Estimating potential additional energy savings from upcoming revisions to existing regulations under the ecodesign and energy labelling directives

-a contribution to the evidence base-

Supported by eceee

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Executive Summary

This discussion paper provides an assessment of the additional energy savings potential from seven product groups where the existing implementing measures are coming up for review between now and the end of 2014: household refrigerating appliances, external power supplies (EPS), household washing machines, household dishwashers, tertiary lighting, non-directional household lamps and simple set-top boxes (SSTB).

The Commission has in the past estimated savings of 99.5 TWh per annum by 2020 can be achieved from the existing implementing measures for the seven product groups reviewed here. Our analysis has identified an *additional* 40-70 TWh per annum by 2030 from these same product groups.

For each product group a stock model was developed enabling a projection of sales and stock to 2030. On this basis a Business as Usual (BAU) scenario was developed and savings from a set of illustrative policy scenarios were calculated. The policy scenarios were developed in light of technological progress. They were based on a high, medium and low level of ambition.

It was not within the scope of the paper, prepared in a relatively short period of time, to include an economic assessment of the technologies assumed. Instead, the scale of increases and timing of new requirements were informed by the scale of increases and timing in the existing implementing measures in addition to the assessment of technological progress.

Product groups were also assessed with reference to additional parameters: 1. the adequacy of the scope of coverage of existing implementing measures; 2. the integrity of existing implementing measures *vis-a-vis* e.g. correction factors and definitional ambiguities; and 3. the communicative effectiveness of the energy label. The relative importance of each of the reviews was assessed based on these three parameters and the energy saving potential taken together to provide an overall qualitative assessment of relative importance. A star rating from (*) to (***) was used to indicate relative importance. The results are shown in the table below:

Table ES-1. Product Group Comparison Overview

Product Group	Energy Savings Potential	Scope of Coverage	Integrity of Regulation	Communicative Effectiveness	Overall Qualitative Ranking
Household Refrigerating Appliances	***	***	***	***	***
External Power Supplies	**	***	*	n/a	**
Household Washing Machines	**	**	**	***	**
Household Dishwashers	**	*	*	***	**
Tertiary Lighting	***	**	*	*	***
Non-Directional Household Lamps	***	**	***	*	***
Simple Set-Top Boxes	*	***	*	n/a	*

Three groups can be distinguished:

(***) the two lighting groups and household refrigerating appliances. Comparatively, the most important to tackle;

(**) household washing machines, dishwashers and EPS. Comparatively, of medium importance. And,

(*) SSTB. When compared to the other six product groups coming up for review by the end of 2014, the least important.

It is clear that tertiary lighting products, household lighting products and household refrigerating appliances continue to offer the greatest potential for savings (respectively 12.1-18.3 TWh; 16.0-18.6 TWh; and 5.4-18.0 TWh per annum by 2030 depending on level of ambition). Household washing machines, household dishwashers and EPS offer somewhat lower additional savings (respectively 2.9-7.3 TWh; 1.4-5.7 TWh; and 1.2-2.8 TWh). Finally, a revision to the implementing measure on SSTB offers some comparatively limited savings of around 0.2 TWh per annum by 2030. These savings do not account for the additional energy savings that would result from any increase in scope of coverage, thus these potential savings may underestimate the actual potential for some product groups. We do not believe, however, that this would alter the relative ranking of the seven product groups with respect to the most important ones from an energy savings perspective. Annexes A to G provide detailed information about the assumptions underlying the estimations for each of the seven product groups.

In its new working plan for ecodesign and energy labelling (under the ecodesign directive), the Commission has set out ambitious plans for the period 2012-2014.

CLASP and eceee hope that this paper will contribute to the discussion among member states, stakeholders and in the Commission about how best to organise the considerable workload associated with the ecodesign and energy labelling directives in a way that yields the greatest energy savings and CO_2 emission reductions.

In particular, we hope that the analysis will help:

1. By contributing to the evidence base required to review and revise the implementing measures for the seven product groups included in this paper. This may help reduce the amount of time taken for any subsequent analysis in support of the required reviews.
2. By comparing the additional savings from revisions to the implementing measures for the seven product groups with each other. This will show the most important reviews in energy saving terms.
3. By comparing additional savings from revised measures with expected savings from the existing measures on the same products. This will help show how much we can hope to achieve in addition to the existing measures.
4. By enabling the comparison of the additional savings from the revisions (individual or as a whole) to the savings from new implementing measures under development. This could help prioritising the overall workload.

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Acronyms and Abbreviations

AC	Alternating Current
APD	Automatic Power Down
ATLETE	Appliance Testing for Energy Label Evaluation
BAT	Best Available Technology
BAU	Business as Usual
BI	Built In
CA	Conditional Access
CC	Climate Class
CEC	Consumer Electronic Control
CEE	Central and Eastern Europe
CELMA	Federation of National Manufacturers Associations for Luminaires and Electrotechnical Components for Luminaires in the European Union
CFL	Compact Fluorescent Lamp (CFLi - with integrated ballast; CFLni - without integrated ballast)
CFLi	Compact Fluorescent Lamps, integrally ballasted
CFLni	Compact Fluorescent Lamps, non-integrally ballasted
CLASP	Collaborative Labelling and Appliance Standards Program
CO2	Carbon Dioxide
CoC	Code of Conduct
CRT	Cathode Ray Tube
CSTB	Complex Set Top Box
DC	Direct Current
Defra	Department for Environment, Food and Rural Affairs (UK)
DOE	Department of Energy (USA)
DRM	Digital Rights Management
DSL	Digital Subscriber Line
DTT	Digital Terrestrial Television
DVD	Digital Video Disc / Digital Versatile Disc
EC	European Commission
eceee	European Council for an Energy Efficient Economy
EEDAL	Energy Efficient Domestic Appliances and Lighting
EEI	Energy Efficiency Index
ELC	European Lamp Companies Federation
EPG	Electronic Programme Guide
EPS	External Power Supply
ErP	Energy related products
EU	European Union
EuP	Energy using products
FF	Frost Free
GDP	Gross Domestic Product
GEA	Group for Efficient Appliances
GfK	Gesellschaft für Konsumforschung (Society for Consumer Research)
HD	High Definition
HDD	Hard Disc Drive
HDMI	High-Definition Multimedia Interface
HELC	Highest Energy Labelling Class
HID	High Intensity Discharge
HL	Halogen
HPM	High Pressure Mercury (HID lamp)
HPS	High Pressure Sodium (HID lamp)
HW	High Wattage
IC	Integrated Circuit
IDTV	Integrated Digital Television
IEC	International Electrotechnical Commission

IPTV	Internet Protocol Television
IRC	Infrared Reflective Coating
JRC	Joint Research Centre (European Commission)
kg	kilogram
kWh	kilowatt-hour
LAN	Local Area Network
LCC	Life-Cycle Cost
LED	Light Emitting Diode
LFL	Linear Fluorescent Lamps
lm/W	lumens per watt
lm-hr/yr	lumen-hours of lighting service per year
LNB	Low Noise Block
LPG	Liquefied Petroleum Gas
LV	Low Voltage (other than Standard Voltage EPS)
LW	Low Wattage
MCU	Micro Control Unit
MEPS	Minimum Energy Performance Standards
MH	Metal Halide (HID lamp)
MOU	Memorandum of Understanding
MPEG	Moving Picture Experts Group
MV	Mains Voltage
NACE	Nomenclature statistique des Activités économiques dans la Communauté Européenne
NEMA	National Electrical Manufacturers Association (USA)
NMS	New Member States
PMU	Power Management Unit
PVR	Personal Video Recorder
RF	Radio Frequency
ROM	Read Only Memory
SD	Standard Definition
SoC	System on a Chip
SSM	Solid State Memory
SSTB	Simple Set Top Boxes
ST	Standard Voltage (other than Low Voltage EPS)
STB	Set Top Box
T5	Fluorescent lamp with 5/8 of an inch diameter
T8	Fluorescent lamp with a one-inch diameter
TEC	Total Energy Consumption
TV	Television
TWh	Terawatt-hour
UCS	Universal Charging Solution
UHF	Ultra High Frequency
UK	United Kingdom
US DOE	United States Department of Energy
USA	United States of America
USB	Universal Serial Bus
UV	Ultraviolet
V	Volts
VA	Voluntary Agreement
VHF	Very High Frequency
VHS	Video Home System
W	Watts
Wh	Watt-hour

1 Introduction

The October 2012 directive on energy efficiency calls for accelerating (and widening) the implementation of the framework directives on ecodesign and energy labelling. It also states that priority should be given to products offering the highest energy-savings potential.

This paper provides an assessment of the additional energy savings potential from seven product groups where the existing implementing measures are coming up for review between now and the end of 2014.[1][2] CLASP and eceee hope that the paper will contribute to the discussion among member states, stakeholders and in the Commission about how best to organise the considerable workload associated with the ecodesign and energy labelling directives in a way that yields the greatest energy savings and CO_2 emission reductions.

