European regulation of standby energy consumption: the case of LCD-TVs and TFT-monitors

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Abstract: This paper describes an example of a regulatory sustainability impact assessment that relates to energy saving and climate protection: recently the European Union has adopted a framework directive on requirements of the ecodesign of Energy-using Products (EuP). An implementing measure on standby energy consumption based on this directive is expected in 2008. Manufacturers of LCD-TVs and TFT-monitors were asked to estimate the energy saving potential and the costs of this implementing measure. The impact assessment outlines the likely ecological benefits and the economic effects. For LCD-TVs and TFT-monitors the potential to reduce energy consumption and carbon dioxide emissions is quite small and consumers are hardly expected to be willing to pay more for an energy efficient product. Especially regulating the off mode is a very expensive option. In a further step CO_2 avoidance costs are calculated. Partly, the avoidance costs are far above alternative avoidance costs represented by the price of emission rights.

Keywords: integrated product policy; IPP; European Union; EU framework directive for energy-using products; EuP; ecodesign; standby energy consumption; off-mode; energy saving; energy efficiency; climate protection; impact assessment; CO_2 avoidance costs.

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1 Introduction

The European Union strives to enforce energy saving by law. This initiative aims to improve climate protection and energy security. Within the approach of the Integrated Product Policy (IPP; European Commission, 2001, 2003) the European Commission recently developed a framework directive on eco-design requirements for Energy-using Products (EuP; European Parliament and the Council of the European Union, 2005). Regulations are not part of the EuP framework itself but are enforced by implementing measures based on this framework. The first measure to be implemented is a regulation on standby energy consumption (EuP Art. 16, No. 2). The ecological and economic impacts of this measure are analysed in this paper (Biebeler and Mahammadzadeh, 2006).

At the European level impact assessments gain in importance. In 2002, the European Commission submitted an action plan (European Commission, 2002b) in its efforts for 'better regulation'. The action plan contains initiatives for more effective, efficient and transparent legislation and a call for impact assessments.

> "The Commission intends to launch impact assessment as a tool to improve the quality and coherence of the policy development process. It will contribute to an effective and efficient regulatory environment and further, to a more coherent implementation of the European strategy for Sustainable Development" (European Commission, 2002c).

Impact assessments in the European Commission are to be conducted in two steps called 'roadmap' and 'extended impact assessment'. The two steps are standardised by a guideline (European Commission, 2005b).

The EuP framework directive and the scheduled implementation measure concerning the standby energy consumption have consequences for manufacturers of electrical and electronic devices. The methods of regulatory impact assessments are particularly favourable to determine all desired and undesired impacts of the arrangement. Although the measure is announced, a draft version is not yet available. However, various proposals to limit energy consumption and energy efficiency standards are being discussed. The Code of Conduct on Energy Efficiency of External Power Supplies (European Commission, Joint Research Centre, 2004b) is an important example which will be considered in this impact assessment.

In many political debates energy consumption connected with different standby modes of electrical devices is considered as avoidable and useless. In the meantime, its share of energy consumption is growing faster than electricity usage of consumer electronics in active mode (International Energy Agency, 2005; Schlomann et al., 2005). Therefore, others argue that a reduction of standby energy losses is not only reasonable but urgently needed. These judgements should be replaced by a closer investigation, as the standby mode fulfils certain functions the consumer wants. Furthermore, improving energy efficiency of standby modes causes additional cost. A cost-benefit-analysis should be carried out before new product regulation is adopted.

2 Standby modes and energy efficiency

Because of the variety of different standby modes, a more detailed reflection on standby energy consumption is essential. An electrical device is in the off mode when it works on the lowest possible energy level without being turned off completely. While the US energy label Energy Star calls this state 'off mode', others use the name 'standby power' (United States Environmental Protection Agency, no date b, p.4). A complete deactivation leads to the states 'hard off' or 'disconnected' (European Commission, 2005a, p.26; United States Environmental Protection Agency, no date b, p.4). When in the off mode, the device does not fulfil any functions anymore. This is the main reason, why this kind of energy consumption is sometimes considered as being wasteful and unreasonable. In fact, the device itself is disconnected from the electrical circuit, but the power supply unit or the loading device need electrical power. Either there is no on–off-switch – as in the case of loading devices – or it is a secondary switch which disrupts the connection between power supply unit and device without disconnecting the power supply from the grid. As the power supply unit is in most cases on the backside of the device while the switch is on the front side, installing a primary switch between grid and power supply unit would be more complex and more costly. Additionally, the switch itself would be more complex if it had to cope with the higher voltage of the external grid. The resulting idle losses depend on the specific construction of power supply units and loading devices. A loss of 0.5 W amounts to 4.4 kWh within one year. The 'off mode' exists in all electrical devices without a primary on–off switch which are not continuously active or in a 'real' standby mode – like telephone answering machines or the base station of a cordless phone, which are always ready to receive incoming calls.

