The impact of the standby consumption in a Passive House

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1 Introduction

According to the International Energy Agency, by 2030, 15% of the total appliance electricity consumption in Europe could be due to standby functions [IEA, 2013].

In the first certified Passive House in Portugal, electricity is the only source of energy and the most efficient appliances and devices in the market were chosen. With a treated floor area of 223 m^2, the PHPP 2007 results were: a specific space heating demand of 7 kWh(m^2a); a heating load of 10 W/m^2; a cooling load of 4 W/m^2; and a specific primary energy demand of 67 kWh(m^2a). The total electricity demand is 5765 kWh, or 26 kWh/(m^2a) of specific demand. In 2014 the electricity consumption measured was 4608 kWh/a [Marcelino & Gavião, 2014].

This paper analyses the impact of the standby consumption in this Passive House discussing how can it be mitigated and how this problem can be avoided in future.

2 Standby consumption

2.1 The importance of standby consumption

In 2012 the standby consumption was responsible for 16% of residential electricity use in the United Kingdom. This consumption share will increase 1% per year and is aligned with other European countries due to the projected growth in energy demand of network-enabled devices worldwide [IEA, 2013].

In 2004, standby losses in Germany's private households and offices account for electricity consumption of at least 22 TWh per year, incurring annual costs of at least 4000 million € [UBA, 2008]. With an increase of 1% per year, it is estimated that in 2014 the consumption was 24 TWh.

2.2 Potential standby savings vs renewables

A mitigation of 75% of standby losses in Germany in 2014 would induce almost 18 TWh of savings per year, which represent an average of 1,5 TWh per month. In figure 1, it is possible to compare the potential standby savings with electricity production from solar and wind in German in 2014 [Fraunhofer ISE, 2014].

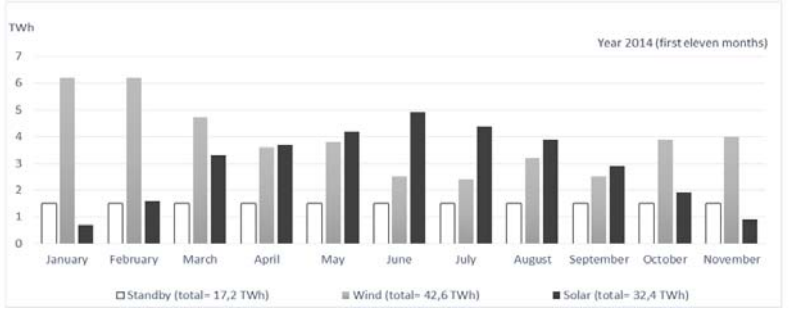


Figure 1: Potential standby savings vs wind and solar monthly production in German

For the first 11 months of 2014 a mitigation of 75% of standby losses in Germany would avoid 17,2 TWh, which is equivalent to 53% of total electricity produced from solar or 40% of total electricity produced from wind.

2.3 Standby mode vs off mode

In order to identify standby losses, detailed definitions of different operation modes are necessary, as differentiating off mode which is often included in standby mode. In the standby mode the appliance fulfils at least one function but not the main purpose. In the off mode the appliance does not fulfil any task, seems to be switched off but still uses energy. Though off mode does not offer any advantage for the user it has significant energy consumption due to bad solutions on electronic design of devices. This allows to define the power use in each operation mode.

Some studies show that standby mode represent almost 60% of the total standby losses while off mode is responsible for almost 30%.

2.4 European regulations

Under the Energy Using Product (EuP) Directive, the Commission sets maximum limits to standby and off-mode power. The objective of the eco-design requirements for standby and off mode is to ensure the lowest possible energy use for household appliances and electronic products on standby and off modes. From 2013, the main requirements are the following: off mode < 0,5 W; standby – appliance with no display < 0,5 W; standby – appliance with information display < 1 W. Furthermore, from 2013 the equipment has been required to offer a power management function, which switches the equipment to off mode or standby mode after the shortest possible period of time (when there is no user intervention and when appropriate for the intended use of the equipment) [EU, 2008].

Since January 2015, new EU-wide Eco-Design Directive requirements have been in effect for energy consumption, stipulating that new devices connected to a network or that have internet access (including routers, video phones and modems) may in future consume only 6 to 12 W on standby mode.

3 Methodology

A monitoring program has been defined for the standby consumption in the first certified Passive House in Portugal, aiming to determine the standby and off mode electricity consumption of all relevant domestic devices. The monitoring occurred during June 2015, with an energy meter of 0,1 W resolution, PeakTech 9035 and was proceeded with Cloogy and Owl online monitor systems.

Along with standby consumption monitoring, a behavior pattern of the house utilization was defined with the goal to interpret the number of hours per year of the standby and off mode of each device. These number of hours of utilization of each device were defined according to the data obtained with the monitoring and corrected with the data obtained from the answers of a survey to define an average annual basis.