In particular we hope that the analysis will help:

1. By contributing to the evidence base required to review and revise the implementing measures for the seven product groups included in this paper. This may help reduce the amount of time taken for any subsequent analysis in support of the required reviews.
2. By comparing the additional savings from revisions to the implementing measures for the seven product groups with each other. This will show the most important reviews in energy saving terms.
3. By comparing additional savings from revised measures with expected savings from the existing measures on the same products. This will help show how much we can hope to achieve in addition to the existing measures.
4. By enabling the comparison of the additional savings from the revisions (individual or as a whole) to the savings from new implementing measures under development. This could help prioritising the overall workload.

The work has been undertaken in a relatively short space of time from September 2012 to February 2013. It relied on independent product experts and has been peer-reviewed.

It is important to note that the level of ambition for each of the product groups is intended to provide an estimate of the relative magnitude of savings, and has been based on available information within a short timescale. The paper, therefore, does not contain information about cost of technologies or an economic analysis of the regulatory levels considered. We believe, however, that the paper provides a good indication of relative potentials and hope it will be of use to the Commission, member states and stakeholders in charting the way forward.

The structure of the paper is as follows:

- Section 2 provides a brief overview of the nature and function of the review and revision requirements under the ecodesign and energy labelling framework directives;
- Section 3 briefly sets out the approach taken for the assessment;

[1] They include: household refrigerating appliances, external power supplies, household washing machines, household dishwashers, tertiary lighting, non-directional household lamps and simple set-top boxes. These product groups were identified in Article 16(2) of the 2005 ecodesign directive. All fall under the "transitional period" (2005-2008), i.e. the period between the entry into force of the ecodesign directive and the adoption of the first working plan.

[2] Televisions are not included. The deadline for the review of the ecodesign regulation was 12 August 2012, and the energy labelling delegated regulation is due for review at the end of 2015. The Commission has issued a consultation paper, presenting proposals for a revision of both regulations. This was discussed at the ecodesign consultation forum of 8 October 2012).

- Section 4 provides a summary overview of the findings for each of the seven product groups and compares the savings potential. A more detailed analysis for each product group can be found in Annex A-G;
- Section 5 compares the energy savings potential and other parameters for determining the relative importance of the reviews; and
- Section 6 offers some concluding remarks.

2 Review and Revision Requirements under the Framework Directives

The purpose of this section is to briefly summarise the review and revision requirements under the framework directives as part of setting the context for what follows (readers familiar with this material may wish to skip to the last paragraph of the section).

The directives on ecodesign and energy labelling set the framework for the review and revision of implementing measures on ecodesign and energy labelling. The governance processes under the ecodesign directive and the labelling directive are different. Implementing measures under the ecodesign directive are developed under comitology while implementing measures under the energy labelling directive are delegated acts.

Annex VII of the ecodesign directive sets out the required content of ecodesign implementing measures. This includes a date for evaluation and possible revision of the implementing measure, "*taking into account the speed of technological progress*." All ecodesign implementing measures therefore contain an article, usually Article 7, with the title "Revision" requiring the review of the implementing measure within a specified time period. Depending on the product group, the revision clause may contain additional requirements which should be considered in the revision in addition to the setting of new minimum performance levels in the light of technological progress. Examples of such additional requirements are, e.g., assessing verification tolerances and/or the inclusion of additional products.

Similarly, Article 10.4(j) of the energy labelling directive requires implementing measures to set out the date for the evaluation and possible revision, "*taking into account the speed of technological progress*." Energy labelling implementing measures therefore also contain an article, again usually Article 7, with the title "Revision" requiring the review of the measure within a specified time period. And again, depending on the product group, the revision clause may contain additional requirements which should be considered in the revision in addition reviewing the classification. Technological development and the potential for additional significant energy savings could make further product differentiation necessary and justify a review of the classification (Recital 22). The directive specifies that such a review should include, in particular, the possibility of rescaling. It also states that the review should be carried out as expeditiously as possible in the case of products which, due to their very innovative characteristics, can make a significant contribution to energy efficiency.

According to Article 10.4 (d) the classification is to be reviewed in particular when a significant proportion of products on the internal market achieves the two highest energy efficiency classes and when additional savings may be achieved by further differentiating products. This formulation does not seem to take into account the effective reduction in the number of classes, e.g., to four in the case of household refrigerating, dishwashers, and washing machines.

The 2010 recasting of the energy labelling directive introduced the possibility of adding up to three A classes at the top of the scale (i.e., A+, A++, A+++). In principle this would mean eliminating from the label a corresponding number of classes at the bottom of the scale (i.e., E, F, G) to retain the total number of seven classes (unless more classes are still populated, although the colour scale should always remain at seven classes).

Table 2-1 gives an overview of the deadline for review of all existing implementing measures as well as any additional issues which should be included in a review as identified in Article 7. The implementing measures in the table are ordered by the deadline for review. When this is held together with implementing measures still under development from the transitional period and from the first and now second working plans, it is clear that a very significant task lies ahead and prioritisation will be of central importance. In this paper we only focus on those reviews which fall in the timescale of the new 2012-2014 working plan, other than televisions which the Commission has already started reviewing.

Table 2-1. Overview of Upcoming Reviews of Implementing Measures

Product	Regulation	Entered into Force	Review Deadline	Summary of Issues to Review	Savings Estimate?
Household refrigeration appliances	643/2009 ecodesign	12 August 2009	12 August 2011	Assess the need to adopt specific ecodesign requirements for wine storage appliances (for the main review see below)	No
Televisions	642/2009 ecodesign	12 August 2009	12 August 2012	In light of technological progress	No[3]
External power supplies	278/2009 ecodesign	27 April 2009	27 April 2013	In light of technological progress	Yes
Simple set-top boxes	107/2009 ecodesign	25 February 2009	25 February 2014	In light of technological progress	Yes
Tertiary lighting	245/2009 ecodesign	13 April 2009	13 April 2014	In light of technological progress	Yes
Non-directional household lamps	244/2009 ecodesign	13 April 2009	13 April 2014	In light of technological progress. Verify that special purpose lamps are not used for general lighting purpose. Development of new technologies such as LEDs. Feasibility of establishing energy efficiency requirements at the 'A' class level as defined in 98/11/EC.	Yes
Household refrigerating appliances	643/2009 ecodesign	12 August 2009	12 August 2014	In light of technological progress; assess the verification tolerances of Annex V and the possibilities for removing or reducing the values of the correction factors of Annex IV (for wine coolers see above)	Yes
Household dishwashers	1016/2010 ecodesign	1 December 2010	1 December 2014	In light of technological progress; asses verification tolerances set out in Annex III, setting requirements with regard to the water consumption; potential for hot water inlet	Yes
Household washing machines	1015/2010 ecodesign	1 December 2010	1 December 2014	In light of technological progress; assess verification tolerances set out in Annex III, setting requirements on rinsing and spin-drying efficiency and the potential for hot water inlet	Yes

[3] This regulation is not addressed in this paper because the Commission initiated its work conducting a review of the ecodesign implementing measure for televisions in August 2012.

Product	Regulation	Entered into Force	Review Deadline	Summary of Issues to Review	Savings Estimate?
Household refrigerating appliances	1060/2010 energy labelling	20 December 2010	20 December 2014	In light of technological progress; asses verification tolerances set out in Annex VII and the possibilities for removing or reducing the values of the correction factors set out in Annex VIII	Yes
Household washing machines	1061/2010 energy labelling	20 December 2010	20 December 2014	In light of technological progress; assess verification tolerances set out in Annex V	Yes
Household dishwashers	1059/2010 energy labelling	20 December 2010	20 December 2014	In light of technological progress; assess verification tolerances set out in Annex V	Yes
Stand-by and off-mode losses	1275/2008 ecodesign	7 January 2009	7 January 2015	In light of technological progress	No
Fans	327/2011 ecodesign	26 April 2011	26 April 2015	Review the regulation; assess the feasibility of reducing the number of fan types; assess whether the scope of exemptions can be reduced, including allowances for dual use fans	No
Electrical lamps and luminaires	874/2012 energy labelling	16 October 2012	16 October 2015	In light of technological progress; assess verification tolerances set out in Annex V	No
Televisions	1062/2010 energy labelling	20 December 2010	20 December 2015	Technological progress	No
Directional lamps, LED lamps, and related equipment	1194/2012 ecodesign	3 January 2013	3 January 2016	In light of technological progress	No
Room air-conditioning and comfort fans	626/2011 energy labelling	26 July 2011	26 July 2016	In light of technological progress; attention to be paid to changes in market shares of types of appliances	No
Electric motors	640/2009 ecodesign	12 August 2009	12 August 2016	In light of technological progress on motors and drives; resource efficiency, re-use, recycling and measurement uncertainty	No
Circulators	641/2009 ecodesign	12 August 2009	1 January 2017	In light of technological progress; assess design options for re-use and recycling	No