The term 'real' standby should emphasise the differences to the 'off mode'. 'Real standby' can be subdivided into various states like 'sleep' and 'deep sleep', 'standby active' and 'standby passive' and further differentiations connected with the terms 'high' or 'low' (EACEM, no date, p.6; European Commission, Joint Research Centre, 2004a, p.10; Schlomann et al., 2005, p.4). A time display or the preparedness to receive a remote control signal are examples for low standby states. The 'sleep mode' characterises the ability to leave a passive state and to restore full functional capability quickly. This is the case when a copying machine warms up to working temperature or when a computer activates its cache memory and rebuilds outside connections. A common definition of standby is a state in which the main function of the electrical device is not fulfilled (Bertoldi et al., 2002, p.1; Schlomann et al., 2005, p.4). However, the main problem with this definition is the correct specification of main functions.

The standby mode involves a huge number of differentiations (Cremer et al., 2003, p.6). The specific definition depends on the specific device. Since product development is an ongoing process a once-and-forever borderline of standby can hardly be defined. The following considerations concentrate on two well defined states for selected products: the 'off mode' and the 'real standby' of LCD-television sets and TFT-monitors.

3 Existing regulation of standby energy consumption

Energy consumption of products is regulated or influenced by a huge amount of mandatory maximum values and voluntary initiatives. Energy consumption in general and especially in the case of standby is in the focus of political actors and the public. Public relations or media campaigns and voluntary labelling are more common than legally binding instructions.

Examples are the Blue Angel (Blauer Engel) of the German Federal Environment Agency (Umweltbundesamt) or the Initiative Energy Efficiency (Initiative EnergieEffizienz), which is supported by the German Energy Agency (Deutsche Energie-Agentur) and the most important national electricity suppliers. Further regional initiatives are the Nordic Swan in Scandinavia (Denmark, Finland, Iceland, Norway and Sweden) and the top-runner programme within the Energy Conservation Law (Law Concerning Rational Use of Energy) in Japan. Three standards with government involvement have international impact: The Energy Star of the US Environmental Protection Agency and the US Department of Energy, the 1-W-Standby Power Initiative of the International Energy Agency and the agreements of the European Commission with the European Association of Consumer Electronics Manufacturers (EACEM), the European Information and Communications Technology Industry Association (EICTA) and other companies on the European market.

Many initiatives have been started within the European Union in order to reduce the energy consumption of products. The labelling of white goods (refrigerators, stoves and washing machines) with simplified and graphically supported energy efficiency information is a successful example. The European Commission considers the efforts to reduce standby energy usage as an important element of its strategy to enhance energy efficiency. A number of voluntary agreements have been negotiated with producers and suppliers of electrical goods in the European market. The first agreement on idle losses of television sets and video recorders was signed in 1997 (European Commission, 1998). A 1999 declaration includes the intention to reduce standby energy consumption of all audio devices to 1 W (EACEM, no date, p.3). A self-commitment on flat screens and other television equipment was ratified in 2003 (EICTA, unpublished).

The European Joint Research Centre has negotiated voluntary codes of conduct on digital TV service systems (European Commission, Joint Research Centre, 2004a) and external power supply units (European Commission, Joint Research Centre, 2004b), which have been signed by several manufacturers. Internal power supply units have not been included into these codes of conduct because of other existing agreements on these products (EACEM, no date; United States Environmental Protection Agency, no date b). Another code of conduct for broadband equipment was prepared and signed in 2006 (European Commission, Joint Research Centre, 2005a,b). Although only a minority of companies agrees to the standards voluntarily, the content of these codes of conduct is supposed to be integrated into the implementing measure of the EuP-directive:

> "Codes of Conduct […] can be used as basis for international consensus and Directives if the voluntary solution does not deliver. […] A Directive for Minimum Efficiency Requirements under the Eco Design Directive could be the most desirable solution for power supplies" (Bertoldi, 2004, p.38f).

While focussing on power supply units and loading devices, the integrated assessment of an electric appliance is replaced with the evaluation of comparable components of different appliances. The limits for standby energy losses and energy efficiency in the active mode of external power supplies and loading devices, which are similar regarding their performance characteristics, are displayed in Tables 1 and 2. Table 3 shows the numerical values of the energy efficiency standards of Table 2.