To analyse the weight of the potential savings of the standby consumption, two scenarios were defined to mitigate the standby consumption in the first certified Passive House in Portugal. The first scenario is based on the limits set for each device (by new EU regulations) for the standby and off mode consumption. The second scenario is based on the utilization of the most relevant solutions which are nowadays available on the market.

4 Solutions to mitigate the standby consumption

Table 1 shows some solutions found among a market survey of devices to mitigate standby consumption. For each one there is a small description, a photo, an indication of cost in euros and if it is a do it yourself (DIY) solution.

These solutions allow a net saving of power so long as the control devices themselves use less power than the controlled equipment in standby mode.

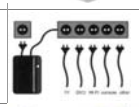
ID	Description	Photo	Cost €	DIY
a	**Wireless energy monitoring:** Online monitoring or a local solution. Can show a historical account of your usage, also telling when you've improved your usage habits. Panel should be installed near the front door.		40 – 55 each	Yes
b	**Energy meter:** to measure the devices when they are on standby mode and take action to switch off those with the highest consumption.		15 – 20 each	Yes
c	**Switchable power strip:** If several devices are used together or only when a room is occupied, they can be connected to a single power strip that is switched off when not needed.		4 – 8 each	Yes
d	**Analog daily programmer timer:** Can be used to turn off standby power of devices that are unused on a regular schedule.		6 – 9 each	Yes
e	**Power safer:** After you switch all your appliances to standby mode, the PowerSafer disconnects them from the power supply.		14 – 25 each	Yes
f	**Energy management solutions:** Allow to monitor all electrical equipment consumption individually, and control their usage time through the Power Plugs via Bluetooth-connected iOS or Android smartphones or tablets.		189 – 210 For 2 plugs	Yes

Table 1: Some solutions nowadays available in the market to mitigate the standby consumption.

5 Monitoring of the standby consumption in the 1st Certified Passive House in Portugal

Table 2 presents the results of the monitoring of the standby consumption of the most relevant devices in the first certified Passive House in Portugal. It shows the off mode and the standby consumption of each device as well as the percentage of the total consumption. One can also see the percentage of each group of devices which are the following: kitchen, living room, garage, technical equipment, electric shutters and electronic devices.

Application	quant	Off-Mode consumption	Off-Mode (h/d)	Standby consumption	Stanby (h/d)	days / year		Off-Mode & Standby Consumption kWh/a		
Dishwashing	1	0.1	18.0	3.4	5.0	365	=	**6.86**	0.8%	
Induction Ceramic Cooktop	1	1.2	20.0	1.2	0.0	365	=	**8.76**	1.0%	
Electrical Oven	1	1.4	23.5	1.4	0.0	365	=	**12.01**	1.4%	
Microwave oven	1	2.3	20.0	2.3	3.5	365	=	**19.73**	2.4%	
Refrigerating	1			0.8	20	365	=	**5.84**	0.7%	
Freezing	1			0.5	20	365	=	**3.65**	0.4%	
Clothes washing	1	0.1	31.0	2.6	3.0	365	=	**3.98**	0.5%	7.3%
TV	1	2.0	22.0	2.0	2.0	365	=	**17.52**	2.1%	
DVD player	1	0.9	23.0	1.5	1.0	365	=	**8.10**	1.0%	
Sound System	1	0.9	23.0	2.0	1.0	365	=	**8.29**	1.0%	
Set-top Box, digital cable	1	13.7	22.0	13.7	2.0	365	=	**120.01**	14.3%	18.4%
Garage Door opener	1	4.9	23.8	4.9	0.0	365	=	**42.57**	5.1%	
Door opener	1	2.9	23.8	2.9	0.0	365	=	**25.19**	3.0%	8.1%
Compact Unit: NILAN compact P	1	9.6	24.0	9.6	0.0	213	=	**49.06**	5.8%	
Solar Tank	1			1.3	12.0	365	=	**5.69**	0.7%	6.5%
Control of electrical window shutters	22			2.4	23.8	365	=	**458.67**	54.7%	54.7%
Samsung laser printer	1	0.9	19.0	8.9	3.0	300	=	**13.14**	1.6%	
Monitors	2	0.9	19.0	0.9	3.0	300	=	**11.88**	1.4%	
Notebook	3	0.9	19.0	0.9	3.0	300	=	**17.82**	2.1%	5.1%
Total						kWh		838.77	100%	100%
Specific demand	tfa = 223 m²					kWh/(m²a)		**3.76**		
Recommend maximum value	assuming max 0.5 W per device							0.79		

Table 2: Standby consumption in the first certified Passive House in Portugal

The total standby and off mode consumption is 838,77 kWh/a of final energy, or 3,76 kWh/m²a, which represents 18,2 % of the total electric consumption of 4608 kWh/a, or 20,66 kWh/m²a, measured in 2014.