Product	Regulation	Entered into Force	Review Deadline	Summary of Issues to Review	Savings Estimate?
Room air-conditioning and comfort fans	206/2012 ecodesign	30 March 2012	30 March 2017	In light of technological progress; assess efficiency and sound power level requirements; low global warming potential refrigerants, changes in market share; standby and off-mode; seasonal calculation and measurement methods (for all air conditioners)	No

Table 2-2. Overview of Upcoming Reviews of Ecodesign and Energy Labelling Directives

Area	Directive	Entered into Force	Review Deadline	Summary of Issues to Review	Savings Estimate?
Ecodesign	Directive 2009/125/EC	20 November 2009	31 December 2012	Inter alia: methodology for identification and coverage of significant environmental parameters, such as resource efficiency, considering the whole life cycle of products; the threshold for implementing measures; market surveillance mechanisms; any relevant self-regulation stimulated; assess the appropriateness of extending the scope of the directive to non-energy related products.	n/a
Energy labelling	Directive 2010/30/EU	19 June 2010 (Article 5 d, g, h from 31 July 2011)	31 December 2014	Overall effectiveness; contribution of Article 4(c); effectiveness of Article 9(1); the need for amending Article 10(4)(d)	n/a

3 Approach to Product Specific Assessments

All seven product groups were assessed with reference to a set of specific issues relevant both to the assessment of relative importance in terms of the potential for additional energy savings and to provide a starting point for subsequent reviews and revisions of the respective implementing measures. Detailed assessments of each product group are set out in annexes A through G, of which a summary of the findings is presented in section 4.

Annexes A through G each contain subsections, presenting the material in the following structure:

1. Timetable and scope of the upcoming review(s).

2. Scope of the implementing measures: discusses what is covered in the current regulations, what is excluded, and whether the scope should be expanded to include new or similar products or whether the scope or exclusions should be modified to accommodate design or technology changes in the products sold.

3. Market projection: provides an estimate of the EU-27 installed stock, lifetime and annual sales of the covered products. Sales and stock estimates are projected forward to 2030, along with a projection of the 'business as usual' (BAU) energy consumption forecast over that same time period.

4. Technology assessment: reviews the average performance of the product; and discusses technology trends and improvements that have been observed since the regulations were adopted. As noted in the introduction, the paper does not contain information about cost of technologies or an economic analysis of the regulatory levels considered.

5. Energy savings potential: a high, medium and low ambition illustrative policy scenario is presented based on the analysis above. The scale of increases and timing of new requirements were informed by the scale of increases and timing in the existing implementing measures in addition to the assessment of technological progress. The policy scenarios provide an indicative estimate of the energy savings potential, based on updated regulatory requirements for each of the product groups, and is calculated for the EU-27 in terawatt-hours (TWh) of savings to 2030.

6. Additional issues: as set out above, the framework directives require, respectively, that reviews assess implementing measures in light of technological progress. Further, implementing measures often require *additional issues* to be assessed in connection with the review. It may also be that some issues have come to light which the implementing measure does not anticipate, but which could nevertheless be relevant to include in a review. Both types of additional issues are briefly discussed in this section of the product specific annexes.

4 Summary of Results

In this section a summary of the results for each product group is provided, this includes a discussion on the review requirements, the market and technology trends, the illustrative policy scenarios and the energy savings potential. Comparisons between the product groups are provided in Section 5.

4.1 Household Refrigerating Appliances

Commission Regulation 643/2009 on the ecodesign requirements for household refrigerating appliances entered into force on 12 August 2009. The implementing measure states that it shall be reviewed no later than five years after its entry into force (*i.e.*, by 12 August 2014) and the results of that review shall be presented to the Ecodesign Consultation Forum. Commission Delegated Regulation 1060/2010 on the energy labelling of household refrigerating appliances entered into force on 20 December 2010. The implementing measure states that it shall be reviewed no later than four years after its entry into force (*i.e.*, by 20 December 2014).

In line with the framework directives, reviews must, respectively, assess potential future minimum performance requirements and potential reclassification of labelling categories in light of technological progress. In addition, both the ecodesign and energy labelling regulation require reviews to assess verification tolerances and the possibilities for removing or reducing the values of existing correction factors. The revision article (7) also required the Commission to assess the need to adopt specific ecodesign requirements for wine storage appliances no later than two years after the entry into force of the regulation (i.e., 12 August 2011). This deadline has now passed and the assessment has been included into a separate work-stream under the ecodesign work plan for 2012-2014. It is, with six other product groups, on the indicative priority list. Apart from the issue of wine coolers, the scope of both implementing measures is still adequate.

The current labelling classification is from A to A+++, the ecodesign regulation removed models less efficient than A from the market in July 2010. Thus in effect, since 2010, the household refrigerating appliances energy label has had only four classes. In July 2014, the ecodesign regulation will remove models less efficient than A+ from the market, retaining only three classes. Emerging evidence from a forthcoming CLASP study on consumer comprehension of the new energy label suggests that consumers do not understand that classes still appearing on the A-G scale are no longer available in the market and that the extended A scale does not have as strong motivational effect as the A-G scale. This suggests that there is a need to revise the energy label to retain its effectiveness.

The EU household refrigerating market is generally considered to be saturated. The market now and in the future is primarily a replacement market, except for where population and thus number of households are increasing. The number of households in the EU-27 is projected to increase by 11.6% between 2012 and 2030. Under stable economic conditions domestic refrigerator sales is driven by changes in the number of households; however, according to Eurostat, sales in the EU have declined over the last few years. This decline is most probably due to the global economic crisis that began in 2008. It is unlikely that the number of domestic refrigerators per household has declined during this period, but instead people are keeping hold of their existing appliances for longer and thus effectively increasing the average refrigerator lifespan. The table below shows the projected levels of sales and stock of household refrigerating appliances and a BAU projection of energy consumption to 2030.

Table 4-1. Projected Sales, Stock and BAU Energy Consumption by 2030, Household Refrigerating Appliances

EU-27 projection	2010	2015	2020	2025	2030
Sales (million units)	14.1	20.3	22.0	23.8	25.9
Stock (million units)	277.4	290.4	300.5	309.7	318.1
Stock annual energy consumption, BAU (TWh)	92.1	79.7	70.6	65.0	62.3

The technologies used in refrigerators have evolved steadily over the last decade rather than undergone any dramatic revolution. The use of electronic controls which allow better regulation of the compartment temperatures and better control of the refrigeration cycle itself have become relatively standard. Better compressors continue to evolve and the best have now attained efficiency levels thought to be near the technological limit of some early studies.[4] Evaporators and condensers have been refined and insulation techniques improved allowing more efficient heat transfer and refrigeration cycles operating closer to the ideal refrigeration thermodynamic cycle on the one level and reducing heat losses on the other. The deployment of electronically regulated valve technology has enabled separate and more efficient operation of the fresh-food compartment refrigeration cycle and the frozen food compartment refrigeration cycle. Computer aided design and related energy simulation techniques have also evolved which has facilitated the adoption of more efficient design options by manufacturers. Vacuum insulation panels and variable speed compressors are high-efficiency design options, but they have yet to be adopted widely in the EU market.

To determine the energy savings potential for household refrigerators, three illustrative policy scenarios were developed with updates to the ecodesign and energy labelling regulations. These policy scenarios provide an indicative estimate of energy savings, based on technology improvements for this product group. The assumptions about the level and timing of new ecodesign and labelling requirements in the three scenarios are shown in the table below.

Table 4-2: Three Illustrative Policy Scenarios for Household Refrigerating Appliances

Scenario	EcoDesign	Energy Label
1	Tier 1 at EEI ≤ 38 from 2016 Tier 2 at EEI ≤ 35 from 2019	HELC[5] in 2016 at EEI ≤ 15
2	Tier 1 at EEI ≤ 36 from 2016 Tier 2 at EEI ≤ 28 from 2019	$HELC_{-1}$ in 2016 at EEI ≤ 18 HELC in 2018 at EEI ≤ 14
3	Tier 1 at EEI ≤ 33 from 2016 Tier 2 at EEI ≤ 22 from 2019	$HELC_{-1}$ in 2016 at EEI ≤ 18 HELC in 2018 at EEI ≤ 14

The first scenario assumes that new ecodesign regulations come into effect in two steps – a Tier 1 requirement with an EEI of 38 from 2016 and a Tier 2 requirement with an EEI of 35 from 2019. The

[4] Cold II (2000) COLD II The revision of energy labelling and minimum energy efficiency standards for domestic refrigeration appliances, ADEME and PW Consulting, for the European Commission, Directorate-General for Transport and Energy, Contract no: XVII/4.1031/Z/98-269, December.