In addition, manufacturers have agreed to include absolute maximum values for standby energy use in self-commitments. A voluntary agreement signed in July 2003 specifies that the 'standby passive' consumption of video recorders and TV sets (without decoding of digital signals) should not exceed 1 W in 2007. The same limit is valid for DVD-recorders since 2005 (EICTA, unpublished, p.6, 13 and 18). The self-commitment also contains a formula which describes the minimum energy efficiency in the active mode depending on the size of the screen. The Energy Star establishes the 1-W-limit for the standby mode for analogous television sets as of 2004 and for digital sets as of 2005 (United States Environmental Protection Agency, no date a, p.5). Since 2002, the EU eco-label (the European Flower) is awarded if energy consumption in passive standby mode is not higher than 1 W and energy efficiency limits are not trespassed Table 1 (European Commission, 2002a, p.2).

Table 1 Maximum values of the code of conduct regarding energy consumption in off mode

Rated output power	*No-load power consumption*	
	Phase 1 *1 January 2005*	*Phase 2* *1 January 2007*
≥0.3 W and <15 W	0.30 W	0.30 W
≥15 W and <50 W	0.50 W	0.30 W
≥50 W and <60 W	0.75 W	0.30 W
≥60 W and <150 W	1.00 W	0.50 W

Source: European Commission, Joint Research Centre (2004b, p.5).

Table 2 Energy efficiency criteria as of 1 January 2007

Rated output power (P_{no})[a]	*Minimum four-point average or 100% load efficiency in active mode (expressed as a decimal)*
>0 W and ≤1 W	$= 0.49 \times P_{no}$
<1 W ≤ 49 W	$= [0.09 \times \ln(P_{no})] + 0.49$
>49 W and ≤150 W	= 0.84

[a] P_{no} = nameplate output power.

Source: European Commission, Joint Research Centre (2004b, p.4).

Table 3 Energy efficiency criteria as of 1 January 2007 (numerical presentation)

Rated output power in Watt	*Minimum efficiency*
1	0.49
2	0.55
3	0.59
4	0.61
5	0.63
6	0.65
7	0.67
8	0.68
9	0.69
10	0.70
15	0.73
20	0.76
25	0.78
30	0.80
35	0.81
40	0.82
45	0.83
≥50	0.84

Source: European Commission, Joint Research Centre (2004b, p.5, own calculations).

A fundamental difference between eco-labels and a legal regulation has to be taken into account: Eco-labels are a positive award for products friendly to the environment. Therefore, the criteria have to be stricter, only the best products should be awarded. Self-commitments or regulations, on the other hand, should be fulfilled by most or all products (Kemna, 2004). These standards cannot be as strict as those of existing eco-labels. Thus, the implementing measure on standby energy consumption should not copy Energy Star standards without consideration of the majority of electrical devices. But as the EuP-implementing measure will not come into force before 2008, technical innovations should be taken into account as well (Grahl and Jepsen, 2005, p.34; Jepsen et al., 2005, p.4; Siderius, 2005, p.14). Therefore, official limit values have to be based upon the anticipated state-of-the-art of 2008.

4 Expected energy consumption and efficiency standards

This study concentrates on the standby and off mode energy consumption of LCD-TVs and TFT-monitors. As an official draft of the implementing measure is still pending, this impact assessment has to be based on anticipated standards. Producers of electronic equipment face the same challenges as they have to adapt their development activities and their products to standards that are not adopted yet but could come into force as of 2008. However, interviews within the industry and the European Commission give an impression of the possibilities. Existing codes of conduct and labels like the Energy Star provide further orientation. Therefore, we assume the standards for standby energy consumption and energy efficiency presented in Table 4. These values provide a basis for the impact assessment in this paper.

Table 4 Implementing measure: assumed standards

	LCD-TVs	*TFT-monitors*
Off mode	0.5 W	0.3 W (up to 60 W) 0.5 W (more than 60 W)
Real standby	1 W	1 W
Energy efficiency of power supply unit	values according to Tables 2 and 3	

5 Compliance with future standards

Some of the electrical products already meet the assumed standards of the implementing measure for standby energy consumption and energy efficiency which could come into force not before 2008. The portion of these products will raise until 2008 but stay below 100% without the implementing measure. The additional effect of the regulation has to be analysed in regard to the different products and the different forms of standby (see Table 5).

5.1 Off mode

The quota of LCD television sets which meet the limit value of 0.5 W in 2005 varies between 0% and 90%, depending on the manufacturer. Some companies expect a 100% fulfilment in

2008, others fear that none of their products could meet the criterion. In general, it will be easier to fulfil the limit value with smaller screens than with large ones. Due to this variety we assume a fulfilment-quota of 50% in 2008 without the implementing measure. Those LDC-TVs that do not meet the assumed standards will have an average off mode energy consumption of 1 W. The manufacturers criticise the 0.5 W-limit as much too strict, especially for screens of average or larger size.

