume time is small.

Table 1. Triggers for (networked) standby

Trigger	Power consumption	Effect on resume time	Examples
Signal wake-up	Very low: <0.1W	Almost zero	Fax
Address wake-up	Low: 0.5 – 2.0 W	Small	Wake-On-LAN (WOL)
Protocol wake-up	Low: 0.5 – 2.0 W	Dependent on protocol	IP

In principle the power consumption of the functionality to be reactivated could be zero because in networked standby this functionality is not needed. However, this could lead to (unacceptable) large resume times in situations where parts need to heat up (printer), software must be loaded (television, computer) or content needs to be moved to the working memory (computer). Also the configuration according to figure 3 suggests that the network interface and the (main) functionality are realized in separate parts of the product. This is currently not always the case. In some products the main processor is used to process the protocol wake-up because the network interface is not intelligent enough to do this. Other products only have one power supply which in networked standby runs at a fraction of the nominal power, this is very inefficient and results in relative large losses.

Network Availability as Performance Parameter

The preparatory study for networked standby in the framework of the EU Ecodesign directive developed the concept of network availability (Nissen 2011, p. 1-13,14), this being the capability of the product to resume applications after having received a trigger via the network. Network availability is expressed in the time it takes to resume an application. It is a performance parameter expressing what the end-user or other products expect from the product being in networked standby. Network availability includes the following aspects:

- connectivity: reaction latency, complexity of network integrity communication
- configuration: the number and type of network connections
- quality-of-Service: redundancy, security, scalability

In order to simplify the analysis and proposed measures, three levels of network availability (NA) have been defined to distinguish between products[3]:

- HiNA: high network availability with a resume time of 100 milliseconds or less
- MeNA: medium network availability with a resume time of 10 seconds or less
- LoNA: low network availability with a resume time of 10 seconds or more

HiNA refers to network products, e.g. routers, switches and hubs, that must respond (almost) immediately. MeNA reflects the response time af an internet connection where the internet protocol requires a reaction within this range. LoNA indicates situations where the resume time is less critical. In the next section network availability and power consumption in networked standby for various product groups will be indicated.

Power Consumption in Networked Standby for Best Available Products

The preparatory study took into account 21 product categories from 4 general product groups: computer equipment, network equipment, consumer electronics and imaging equipment. Table 2 provides an overview of power consumption in networked standby of current best available products based on Nissen (2011, p. 6-15-25) and data from industry. Note that for the computer products in this table WOL does not provide protocol level support.

[3] The boundaries between the categories have been set at a level far away from actual resume times in order to avoid uncertainties regarding the category a product belongs to. For example a product in the HiNA category will have a resume time in the millisecond range. Therefore these definitions should not be read in such way that e.g. all MeNA products should allow for a resume time of 10 seconds.

Table 2. Power consumption in networked standby – best available products

Product	Power consumption in networked standby (W)	Resume time (category)	Remarks*
Desktop computer	1.65	MeNA	S3+WOL
Notebook computer	1.25	MeNA	S3+WOL
Notebook computer	< 1	LoNA	S4/S5+WOL
Network Attached Storage (Home NAS)	2.3	MeNA	
Inkjet printer	3.7	MeNA	WLAN, USB
Large format printer	9.7	LoNA	
Home Gateway	3.3 – 8.1 11	HiNA	Depending on configuration With DOCSIS modem
Complex set-top box	4.5 – 7.5	MeNA	Cable - Sattelite
Mobile (handheld) products	< 1	HiNA	WLAN

* S3-S5 refer to ACPI states: S3=suspend to RAM; S4=suspend to disk; S5=soft off. WLAN=Wireless LAN. USB=Universal Serial Bus. DOCSIS=Data Over Cable Service Interface Specification

Networked Standby: Product Policies

Introduction: 1 W+ Target

The IEA 1 Watt target has been instrumental in reducing standby consumption worldwide. This can be attributed to the following characteristics. First and foremost the message is simple, politicians can understand it: it contains only one figure, there are no exemptions, it is horizontal, across the board, including all products. Furthermore, the message is appealing – reducing energy waste to a low level – and does not require difficult explanations. The IEA 1 W target is not a policy measure, e.g. regulation, itself but is depent on governments to implement policy measures to achieve this target. Implementations like the US Federal Energy Management Program (FEMP, 2008) and especially the EU Ecodesign Regulation 1275/2008/EC on standby and off mode (Official Journal of the European Union, 2008) show that horizontal implementation is possible. Networked standby is currently (being) addressed in several ENERGY STAR specifications, but not yet horizontally.

For networked standby a 1 Watt plus (1W+) target can be formulated that resembles the 1 Watt standby target. It is simple, horizontal and appealing. Furthermore the "+" makes it flexible, acknowledges that the networked part might need a bit more power than 1 W but at the same time suggests that the power consumption should not be too far from 1 W. Table 2 shows that 1 W in networked standby is already benchmark technology for mobile products but also that several other product categories will need to come a long way before coming close to this target.