[5] Highest Energy Labelling Class (HELC). Illustrative new next highest classes are represented with sub-scripts in this table.

scenario also assumes that a new energy label class is introduced in 2016 having a new, higher energy label class with an EEI of 15.

The second scenario assumes a new ecodesign regulation with two tiers, the first from 2016 at an EEI of 36 and the second from 2019 with an EEI of 28. This scenario also considers two new energy label classes are introduced, one with an EEI threshold of 18 and the other with an EEI threshold of 14.

The third scenario also assumes a new ecodesign regulations would come into effect in two steps – an EEI of 33 from 2016 and an EEI of 22 from 2019. In addition, this scenario assumes two new energy label classes, one with an EEI of 18 and one with an EEI of 14.

The energy saving potentials arising from the three policy scenarios are shown in the table below. More detail can be found in Annex A, Household Refrigerating Appliances.

Table 4-3. Projected Annual Energy Savings to 2030, Scenarios 1-3, Household Refrigerating Appliances

Scenario	2010 (TWh/yr)	2015 (TWh/yr)	2020 (TWh/yr)	2025 (TWh/yr)	2030 (TWh/yr)
Scenario 1	-	-	1.5	3.8	5.4
Scenario 2	-	-	2.3	7.5	11.4
Scenario 3	-	-	3.4	11.5	18.0

In addition to assessing potential future minimum performance requirements and potential reclassification of labelling categories in light of technological progress, both implementing measures require reviews to assess verification tolerances and the possibilities for removing or reducing the values of existing correction factors. The issue of verification tolerances will be important in a review but is not discussed in this paper. In relation to correction factors, a study published last year by the UK Department for Environment, Food and Rural Affairs (Defra) found that most of the correction factors are either no longer required, or should be reduced.[6]

In addition to the topics already required to be included in the review, it would be desirable to consider whether it is now time to introduce performance requirements that increase *more than proportionally* with volume. The new international test method, IEC 62552, should also be taken into account. Finally, the potential value of introducing allowances for refrigerants with a low global warming potential should be considered. This should be based on experience elsewhere, from the point of view of the capacity of such allowances to deliver effective and secured GHG emission reductions and energy saving.

In summary for household refrigerators, the scope of the regulation does not necessarily need to be revised at this time, although wine storage appliances must be addressed. There is a need to revise the energy label as nearly the entire 2012 market in the EU is class A or higher. Further opportunity exists for technological improvement in the efficiency of household refrigerators, particularly incorporating vacuum insulation panels and variable speed compressors into new products. Across the EU, with more

[6] "Assessment of the applicability of current EC correction factors and tolerance levels for domestic refrigerating appliances, Final Report Version 1.0", Intertek, A research report completed for the Department for Environment, Food and Rural Affairs, London, UK. August 2012

than 300 million units installed by 2020, household refrigerators are projected to consume 70.6 TWh of electricity in 2020. The electricity savings estimate from Scenario 2 is 2.33 TWh in that year, or approximately 3.3% of the business as usual electricity consumption estimate. By 2030, the electricity savings estimate from Scenario 2 is 11.44 TWh, or 18.4%.

4.2 External Power Supplies

Commission Regulation (EC) No 278/2009 of 6 April 2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for no-load condition electric power consumption and average active efficiency of external power supplies (EPS) entered into force on 26 April 2009. The implementing measure states that no later than four years after the entry into force (i.e., 26 April 2013), the Commission must review the regulation in light of technological progress and present the result of this review to the consultation forum. No additional issues to be integrated into the review are specified.

There is no energy labelling regulation for EPS.

The scope of coverage for Regulation 278/2009 requires revision because several types of EPS are omitted from the current definition. Regulations currently being proposed in the US encompass a more comprehensive scope, including seven product classes, of which not all are covered in the EU. This suggests that the European regulation could also be expanded. In addition it will be important to clarify whether there are any areas of ambiguity with respect to the European scope, such as whether power supplies sold as accessories of products are covered by the regulation.

The EPS market is projected to grow in the coming years, adopting new power architectures, smaller form factors, more efficient designs and improved power management technology. The applications that will contribute to this growth include communications, computers, consumer electronics, and many other products. The consumer market is offering new applications that were not considered in the 2007 preparatory study[7], such as tablet computers, smart phones, and gaming devices, that require higher wattage EPS than simple mobile phones. The communications segment is projected to maintain the largest unit market and will be dominated by the mobile phone industry, which uses inexpensive, commoditised low-wattage power supplies. The largest number of EPS units sold is presently, and is projected to be in the future, the lower wattage categories. The table below shows the projected levels of sales and stock of external power supplies and a BAU projection of energy consumption to 2030.

Table 4-4. Projected Sales, Stock and BAU Energy Consumption to 2030, External Power Supplies

EU-27 Projection	2010	2015	2020	2025	2030
Sales (million units)	381	387	391	395	397
Stock (million units)	1,758	1,784	1,807	1,826	1,840
Stock annual energy consumption, BAU (TWh)	7.3	7.4	7.5	7.6	7.7

The technologies used in EPSs have improved significantly over the last decade. A movement from simple transformers to electronic architecture, mainly driven by copper and iron laminate cost as well

[7] Preparatory Studies for Eco-design Requirements of EuPs, Lot 7: Battery chargers & external power supplies. BIOS, January 2007.

as weight and size savings was the first step. Electronic architecture enabled the design of a single product to have a wide range of input voltages enabling the mass production of a small number of models, which could then be operated on different voltages and frequencies around the world. Further study of these products now indicates that there are further technological improvements that could be exploited to bring additional reductions in energy consumption while not compromising product performance. Advances in power semiconductor technology have contributed to the largest performance improvements, followed by gains made in magnetic materials and capacitors. In addition, design engineers are encouraged to reduce size without compromising performance, which leads to incremental improvements in every aspect of the design, including electrical and mechanical.

To determine the energy savings potential for EPS, three illustrative policy scenarios were developed with updates to the ecodesign regulations. These policy scenarios provide an indicative estimate of energy savings, based on technology improvements for this product group. The three scenarios have differing levels of ambition, with Scenario 2 being the mid-range scenario. The three scenarios were adapted from the draft Code of Conduct on Energy Efficiency of External Power Supplies[8] that was being developed in late 2012. The assumptions about the level and timing of new ecodesign and labelling requirements in the three scenarios are shown in the table below.

Table 4-5: Three Illustrative Policy Scenarios for External Power Supplies

Scenario	Tier 1	Tier 2
1	CoC Tier 1 from 2015	CoC Tier 2 from 2016
2	CoC Tier 1 from 2014	Modified CoC Tier 2 (Tier 2+) from 2016, no-load ÷ 1.025; efficiency x 1.025
3	Modified CoC Tier 1 (Tier 1+) from 2014 no-load ÷ 1.025; efficiency x 1.025	Modified CoC Tier 2 (Tier 2++) from 2016, no-load ÷ 1.05; efficiency x 1.05

For Scenario 1, the CoC Tier 1 level is introduced in 2015 and the CoC Tier 2 level in 2016. These years were selected on the basis that the previous ecodesign requirements were introduced in 2010 and 2011. Thus, the timing associated with the two tiers is based on a similar magnitude of step increases and timing of the existing ecodesign requirements.

For Scenario 2, the CoC Tier 1 level is introduced in 2014 (i.e., one year earlier) and a slightly more ambitious requirement based on the CoC Tier 2 level is introduced in 2016. This two year gap is created between the two tiers because the level of ambition for the Tier 2 requirement is slightly more stringent than the CoC Tier 2 level (increased by a scalar of 2.5%).

For Scenario 3, the schedule of 2014 for Tier 1 and 2016 for Tier 2 is maintained, but the level of ambition is increased for both Tier 1 and Tier 2. The CoC Tier 1 equations are made slightly more stringent using a 2.5% scalar. The Tier 2 equations were also made more stringent, using a 5% scalar.

The energy saving potentials arising from the three policy scenarios are shown in the following table. More detail can be found in Annex B, External Power Supplies.

[8] DRAFT Code of Conduct on Energy Efficiency of External Power Supplies, Version 5, the European Commission, Directorate-General JRC, Joint Research Centre, Institute for Energy, Renewable Energy Unit; 19 September 2012.

Table 4-6. Projected Annual Energy Savings to 2030, Scenarios 1-3, External Power Supplies

Scenario	2010 (TWh/yr)	2015 (TWh/yr)	2020 (TWh/yr)	2025 (TWh/yr)	2030 (TWh/yr)
Scenario 1	-	0.10	1.04	1.17	1.17
Scenario 2	-	0.20	1.71	1.92	1.93
Scenario 3	-	0.57	2.50	2.80	2.82

The implementing measure does not identify any issues to be included in the review in addition to the consideration of future minimum performance requirements. However, there are grounds for revisiting the scope of coverage of the implementing measure. There is an opportunity for securing material resource gains by extending the memorandum of understanding (MOU) between the Commission and Digital Europe on the compatibility of EPS which recently expired.[9] It may be that the extension of the MOU can be addressed ahead of a review. Finally, an assessment of the potential for additional savings from addressing the power factor not only in full load but also in no-load (especially in a commercial environment) could be made.