Table 5 Compliance of standards 2005 and 2008

		LCD-TVs	*TFT-monitors*
Off mode	Compliance 2005	20%	70%
	Compliance 2008	50%	90%
	Consumption 2008 (if above standard)	1 W	0.8 W
Real standby	Compliance 2005	25%	40%
	Compliance 2008	25%	75%
	Consumption 2008 (if above standard)	2 W	3 W
Energy efficiency	Compliance 2005	70%	80%
	Compliance 2008	90%	90%

Note: Compliance: share of devices that meet the criteria in Table 4.

The situation of TFT-monitors is less critical. Today, up to 80% of the devices fulfil the future limit values, the share of those which will meet the criterion in 2008 is much higher than in the case of LCD-TVs. About 10% of the monitors will have an off mode energy consumption of more than 0.5 W – that is 0.3 W more on average. A majority of producers believes the 0.5-W limit to be appropriate.

5.2 Real standby

About one out of four LCD-television sets needs 1 W or less in the real standby mode. This proportion will not increase significantly until 2008. Three quarters of the devices will not reach the standards, the average gap will be about 1 W. Most producers characterise the limit as too strict, especially because of new digital components. Only smaller TV sets will be able to meet the standard.

In the case of TFT-monitors, the situation is slightly better. For about 75% of the devices, the standby energy consumption criterion will be within reach in 2008. Today, about 40% fulfil this limit value. Those new monitors that do not meet these standards will need 3 W on average in the real standby-mode. Manufacturers rate the 1-W-limit to be between fair and too strict.

5.3 Energy efficiency

An analysis of future energy efficiency achievements is much more limited. The standards for power supply units, which are assumed to be defined in the EuP-implementation measure, are already met by 70–80% of all LCD-TVs and TFT-monitors. This share will rise to approximately 90% for both products in 2008. However, a good estimation of the energy efficiency level of the remaining 10% is not possible. A majority of manufacturers of LCD-television sets regards these standards as fair, while producers of TFT-monitors judge them to be between fair and too strict.

6 Direct cost effects for manufacturers

The reduction of standby energy consumption can be achieved with technical changes of the electrical devices. Variable costs per unit are calculated between 0.20 € and 5.00 €. The average additional costs for television sets are about 1.50 € and about 5.00 € for TFT-monitors. The main fraction of the additional production costs of a TFT-monitor results from efforts to reduce the off mode energy consumption, while off mode and real standby will equally add to the production costs of LCD-TVs.

As long as customers demand more efficient technology, they are sufficiently willing to pay for the additional costs. In these cases, costumers will gauge additional purchasing costs against lower energy costs during the lifetime. In addition, further advantages of the new electricity saving technical solutions can lead costumers to accept higher prices. However, manufacturers fear that they will not be able to increase prices further for the additional efforts enforced by the EuP-implementing measure. Only the manufacturers of modern flat TFT-monitors are less pessimistic, while most suppliers of LCD-television sets expect shrinking demand because of higher prices.

7 Ecological benefits and avoidance costs

When calculating the economic effects of a tighter regulation of standby energy consumption, costs and benefits have to be considered. The main positive effects of an implementing measure will be energy savings and a reduction of greenhouse gas emissions. These savings depend on the number of electrical devices that are more energy efficient due to the regulation. The resulting avoidance costs of carbon dioxide emissions are a good indicator to compare the efficiency of this instrument with other options to reduce emissions. We calculate two types of avoidance costs: microeconomic avoidance costs are the costs companies have to bear if product prices cannot be raised. Macroeconomic avoidance costs, however, take into account the advantages for costumers who save energy while using the electrical devices.

The example of off mode energy consumption of LCD television sets is used to demonstrate the principle of our calculations. As the real standby mode is very important for television sets, the average TV set is in off mode for 800 hr a year only (Schlomann et al., 2005, pp.60–65). Most of the devices will fulfil the standards of an implementing measure in 2008 anyway. For the remaining TV sets, off mode energy consumption can be reduced by 0.5 W which leads to a reduction of 0.4 kWh per device per year. As the average life span of a TV set is 12 years (Kemna et al., 2005, p.376), each of the devices with additional reduction potential will save 4.8 kWh. Furthermore, we estimate that the average European carbon dioxide emissions will be 0.36 tonnes per 1000 kWh (Eurelectric, 2003, p.27; own calculations), which leads to a reduction of 1.7 kg carbon dioxide emissions per television set. As the additional unit costs are 0.75 €, microeconomic avoidance costs sum up to 434 € per tonne carbon dioxide – about 25 times more than the price for carbon dioxide emissions rights. Reduced energy costs for consumers have to be taken into account to calculate macroeconomic costs. In 12 years, these savings amount to 0.53 € per television set (in 2008 prices, discounted by 5% annually). Therefore, net additional costs of the televisions set are 0.22 € which lead to macroeconomic avoidance costs of 127 € per tonne carbon dioxide.