The implementation of a 1W+ target is more complicated than of a 1 W target for standby. As indicated above it is not only the product that must be able to receive and process a wake-up signal, the network must be able to produce and transport the signal, and other products must not unnecessarily interfere, e.g. wake-up or keep awake products in the network. Therefore the implementation requires coordinated action from a broad range of stakeholders: e.g. manufacturers of products and chip-sets, network operators, standardization organizations and governments. Nordman et al. (2009) provide general guiding principles for the implementation of energy efficient digital networks, including the implementation of a 1W+ target. The next section gives an example of how requirements for networked standby can be set at the product level.

EU Ecodesign Networked Standby Implementing Measure

The EU adopted end of 2008 the first horizontal measure on standby, including off mode, in the framework of the Ecodesign Directive (Official Journal of the European Union, 2009). This measure in the form of a regulation consists of two tiers coming into force one and four years after publication of the regulation and includes a requirement on power management in the second tier. Although in the preparatory study for this regulation networked standby was mentioned (Nissen, 2007), at the time of adopting the regulation it was thought too early to include networked standby in the regulation itself. To prepare for a measure on networked standby a separate preparatory study was conducted (Nissen, 2011). When discussing the results of this study with EU Member State experts and stakeholders in February 2011, it was concluded that a practical way to accommodate for networked standby was to amend the current standby and off mode regulation 1275/2008/EC. A working document of the European Commission (EC) (2011) was discussed at a Consultation Forum meeting in September 2011 and currently the EC is preparing the final draft of the amendment that will be voted upon in the Ecodesign Regulatory Committee. This section shortly describes the main elements of this amendment: definitions, requirements and test method for compliance testing. At the end the expected savings and limitations of the proposal are indicated.

Definitions. The key definitions of the proposal are networked standby, network port and network availability.

Networked standby is a condition where the product is able to resume a function through a remotely initiated trigger via a network connection (remote activation). Note that networked standby is presented as a condition and not as a mode because it is assumed that this condition can be present in many modes. Consequently it is unnecessary to require a networked product to have a networked standby mode, which then would require a definition of this mode. Since products could have multiple functions alongside network standby, it would be hard to define a mode suitable for use in a horizontal regulation.

A network port is a physical interface of the network connection at the product through which the product is able to be remotely activated. Only products that have one or more network ports are networked products. Note that not every network connection is a network port, it is essential that the product can be reactivated through the network connection. However, the definitions do not say that the remotely initiated trigger need to be part of a standard protocol.

Network availability means the product has the capability to resume functions after a remotely initiated trigger has been detected by a network port. Network availability has been identified in the preparatory study as the single main parameter that determines functionality and relates to power consumption and can be expressed as the time to resume. Although the resume time is a clear concept, measuring resume time is not easy especially not for the large variety of products being covered by the regulation. Therefore as an alternative a short list of HiNA products was defined: router, switch, hub, modem, network access point (not being a terminal), VoIP telephone, video phone. Furthermore, products with the functionality included of a router, switch, hub, modem and network access point (not being a terminal), were defined as products with HiNA functionality. Contrary to HiNA products, products with HiNA functionality need to comply with the current standby regulation when the HiNA functionality is nor used or switched off. Furthermore no distinction was made between MeNA and LoNA, thus resulting in three categories: HiNA products, products with HiNA functionality and other networked products.

Examples of other networked products are PCs, audio equipment, set-top boxes, televisions, printers. Of course from a user experience perspective other networked products would need to have a short as possible resume time, but it is assumed that this will be market driven.

Requirements. The main requirements consist of a power management requirement and requirements for the power consumption in a mode with networked standby. The power management requirement indicates that the product shall automatically switch into a mode having networked standby when the product is not providing a main function. The default period for networked standby shall be no more than 20 minutes. The power consumption requirements are specified in two tiers for HiNA networked products and networked product with HiNA function(s), and other networked products; see table 3.