The biggest standby consumer is the electric control of the window shutters with a total of 458,67 kWh/a representing itself almost 10 % of total consumption. The inadequate building orientation due to the municipal planning resulted in a less favorable solar radiation balance, with 75 % of the glazing areas facing west. This fact imposed the installation of an automatic system to control each window shutter to optimize solar gains and avoid overheating. This automatic control system allows controlling the window shutters individually, per façade and globally. Unfortunately enough attention wasn't paid to the standby consumption of this system.

6 Scenarios for standby consumption mitigation

6.1 Scenario 1 – less than 0,5 W of standby consumption per device

Scenario 1 was established based on the limits set by the European regulations for the standby and off mode consumption, mentioned above. With a maximum value of 0,5 W for each device, the total standby consumption would correspond to 176,17 kWh/a, or 0,79 kWh/(m^2a). This scenario results in a share of the standby consumption of 4,5 % in relation to the total electrical consumption of 3945,4 kWh/a and a reduction of the standby consumption of 79,0 %.

6.2 Scenario 2 – use of solutions to control standby consumption

Application	quant	Off-Mode consumption	Off-Mode (h/d)	Standby consumption	Stanby (h/d)	days / year		Off-Mode & Standby Consumption kWh/a			Off-Mode & Standby Mitigation
Dishwashing	1	0.1	1.0	3.4	1.0	365	=	**1.28**	1.2%		f
Induction Ceramic Cooktop	1	1.2	1.0	1.2	1.0	365	=	**0.88**	0.8%		f
Electrical Oven	1	1.4	1.0	1.4	1.0	365	=	**1.02**	1.0%		f
Microwave oven	1	2.3	1.0	2.3	1.0	365	=	**1.68**	1.6%		f
Refrigerating	1			0.8	20	365	=	**5.84**	5.6%		----
Freezing	1			0.5	20	365	=	**3.65**	3.5%		----
Clothes washing	1	0.1	1.0	2.6	1.0	365	=	**0.99**	0.9%	14.7%	f
TV	1	2.0	0.0	2.0	0.0	365	=	**0.00**	0.0%		e
DVD player	1	0.9	0.0	1.5	0.0	365	=	**0.00**	0.0%		e
Sound System	1	0.9	0.0	2.0	0.0	365	=	**0.00**	0.0%		e
Set-top Box, digital cable	1	13.7	0.0	13.7	0.0	365	=	**0.00**	0.0%	0.0%	e
Garage Door opener	1	4.9	0.0	4.9	1.0	365	=	**1.79**	1.7%		e
Door opener	1	2.9	0.0	2.9	1.0	365	=	**1.06**	1.0%	2.7%	e
Compact Unit: NILAN compact P	1	9.6	24.0	9.6	0.0	213	=	**49.06**	47.1%		----
Solar Tank	1			1.3	12.0	365	=	**5.69**	5.5%	52.5%	----
Control of electrical window shutters	22			2.4	1.0	365	=	**19.27**	18.5%	18.5%	f
Samsung laser printer	1	0.9	0.0	8.9	3.0	300	=	**8.01**	7.7%		e
Monitors	2	0.9	0.0	0.9	3.0	300	=	**1.62**	1.6%		e
Notebook	3	0.9	0.0	0.9	3.0	300	=	**2.43**	2.3%	11.6%	e
Total							kWh	**104.26**	100%	100%	
Specific demand	tfa = 223 m^2						kWh/(m^2a)	**0.47**			
Recommend maximum value	assuming max 0.5 W per device							0.79			

Table 3: Mitigation of standby consumption in the first certified Passive House in Portugal

Scenario 2 is based on the utilization of the most relevant solutions (which are nowadays available on the market) that were presented before. The most relevant solutions for this case are power safer (e) and energy management solutions (f). These solutions were chosen based on its cost-effectiveness and on the users preferences. The results of Scenario 2 are shown on table 3.

The total standby consumption in Scenario 2 corresponds to 104,26 kWh/a, or 0,47 kWh/(m2a). This scenario results in a share of the standby consumption of 2,7% in relation to the total electrical consumption of 3873,49 kWh/a and a reduction of the standby consumption of 87,6 %.

The total investment of this standby consumption mitigation system was 405 €, with a payback of 3 years, considering the cost of electricity of 0,18 €/kWh.

7 Conclusions and future work

The standby consumption already has a significant share of the total electricity consumption in buildings and it is expected to rise due to the increase of network-enabled devices worldwide. There is a huge saving potential in standby consumption in the building sector, quoting Wolfgang Feist "The best energy is less energy".

In this Passive House the standby consumption had a relevant share of the total electricity consumption. This paper shows that at the moment it is possible to mitigate almost 90% of the standby consumption in a cost-effective and easy way with solutions which are currently available on the market.

PHPP could avoid this problem by demanding inputs regarding the standby consumption of the devices and equipment.

Attention must be paid to every device and system installed in the building and the most efficient ones selected. There are online tools that can help this search and selection such as Topten website which provide a selection of best appliances from the energy point of view, www.topten.eu. The labeling of the devices and equipment should have in the near future the standby and off mode consumption.

8 References

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