In summary for EPS, the scope of coverage needs to be revised to adopt product classes. There is no energy labelling regulation for this product, so the focus is on ecodesign. Further opportunity exists for technological improvement in the efficiency of EPS. Across the EU, with more than 1.8 billion units installed by 2020, EPS are projected to consume 7.5 TWh of electricity in 2020. The energy savings estimate from Scenario 2 is 1.71 TWh in that year, or approximately 23%. By 2030, the baseline energy consumption is 7.66 TWh of electricity and the energy savings estimate from Scenario 2 is 1.93 TWh, or 25%.

4.3 Household Washing Machines

Commission Regulation 1015/2010 on the ecodesign requirements for household washing machines entered into force on 1 December 2010. The implementing measure states that it shall be reviewed no later than four years after its entry into force (i.e. by 1 December 2014) and the results of that review shall be presented to the Ecodesign Consultation Forum.

Commission Delegated Regulation 1061/2010 on the energy labelling of household washing machines entered into force on 20 December 2010. The implementing measure states that it shall be reviewed no later than four years after entry into force (*i.e.*, by 20 December 2014).

In line with the framework directives, reviews must, respectively, assess potential future minimum performance requirements and potential reclassification of labelling categories in light of technological progress. In addition, both the ecodesign and energy labelling regulation require reviews to assess verification tolerances. The ecodesign regulation must further assess the opportunity of setting requirements on rinsing and spin-drying efficiency and the potential for hot water inlet.

The scope of coverage for household washing machines is adequate. It does however not include washer-dryer combinations. These represent about 2.5% of the units sold in the EU. It could therefore

[9] MoU regarding Harmonisation of a Charging Capability for Mobile Phones June 5, 2009. See: http://ec.europa.eu/enterprise/sectors/rtte/files/chargers/chargers_mou_en.pdf

be considered whether it would be worthwhile, from and energy saving point of view to include these products in a revised regulation.

The current labelling classification is from A to A+++, the ecodesign regulation having removed models less efficient than A from the market in December 2011. From December 2013, only classes A+ to A+++ will remain for machines with a rated capacity ≥ 4 kg. Thus in effect, since 2011, the household washing machine label has had only four classes instead of seven. The energy label is reaching the end of its scale, with the entire market projected under the BAU case of reaching A+ or better by 2015. Emerging evidence from a forthcoming CLASP study on consumer comprehension of the new energy label suggests that consumers do not understand that classes still appearing on the A-G scale a no longer available in the market and that the extended A scale does not have as strong motivational effect as the A-G scale. This suggests that there is a need to revise the energy label for household washing machines to retain its effectiveness.

The EU washing machine market is saturated, and is expected to be driven primarily by the replacement of old appliances. A slight increase in the percentage of household ownership may occur, but it is unlikely ever to reach 100% due to the practice of some households and apartment blocks using collective laundry rooms. Therefore, the future sales percentage going to increases in the net stock will largely depend on the growth rate of households in the EU. The table below shows the projected levels of sales and stock of household washing machines and a BAU projection of energy consumption to 2030.

Table 4-7. Projected Sales, Stock and BAU Energy Consumption to 2030, Household Washing Machines

EU-27 Projection	2010	2015	2020	2025	2030
Sales (million units)	13.8	14.4	15.1	15.7	16.4
Stock (million units)	189	200	209	219	229
Stock annual energy consumption, BAU (TWh)	47.5	43.3	40.8	38.9	37.7

The most significant environmental aspects of washing machines are energy and water consumption in the use phase. Regarding energy, the influence of the power consumption in low power modes such as left-on mode and off mode are of secondary importance. Areas of possible technology improvement include improved motor efficiency, temperature-time trade-off, improved mechanical action in the wetting phase, sophisticated electronic process controls and sophisticated electronic water and temperature controls. Further improvements are still possible in all five of these areas, and if exploited would result in further reduction in energy consumption.

To determine the energy savings potential for washing machines, three illustrative policy scenarios were developed that update the ecodesign and energy labelling regulations. The assumptions about the level and timing of new ecodesign and labelling requirements in the three scenarios are shown in the table below.

Table 4-8: Three Illustrative Policy Scenarios for Washing Machines

Scenario	Ecodesign	Energy Label
1	Tier 1 at EEI ≤ 52 from 2018 Tier 2 at EEI ≤ 46 from 2022	HELC[10] in 2016 at EEI ≤ 41
2	Tier 1 at EEI ≤ 52 from 2017 Tier 2 at EEI ≤ 46 from 2020	$HELC_{-1}$ in 2016 at EEI ≤ 41 HELC in 2016 at EEI ≤ 37
3	Tier 1 at EEI ≤ 52 from 2016 Tier 2 at EEI ≤ 46 from 2018	$HELC_{-2}$ in 2016 at EEI ≤ 41 $HELC_{-1}$ in 2016 at EEI ≤ 37 HELC in 2016 at EEI ≤ 33

The first scenario assumes that new ecodesign regulations come into effect in two steps – a Tier 1 requirement with an EEI of 52 from 2018 and a Tier 2 requirement with an EEI of 46 from 2022. The scenario also assumes that a new energy label class is introduced in 2016 having a new, higher energy label class with an EEI of 41.

The second scenario assumes a new ecodesign regulation with two tiers, the first from 2017 at an EEI of 52 and the second from 2020 with an EEI of 46. This represents the same requirements as Scenario 1; however the schedule is slightly accelerated. This scenario also considers two new energy label classes are introduced in 2016, one with an EEI threshold of 41 and the other with an EEI threshold of 37.

The third scenario assumes a new ecodesign regulation would come into effect in two steps – an EEI of 52 from 2016 and an EEI of 46 from 2018. This also represents the same requirements as the previous two scenarios, but they take effect much sooner. In addition, this scenario assumes three new energy label classes are introduced in 2016, one with an EEI of 41, one with an EEI of 37 and a third one with an EEI of 33.

The energy saving potentials arising from the three policy scenarios are shown in the table below. More detail can be found in Annex C, Household Washing Machines.

Table 4-9. Projected Annual Energy Savings to 2030, Scenarios 1-3, Household Washing Machines

Scenario	2010 (TWh/yr)	2015 (TWh/yr)	2020 (TWh/yr)	2025 (TWh/yr)	2030 (TWh/yr)
Scenario 1	-	0.1	0.6	1.8	2.9
Scenario 2	-	0.2	1.5	3.2	5.2
Scenario 3	-	0.3	2.2	4.7	7.3

In addition to assessing potential future minimum performance requirements and potential reclassification of labelling categories in light of technological progress, both implementing measures require reviews to assess verification tolerances. The ecodesign regulation also requires that the opportunities for setting requirements for rinsing and spin-dry efficiency and hot water inlet should be assessed. In relation to verification tolerances it will be important to consider the actual remaining uncertainty. In relation to the opportunity for setting requirements on rinsing and spin-dry efficiency,

[10] Highest Energy Labelling Class (HELC). Illustrative new next highest classes are represented with sub-scripts in this table.

there is room to improve the existing test standard (EN 60456). The opportunities for setting requirements in relation to a hot water inlet are not discussed in this paper.

In addition to the topics already required to be included in the review, it should be considered whether consumers are confused about the fact that more efficient wash programmes take longer, assuming that longer wash times mean higher energy consumption. Finally, consideration should also be given to ensuring the integrity of the test standard when used with "intelligent" appliances.

In summary, the scope of coverage is still appropriate although the exclusion for combination washer-dryer products may need revision. The energy label is reaching the end of its scale, with the entire market projected under the BAU case of reaching A+ or better by 2015. Therefore, a discussion about the reclassification of energy labels is an important priority. There is still further potential for technological improvement in several areas, including motor efficiency, time and temperature trade off, mechanical action and controls. Across the EU, washing machines are projected to consume 40.8 TWh of electricity in 2020. The electricity savings estimate from Scenario 2 is 1.5 TWh in that year, or approximately 3.7% of the estimated baseline scenario electricity consumption. By 2030, the electricity savings estimate from Scenario 2 is 5.2 TWh, or 13.8% of the projected baseline.

4.4 Household Dishwashers

Commission Regulation 1016/2010 on the ecodesign requirements for dishwashers entered into force on 1 December 2010. The implementing measure states that it shall be reviewed no later than 4 years after its entry into force (i.e., by 1 December 2014), and the result of that review shall be presented to the Ecodesign Consultation Forum.

Commission Delegated Regulation 1059/2010 on the energy labelling of household dishwashers entered into force on 20 December 2010. The implementing measure states that the Commission shall review this regulation no later than four years after its entry into force (i.e., by 20 December 2014).