The calculated values refer to devices sold in 2008. For further generalisation we have to consider that there will be a further reduction of standby energy losses even without an additional regulation. In 2008, 14 million LCD television sets are supposed to be sold (Kemna et al., 2005, p.374). One half of these devices will fulfil the assumed standards of an implementing measure, the other half will not. Within 12 years, total savings of the 2008 generation of LCD-TVs affected by the implementing measure will be 33.6 GWh or 12,100 tonnes carbon dioxide.

As television sets are in real standby for 5360 hr a year, the potential energy savings are significantly higher – up to 5.4 kWh annually. Microeconomic avoidance costs are 32 € per tonne carbon dioxide. From a macroeconomic perspective, there is a surplus of 6.37 €. However, if it is impossible to raise product prices, manufacturers have to bear avoidance costs of 32 €, which is about twice the price for emission rights. Ecological effects are larger as well. During their lifespan, all devices affected by the implementing measure to be built in 2008 will save 675.4 GWh or 243,100 tonnes carbon dioxide through a more efficient real standby mode.

TFT-monitors can be used for private and business purposes with different periods of time in off mode and real standby. We assume a weighted average of 3930 hr in real standby and 1145 hr per year in off mode. The microeconomic avoidance costs of a regulation of the off mode will be as high as 1885 € per tonne carbon dioxide, macroeconomic avoidance costs will still be 1536 €. One generation of TFT-monitors will save 8.8 GWh electrical energy and 3200 tonnes carbon dioxide within its lifespan of five years, if the implementing measure for off mode energy consumption comes into force. Regulating real standby will cause microeconomic avoidance costs of 485 € and macroeconomic avoidance costs of 136 € per tonne. Ecological effects will be energy savings of 21.5 GWh and a reduction of carbon dioxide emissions of 770 tonnes within five years (Tables 6 and 7).

Table 6 Estimated energy savings and avoidance costs

	Energy savings in Watt	*Energy savings per year in kWh*	*Additional unit costs in €*	*Microeconomic avoidance costs in €/t CO_2*	*Macroeconomic avoidance costs in €/t CO_2*
LCD TV, off mode	0.4	0.5	0.75	434	127
LCD TV, real standby	1.0	5.4	0.75	32	–6
TFT-monitor, off mode	0.3	1.2	4.00	1885	1536
TFT-monitor, real standby	1.0	1.1	1.00	485	136

Source: own calculations.

Table 7 Estimated ecological effects of one generation during the lifespan

	Non-compliance (2008)	*Devices sold per year (million pieces)*	*Total energy savings in GWh*	*Reduced emissions in 1.000 t CO_2*
LCD TV, off mode	50%	14	33.6	12.1
LCD TV, real standby	75%	14	675.4	243.1
TFT-monitor, off mode	10%	15	8.8	3.2
TFT-monitor, real standby	25%	15	21.5	0.8

Source: own calculations.

8 Summary and conclusions

The impact assessment demonstrates that the off mode of a LCD television set and off mode and real standby of a TFT-monitor only have a small potential to reduce energy consumption and carbon dioxide emissions. Regulating the off mode is the most expensive option. In all cases, microeconomic avoidance costs are far above alternative avoidance costs represented by the price of emission rights. Consumers can benefit from further energy savings in the case of real standby of LCD television sets, but avoidance cost for manufacturers will still be up to 32 € per tonne carbon dioxide – as long as they cannot increase the prices of their products.

A regulation of standby energy consumption focuses on a limited fraction of the total potential to increase energy efficiency. The introduction of new technologies (e.g. laptops instead of personal computers with separated monitors) can lead to higher savings. Energy consumption of a TFT-monitor is 25 W, the previous technology (cathode ray) needed 73 W (Schlomann et al., 2005, p.60). When replacing old technology monitors by well designed new devices a huge amount of energy can be saved.

The European Commission appointed the EuP framework directive with the aim to reduce the annual carbon dioxide emissions by 180 million tonnes. The regulation of standby energy consumption of modern television sets and monitors can only contribute little to this target: less then 260,000 tonnes per generation. Although more products will be affected by standby regulation, it is doubtable whether a significant contribution can be reached.

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