Table 3. Suggested power requirements for networked products in networked standby

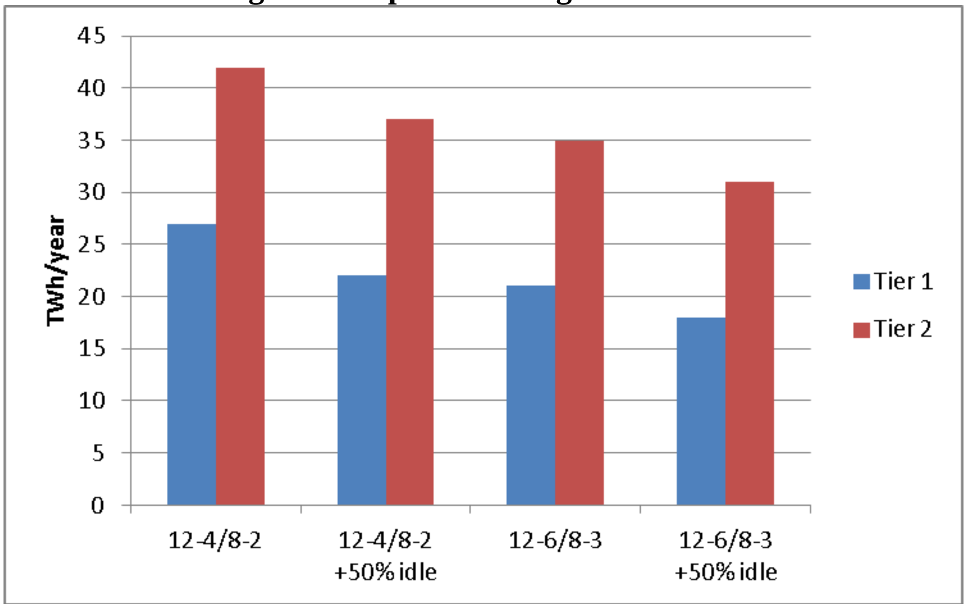
Networked product	Tier 1 (1-Jan-2014)	Tier 2 (1-Jan-2016)
HiNA network products Networked products with HiNA function(s)	12 W	8 W
other networked products	4 W	2 W

Source: European Commission (2011, p. 3)

Test method for compliance testing. The test method for compliance testing is crucial for dealing with products having multiple ports for different type of networks. In order to avoid dealing with multiple network connections by allowances, which would very quickly become a very long list, the product shall comply with the required value for all types of network connection when *one* network connection is present. If for a certain type of network connection, e.g. LAN, more than one network port is present, one port is randomly selected while leaving the others disconnected. This stimulates other network ports being power managed (i.e. switched off because the connection is not used) so that the product meets the requirements. Wired network ports, e.g. ethernet, USB, can easily detect whether there is a connector attached. For wireless connections, the connections that are not used may be switched off during the test.

Expected savings. The expected savings of the proposal have been calculated for the household and office products as included in the preparatory study. The savings are achieved by a combination of the effect of power management (the product spends less time in idle; time in on-mode was kept equal) and the difference between the power consumption in idle and networked standby. For tier 1 savings of 27 TWh/year are estimated, and 42 TWh/year for tier 2 respectively for the EU in 2020. The savings for less stringent targets for other networked products (6 and 3 W) and savings with a 30 minutes idle time (+ 50%) were based on the same assumptions and calculated; see figure 4. Figure 4 shows that the effect on the savings of relaxing the second tier requirements and allowing 50 % more time in idle are in the same range.

Figure 4. Expected savings for the EU in 2020



Limitations of the proposal. First of all it should be noted that Ecodesign implementing measures (in this case the amendment of the regulation) are limited to addressing products placed on the EU market. This means that the requirements cannot be imposed on service providers forcing them to use appropriate protocols to reactivate products in networked standby. However the horizontal nature of the measure ensures that technical solutions will find a large volume to that they can be implemented at low cost. Second, product specific measures can be better tailored and might set more ambitious targets for certain products. Looking at table 2, for certain Home Gateways (HiNA products) a target value of 4 W may already be appropriate. The Ecodesign framework allows for including networked standby in specific product measures. However, it would not be feasible, at this stage, to set specific product measures for all products covered by the horizontal measure. Moreover the main aim of the horizontal measure is to introduce power management for as many products as possible.

Summary and Conclusions

As continuously more products are becoming networked products, energy consumption in networked standby could counteract the savings made by worldwide standby policies in the framework of the IEA 1 W standby target. Therefore this paper calls for a 1 W+ target for networked standby. Currently this target could only achieved by mobile (handheld) products and notebooks.

Within a network environment, network availability expressed in resume time is an important parameter. The resume time is in general determined by the resume time of the functionality that is reactivated. The ideal would be to have a low power mode with networked standby functionality and a short resume time.

For networked standby to function, not only the product itself needs to be able to receive and process a network signal (trigger) to reactivate the required functions, but the network also needs to be able to generate and/or transport a trigger. This paper concentrated on the product aspects of networked standby, but the development of (standard) protocols, e.g. energy efficient

Ethernet, is another essential requirement for the implementation of networked standby. This paper shows how a horizontal measure could address products in the framework of a 1 W+ target for networked standby. In general mandatory product policies, e.g. MEPS, cannot mandate the use or development of protocols because these policies address the manufacturers of products. Therefore the full deployment of networked standby requires (coordinated) action from a broad range of stakeholders.