In line with the framework directives, reviews must, respectively, assess potential future minimum performance requirements and potential reclassification of labelling categories in light of technological progress. In addition, both the ecodesign and energy labelling regulation require reviews to assess verification tolerances. Further, the ecodesign regulation must assess the opportunity of setting requirements with regard to the water consumption of household dishwashers and the potential for a hot water inlet.

The scope of coverage of the ecodesign and energy labelling implementing measures still include all types of domestic dishwashers and therefore do not need to be extended or modified.

The current labelling classification is from B to A+++, the ecodesign regulation having removed models less efficient than B from the market in December 2011. Class B is only allowed for dishwashers with 10 settings and 45 cm width or less. Therefore in effect, most of the market currently only has four energy labelling classes. After 1 December 2013, the Tier 2 requirements will come into force eliminating class A for all machines with a rated capacity of 11 or more place settings and machines with a rated capacity of 10 place settings and a width greater than 45 cm. As this point there will be only three labelling classes for dishwashers. The energy label is reaching the end of its scale, with the entire market projected under the BAU case of reaching A+ or better by 2015. Emerging evidence from a forthcoming CLASP study on consumer comprehension of the new energy label suggests that consumers do not understand that classes still appearing on the A-G scale are no longer available in the market and that the extended A scale does not have as strong motivational effect as the A-G scale. This suggests that there is a need to revise the energy label to retain its effectiveness.

Dishwashers have a lower saturation level than other household appliances such as refrigerators and washing machines. By 2012, the ownership rate of dishwashers had reached approximately 40% of households in the EU-27. Ownership rates vary widely between countries and ownership is substantially lower in NMS-12 than in the EU-15. It is expected that there will be moderate increases in dishwasher ownership in the EU-15, but faster growth in the NMS-12 market, reaching an overall EU-27 average household ownership level of just above 60% in 2030. The table below shows the projected levels of sales and stock of household dishwashers and a BAU projection of energy consumption to 2030.

Table 4-10. Projected Sales, Stock and BAU Energy Consumption to 2030, Household Dishwashers

EU-27 Projection	2010	2015	2020	2025	2030
Sales (million units)	7.4	8.8	9.8	10.9	11.9
Stock (million units)	82.2	99.1	118.2	137.0	153.4
Stock annual energy consumption BAU, (TWh)	33.4	36.7	39.3	41.1	42.4

The most significant environmental impacts associated with the life-cycle of dishwashers are energy and water consumption in the use phase. Regarding energy, the influence of the power consumption in low power modes such as left-on mode and off mode are of secondary importance. The design options that are related to improving the energy-efficiency of dishwashers include improved pump and motor efficiency, temperature-time trade-off, improved water spraying, sophisticated electronic process controls and sophisticated electronic water and temperature controls. Overall, these technological improvements resulted in a reduction in the average energy consumption of 25% between 1997 and 2010.

Further improvements with these design options are still possible, with the greatest potential to further reduce the energy consumption are temperature-time trade-off, sensors and innovative drying systems (e.g., the adsorption drying systems that were only recently introduced to the market).

The energy savings scenarios for dishwashers are based on three illustrative potential policy scenarios including updated ecodesign requirements and energy labelling categories. They provide an indicative estimate of energy savings, based on possible technology improvements for this product group. The three scenarios have differing levels of ambition, with scenario 2 being the mid-range scenario. The assumptions about the level and timing of new ecodesign and labelling requirements in the three scenarios are shown in the table below.

Table 4-11: Three Illustrative Policy Scenarios for Dishwashers

Scenario	Ecodesign	Energy Label
1	Tier 1 from 2019 with EEI ≤ 56 for machines with 11 place settings and EEI ≤ 63 for 10 place settings or less	HELC[11] in 2016 at EEI ≤ 45
2	Tier 1 from 2017 with EEI ≤ 56 for machines with 11 place settings and EEI ≤ 63 for 10 place settings or less	$HELC_{-1}$ in 2016 at EEI ≤ 45 HELC in 2016 at EEI ≤ 40
3	Tier 1 from 2016 with EEI ≤ 56 for machines with 11 place settings and EEI ≤ 63 for 10 place settings or less Tier 2 from 2019 with EEI ≤ 50 for machines with 11 place settings and EEI ≤ 56 for 10 place settings or less	$HELC_{-2}$ in 2016 at EEI ≤ 45 $HELC_{-1}$ in 2016 at EEI ≤ 40 HELC in 2016 at EEI ≤ 36

The first scenario assumes that new ecodesign regulations come into effect from 2019 at an EEI of 56 for machines with 11 or more place settings and an EEI of 63 (i.e., one class more ambitious) for machines with 10 place settings or less. This scenario also assumes a new energy label is introduced in 2016 having a new, higher energy label class with an EEI of 45.

The second scenario assumes a new ecodesign regulation that enters into effect from 2017 at an EEI of 56 for machines with 11 or more place settings and an EEI of 63 (i.e., one class more ambitious) for machines with 10 place settings or less. This scenario also includes two new energy label classes are introduced in 2016, one with an EEI threshold of 45 and the other with an EEI threshold of 40.

The third scenario assumes a new ecodesign regulation comes into effect in two steps – an EEI of 56 from 2016 and an EEI of 50 from 2019 for machines with 11 or more place setting and levels one class more ambitious for machines with 10 place settings or less. This scenario also includes three new energy label classes are introduced in 2016, one with an EEI of 45, one with an EEI of 40 and a third one with an EEI of 36.

The energy saving potentials arising from the three policy scenarios are shown in the table below. More detail can be found in Annex D, Household Dishwashers.

Table 4-12. Projected Annual Energy Savings to 2030, Scenarios 1-3, Household Dishwashers

Scenario	2010 (TWh/yr)	2015 (TWh/yr)	2020 (TWh/yr)	2025 (TWh/yr)	2030 (TWh/yr)
Scenario 1	-	-	0.03	0.32	1.40
Scenario 2	-	0.02	0.56	1.27	3.01
Scenario 3	-	0.07	1.15	2.86	5.66

[11] Highest Energy Labelling Class (HELC). Illustrative new next highest classes are represented with sub-scripts in this table.

In addition to assessing potential future minimum performance requirements and potential reclassification of labelling categories in light of technological progress, both implementing measures require reviews to assess verification tolerances. In relation to verification tolerances, as for washing machines, and indeed other product groups, it will be important to consider the actual remaining uncertainty. The opportunity for setting requirements with regard to the water consumption of household dishwashers and the potential for hot water inlet are not discussed in this paper.

In addition to the topics already required to be included in the review, it should be considered whether consumers are confused about the fact that more efficient wash programmes can take longer, when they may assume that longer wash times mean higher energy consumption.

In summary for dishwashers, the scope of coverage is still appropriate and does not require revision at this time. The energy label has already reached the end of its scale, with all products in the market rated class A or better in 2012. By 2015, the market will only carry A+ or better. Therefore, a discussion about the reclassification of energy labels is needed. There is still further potential for technological improvement in several areas, including temperature-time trade-off, sensors and innovative drying systems. Across the EU, dishwashers are projected to consume 39.3 TWh of electricity in 2020. The electricity savings estimate from Scenario 2 is 0.56 TWh in that year, or approximately 1.4% of the baseline electricity consumption estimate in that year. By 2030, the electricity savings estimate from Scenario 2 is 3.0 TWh, or 7.1% of the baseline.

4.5 Tertiary Lighting

Commission Regulation 245/2009 on the ecodesign requirements for fluorescent lamps without integrated ballast, for high intensity discharge (HID) lamps, and for ballasts and luminaires able to operate such lamps (hereafter referred to as “tertiary lighting”) entered into force on 13 April 2009. The implementing measure states that it shall be reviewed no later than 5 years after its entry into force (i.e., by 13 April 2014), and the result of that review shall be presented to the Ecodesign Consultation Forum. In line with the framework directives, the review must assess potential future minimum performance requirements in light of technological progress.

Regulation EU No 874/2012 on energy labelling of electrical lamps and luminaires entered into force on 14 October 2012 and will become applicable from 1 September 2013 (except for cases listed in Article 9).[12] This new labelling regulation applies to wider scope of lamp technologies, including tertiary lighting products.[13] The new regulation also introduces two new energy label classes: A+ and A++, which are above the previous highest class threshold. These new classes will enable better distinction between the higher-end technologies, including high efficiency light emitting diode (LED) lamps. The regulation is required to be reviewed within three years of publication, i.e. by 14 October 2015. It is therefore not included in the scope of this paper.

[12] Commission Delegated Regulation (EU) No 874/2012 of 12 July 2012 supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to energy labelling of electrical lamps and luminaires, in the Official Journal of the European Union, 26 September 2012

[13] In Article 1, section 1 of the new regulation 874/2012 on energy labelling of electrical lamps and luminaires, the scope of coverage is defined as follows: *1. This Regulation establishes requirements for labelling of and providing supplementary product information on electrical lamps such as: (a) filament lamps; (b) fluorescent lamps; (c) high-intensity discharge lamps; (d) LED lamps and LED modules. This Regulation also establishes requirements for labelling luminaires designed to operate such lamps and marketed to end users, including when they are integrated into other products that are not dependent on energy input in fulfilling their primary purpose during use (such as furniture).*

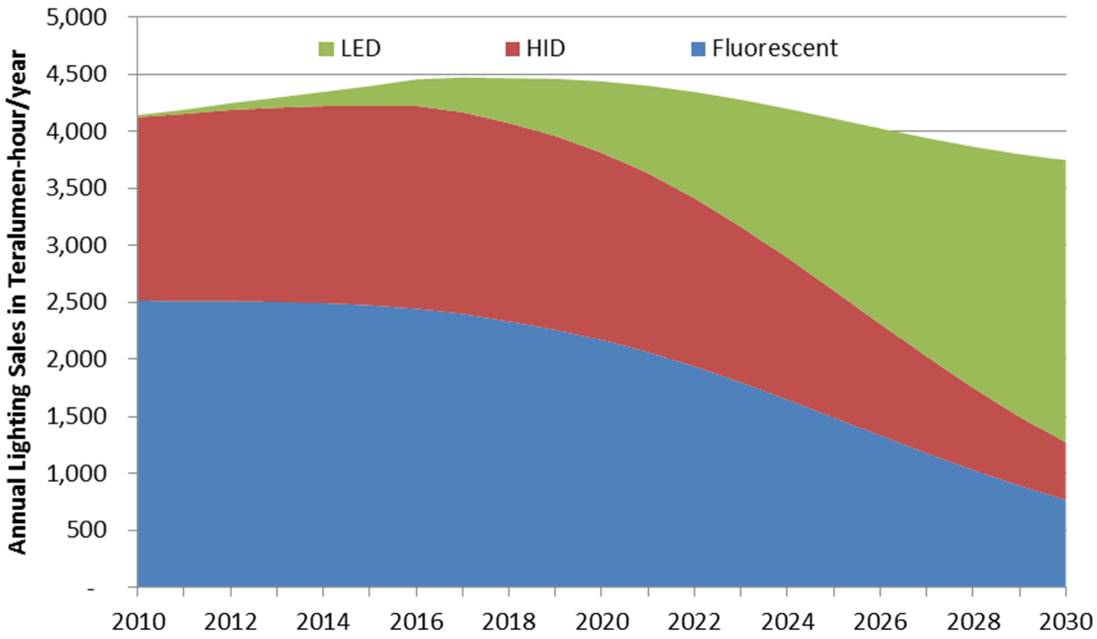
The scope of coverage of the ecodesign implementing measure EC No 245/2009 seems adequate from the point of view of fluorescent and HID lamps and ballasts and luminaires that operate such lamps. However, it does not include all HID lamp base types, certain halogen lamps or LED technology[14]. It would therefore be appropriate to review the scope of coverage associated with this regulation, taking into consideration products that are covered under the recent labelling regulation for lighting products, Regulation EU No 1194/2012.

Many different types of products are covered under regulation EC No 245/2009. These include fluorescent lamps – both single and double-ended, HID lamps, and operating ballasts and luminaires for both lamp types. Modelling all of these products accurately, taking into account differential growth in commercial and industrial buildings and roadways, typical fixtures and lighting levels, and accounting for replacements of ballast and fixtures would be a complex task. Indeed, the impact assessment[15] did not attempt to prepare a detailed model in quantifying the estimated energy savings potential. Instead, the impact assessment presents a projection of lamp shipments to 2020 looking at sales, stock and turnover of affected lamps. The energy savings potential model presented Annex E follows this same approach, calibrating the projections of lamp shipments, energy consumption and energy savings to the impact assessment. There is, however, one important difference between the impact assessment and the model developed in Annex E: whereas the impact assessment did not take into account the market penetration of LED lighting technologies, the model developed for this paper does.

The figure below presents the BAU market projection of lighting sales of products covered under this regulation measured in units of teralumen-hours[16] per year of shipments. The figure aggregates together fluorescent lamps (including compact and linear lamps) and HID lamps (including metal halide, high pressure sodium and mercury vapour). LED products are introduced to the market, based on the methodology followed in the US DOE energy savings forecast of solid state lighting[17] (see Annex E for detail on the steps followed).

[14] The HID lamp base types and halogen lamps that are not included in the scope of the present implementing measure are low volume products and are expected to remain so. This is not the case for LEDs.
[15] COMMISSION STAFF WORKING DOCUMENT Accompanying document to the Commission regulation implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for fluorescent lamps without integrated ballast, for high intensity discharge lamps, and for ballasts and luminaires able to operate such lamps, and repealing Directive 2000/55/EC of the European Parliament and of the Council FULL IMPACT ASSESSMENT
Link: http://ec.europa.eu/governance/impact/ia_carried_out/docs/ia_2009/sec_2009_0324_en.pdf
[16] Due to the magnitude of calculated national lumen demand, the notation "tera" is used, denoting 10E+12 (1,000,000,000,000) lumen-hours of annual lighting service. One thousand lumen-hours are approximately equal to the light output from a standard 75 watt incandescent lamp for one hour.
[17] Energy Savings Potential of Solid-State Lighting in General Illumination Applications, Prepared for: Solid-State Lighting Program; Building Technologies Program Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy; Prepared by: Navigant Consulting, Inc. January 2012.

Figure 4-1. Annual EU Tertiary Lighting Sales in Teralumen-hours/year



The table below presents the same shipment information in a tabular format, along with the stock projection (also measured in terms of lighting service) and the associated energy consumption per year for the stock tertiary lighting. Please note that in the BAU scenario, the lighting service increases while the energy consumption is decreasing in real terms.

Table 4-13. Projected BAU Energy Consumption to 2030, Tertiary Lighting

EU-27 projection	2010	2015	2020	2025	2030
Shipments Lighting Service, Tlm-hr/yr	4,143	4,397	4,438	4,114	3,749
Stock Lighting Service, Tlm-hr/yr	17,803	18,504	19,666	21,016	23,950
Stock annual energy consumption BAU, (TWh)	219	218	214	193	166

Research into efficacy improvements for HID lighting technologies has generally followed market demand for these lamps. Of the HID lamp research programmes that remain, manufacturers tend to concentrate on MH technologies, with some limited amount of investment in HPS for specific niche applications (e.g., agricultural greenhouses). Thus, the efficacy values of commercially available HPM and HPS lamps are not expected to improve. MH lamps, and more specifically, ceramic MH lamps are continuing to improve in efficacy as well as light quality, manufacturability and lamp life. For fluorescent lamps, despite having commercialised lamps that offer more than 115 lumens per watt of energy, there are still areas where research may result in some performance improvements. Some of these areas include further phosphor improvements, enhanced fill gas, improved cathode coatings and UV-reflective glass coatings.

LED technology is the focus of the majority of the research and development investment in lighting technology today. Efforts are being made to simultaneously lower manufacturing costs while improving efficacy (i.e., more light-output per watt of power consumed). LED technology is fulfilling its promise of offering the market the most efficient means of converting electrons into photons. In 2010, LED efficacy exceeded 200 lumens per watt in the laboratory, and leading researchers projected a future device-level efficacy of between 250 to 280 lm/W.[18] At the device-level, these prototype laboratory LEDs have more than double the efficacy of LEDs being used in lamps today.

The energy savings scenarios for tertiary lighting are based on three illustrative potential policy scenarios based on holding light output constant and improving lamp efficacy while reducing the wattage of the regulated lamp types. Three scenarios were prepared each with increasing levels of regulatory ambition and potential energy savings. For these illustrative policy scenarios, a fixed percentage improvement in efficacy requirements for the general classes of lamps is presented.

Table 4-14. Three Illustrative Policy Scenarios for Tertiary Lighting

Scenario	Tiers	Year Effective	% Increase in Efficacy Relative to EC No 245/2009	
			Fluorescent Lamps	Metal Halide Lamps
Scenario 1	Tier 1	2018	+ 5%	+ 20%
	Tier 2	2021	--	+ 10%
	Tier 3	2023	+ 5%	+ 10%
Scenario 2	Tier 1	2018	+ 10%	+ 20%
	Tier 2	2020	--	+ 10%
	Tier 3	2022	+ 5%	+ 10%
Scenario 3	Tier 1	2018	+ 10%	+ 20%
	Tier 2	2020	--	+ 15%
	Tier 3	2022	+ 10%	+ 15%

Scenario 1 considers the situation where efficacy requirements for both T8 and T5 lamps are increased by 5% at Tier 1 and by a further 5% at Tier 3. MH lamps are improved by 20% in Tier 1 and a further 10% in Tier 2 and Tier 3. HPS lamps are not subject to any new regulation, and CFLni lamps are increased by the same amount and the same Tiers as the linear fluorescent lamps. The final regulatory measure of EC No 245/2009 will take effect in 2017, however no increase in efficacy requirements for T8 and T5 lamps has occurred since 2010 and the levels of ambition for MH lamps in 2017 are significantly lower than many MH products in the market today, therefore Tier 1 is proposed in 2018, followed by Tier 2 in 2021 and Tier 3 in 2023.