Acknowledgements

The author would like to thank three anonymous reviewers for their comments and Lucinda Maclagan for proof reading.

References

4E Mapping & Benchmarking. 2012. *Standby trends for televisions*. http://mappingandbenchmarking.iea-4e.org.

Almeida, Aníbal de, Carlos Patrão, Philippe Rivière, David da Silva, Barbara Schlomann & Bob Harrison. 2011. "Standby and off-mode power demand of new appliances in the market." In *Proceedings of the EEDAL 2011 conference*. http://re.jrc.ec.europa.eu/energyefficiency/EEDAL/index.htm.

Energy Efficient Strategies. 2006. *Standby Power – Current Status.* Report 2006/02 prepared for the Equipment Energy Efficiency Committee Australia. http://www.energyrating.gov.au/library.

Energy Efficient Strategies. 2008. *Projected Energy Consumption in Australian homes to 2020*, prepared for the Department of the Environment, Water, Heritage and the Arts. www.energyrating.gov.au.

Energy Efficient Strategies. 2010. *Standby Power and Low Energy Networks – issues and directions*, prepared for APP and IEA 4E Standby Annex. http://standby.iea-4e.org/reports.

European Commission. 2011. *Working document on COMMISSION REGULATION ../…/ of […]amending Regulation (EC) 1275/2008 of 17 December 2008 implementing Directive 2005/32/EC with regard to ecodesign requirements for standby and off mode electric power consumption of electrical and electronic household and office equipment.* http://ec.europa.eu/energy/efficiency/ecodesign/doc/forum/working_document_networked_standby_27072011.pdf. Brussels: European Commission.

FEMP. 2008. Federal Energy Management Program (USA) – *Summary of FEMP Recommended Levels of Standby*, website hosted by LBNL, see http://oahu.lbl.gov/level_summary.html.

G8 Gleneagles. 2005. *The Gleneagles Communiqué*. http://www.g8.gov.uk.

Harrington, Lloyd, Hans-Paul Siderius & Mark Ellis. 2008. "Standby Power: Building a coherent international framework." In *Proceedings of the 2008 ACEEE Summer Study on Energy Efficiency in Buildings*, 9:134-149. Washington D.C.: American Council for an Energy Efficient Economy.

IEA. 2007. *International Workshop on Set-top Boxes and Digital Networks.* http://www.iea.org/Textbase/work/workshopdetail.asp?WS_ID=285. Paris: International Energy Agency

IEA. 2009. *Gadgets and Gigawatts – Policies for Energy Efficient Electronics*. Paris: International Energy Agency.

IEC62301. 2011. *International Standard 62301 Ed. 2: Household electrical appliances – Measurement of standby power*. www.iec.ch. International Electrotechnical Commission: Geneva.

Kim, Nam Kyun. 2011. "2011 Standby Status of Korea". Presentation at the IEA 4E Standby Power Annex meeting, 10-11 October 2011, Sydney.

Meier, A. & B. Nordman. 2008. *Low Power Mode Energy Consumption in California Homes*. Report CEC-500-2008-035 Public Interest Energy Research Program. http://www.energy.ca.gov/. Sacramento: California Energy Commission.

Mudgal, Shailendra, Locran Lyons & Alvaro de Prado Trigo. 2011. *Estimate of energy wasted by network-connected equipment*, prepared for the Australian Government (Department of Climate Change and Energy Efficiency). http://standby.iea-4e.org/reports.

Mudgal, Shailendra, Kurt Mehmel & Thibault Faninger. 2011. *List of technical standards for equipment connected to energy-using networks*, prepared for the Australian Government (Department of Climate Change and Energy Efficiency). http://standby.iea-4e.org/reports.

Nissen, N.F. 2007. *EuP Preparatory Study Lot 6. Standby and Off-mode Losses.* http://www.ecostandby.org/. Berlin: Fraunhofer IZM.

Nissen, N.F. 2011. *EuP Preparatory Study Lot 26. Networked Standby Losses.* http://www.ecostandby.org/. Berlin: Fraunhofer IZM.

Nordman, Bruce, Alan Meier, Hans-Paul Siderius, Lloyd Harrington & Mark Ellis. 2009. "Network connectivity and low-power mode energy consumption." In *Proceedings of the EEDAL 2009 Conference.* Berlin.

Nordman, Bruce. 2011. *Testing products with network connectivity*, prepared for the Australian Government (Department of Climate Change and Energy Efficiency). http://standby.iea-4e.org/reports.

Official Journal of the European Union. 2008. *COMMISSION REGULATION (EC) No 1275/2008 of 17 December 2008 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.* Official Journal of the European Union L339, 18.12.2008, p.45-52.

Official Journal of the European Union. 2009. *Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of ecodesign requirements for energy-related products (recast).* Official Journal of the European Union L280, 31.10.2009, p.10-35.