Scenario 2 considers the same levels of ambition, but the schedule is accelerated so that Tier 2 occurs in 2020 and Tier 3 in 2022.

Scenario 3 considers the same schedule as Scenario 2, however the ambition of the requirements are greater, with a further 10% at Tier 3 for the fluorescent lamps and an additional 15% at Tiers 2 and 3 for MH lamps.

[18] White Paper Summarizing Findings of a One-Day Workshop: Fast-Tracking Widespread Adoption of LED Lighting, May 2010, The Institute for Energy Efficiency, University of California Santa Barbara.

The energy saving potentials arising from the three policy scenarios are shown in the table below. More detail can be found in Annex E, Tertiary Lighting.

Table 4-15. Projected Annual Energy Savings to 2030, Scenarios 1-3, Tertiary Lighting

Scenario	2010 (TWh/yr)	2015 (TWh/yr)	2020 (TWh/yr)	2025 (TWh/yr)	2030 (TWh/yr)
Scenario 1	-	-	10.3	18.5	12.1
Scenario 2	-	-	14.5	24.3	14.8
Scenario 3	-	-	14.9	28.8	18.3

The ecodesign regulation does not identify any issues to be integrated into the review in addition to reviewing it in the light of technological progress. However, in common with several of the other reviews, it would be appropriate to assess verification tolerances and the possibilities for removing or reducing the values of existing correction factors. There may also be opportunities for additional energy savings by addressing electronic ballasts and tertiary luminaires, not currently in the scope of the ecodesign implementing measure. Certain lamp base types, certain halogen lamps, and LED technologies are not currently included. From the point of view of the broader environmental impacts of lighting services, the implications of the recently concluded Minamata Convention on mercury should be considered.

Finally, the level of ambition of the next, tier (Tier 3) for MH lamps under the *existing* ecodesign implementing measure appears somewhat modest compared to products available on the market. The potential opportunity for making additional energy savings by making Tier 3 more ambitious should be balanced against the need for regulatory certainty. This could be done ahead of the review and together with an assessment of the level of ambition of Tier 6 for halogen lamps in the *existing* implementing measure for non-directional household lamps (see Section 4.6 and particularly Section 4.7).

In summary for tertiary lighting, the scope of coverage may require review to add certain HID lamp base types, certain halogen lamps and/or LED lighting technologies. There may also be opportunities for addressing electronic ballasts and tertiary luminaires not currently in the scope of the implementing measure. The energy label was recently published. It will take effect from 1 September 2013, and is required to be reviewed by October 2015. Across the EU, tertiary lighting is projected to consume 214 TWh of electricity in 2020. The energy savings estimate from Scenario 2 is 14.5 TWh in that year, or approximately 6.8%. By 2030, the baseline energy consumption is 166 TWh of electricity and the energy savings estimate from Scenario 2 is 14.8 TWh, or 8.9% of the baseline.

4.6 Non-Directional Household Lamps

Commission Regulation EC No 244/2009 on the ecodesign requirements for non-directional household lamps entered into force on 13 April 2009. The implementing measure states that it shall be reviewed no later than five years after its entry into force (i.e., by 13 April 2014) and the results of that review shall be presented to the Ecodesign Consultation Forum. The Commission shall review the regulation in the light of technological progress.

Delegated regulation EU No 874/2012 on energy labelling of electrical lamps and luminaires entered into force on 14 October 2012 and will become applicable from 1 September 2013 (except for cases listed in Article 9). As noted in the tertiary lighting summary above, the review of the regulation is not regulation is not required until October 2015 as is thus not included in this paper.

In line with the ecodesign framework directive, the review of the implementing measure must assess potential future minimum performance requirements in light of technological progress. No additional issues to be integrated into the review were specified in Article 7.

The scope of coverage for non-directional household lamps includes incandescent, halogen, compact fluorescent and light-emitting diode lamps. The exemptions identified in Article 1 of the ecodesign regulation still appear to be appropriate, particularly as many of these lamps such as fluorescent lamps and HID lamps are covered under other regulatory measures. Attempts to promote incandescent lamps as space heating appliances and to promote sales of incandescent lamps intended for industrial applications to the household market, may be mainly a matter of enforcement at the member state level, or may raise issues of scope and definitions in the implementing measure. The topic should be included as part of the review.

In accordance with Regulation EC No 244/2009, the EU lighting market is undergoing a transition from inefficient lighting to energy-efficient, lower life-cycle cost, alternatives. Starting in September 2009, the regulation has gradually introduced requirements across all the wattages of incandescent lamps. At the same time that inefficient incandescent technologies are being removed from the market, a new light source – light emitting diodes (LEDs) – have started to penetrate the general lighting market, and are offering new and improved products to consumers. In December 2012, Commission Regulation EU No 1194/2012 was published which establishes minimum performance requirements for certain LED lamps that will ensure products maintain a basic level of quality.

A BAU Scenario was developed which shows a rapid decline in the remaining special-purpose incandescent lamp shipments, reaching zero by 2021. Halogen becomes a popular replacement for incandescent, however it starts to decline around 2015 and trends downward in response to Stage 6 in September 2016 which requires halogen lamps to achieve energy label B rating. CFLs peak in 2012 and then decline as the most suitable sockets for CFLs will then have long-life CFLs installed and consumers are expected not to fully embrace the technology due to warm-up time, mercury content and other issues. LEDs start to gain market-share, surpassing CFLs on a unit basis in 2015 and halogens in 2017. However, LEDs are very long life, thus once installed the socket is not available for replacement in the domestic setting for approximately 20 years – leading to peak in LED replacement lamp sales around 2020 and a gradual decline and levelling off by 2030 at around 200 million unit LED lamp sales per annum. The table below shows the projected unit sales and installed stock of non-directional household lamps and a BAU projection of electricity consumption to 2030. Similar to the trend in tertiary lighting, the market is expected to increase lumen output while decreasing energy consumption under a BAU scenario.

Table 4-16. Projected Sales, Stock and BAU Energy Consumption to 2030, Non-Directional Household Lamps

EU-27 projection	2010	2015	2020	2025	2030
Sales (million units)	1,485.0	1,036.7	883.0	522.3	380.7
Stock (million units)	4,377.0	4,580.2	4,927.7	5,201.7	5,556.2
Stock annual energy consumption BAU, (TWh)	111.92	106.82	89.07	81.49	79.56

Halogen technology has some room for improvement through the use of infrared reflective coatings, low voltages and improvements to halogen capsules. CFLs are only expected to experience minor improvements in performance, as they are already a mature technology and are not the focus of any significant research and development investment. LED technology, on the other hand, is the subject of large research investments, on every aspect of an LED lamp, from chip and package-level improvements through to the LED driver and optical performance. LED technology, however, currently relies on rare earths and other precious material, and future research should investigate the possibility of increasing material efficacy.

The energy savings scenarios developed for non-directional household lamps all assume that new ecodesign regulations come into effect in two steps – a Tier 1 requirement with an EEI of 0.24 (energy label class A) and a Tier 2 requirement with an EEI of 0.17 (energy label class A+). The difference between the scenarios is essentially the timing of when the regulation becomes effective. These scenarios are based on the assumption that LED technology will be diverse, compatible and offer performance equivalent to products servicing these lighting applications today. As noted before, the analysis underlying this paper did not extend to an economic assessment of technological options, and so scenarios would have to be assessed with respect to whether they offer the least life-cycle cost.

Table 4-17: Three Illustrative Policy Scenarios for Non-Directional Lamps

Scenario	Ecodesign
1	Tier 1 at EEI ≤ 0.24 from 2019 Tier 2 at EEI ≤ 0.17 from 2022
2	Tier 1 at EEI ≤ 0.24 from 2018 Tier 2 at EEI ≤ 0.17 from 2021
3	Tier 1 at EEI ≤ 0.24 from 2017 Tier 2 at EEI ≤ 0.17 from 2020

Scenario 1 includes the adoption a Tier 1 requirement with an EEI of 0.24 (energy label class A) from 2019 and a Tier 2 requirement with an EEI of 0.17 (energy label class A+) from 2022. Thus, Tier 1 is introduced three years after the final Stage 6 of Regulation 244/2009, when LED lamps are projected to be much less expensive and cost-effective replacement clear (and non-clear) lamps should be widely available. Scenario 2 assumes the same new ecodesign requirement of 0.24 at Tier 1 and 0.17 at Tier 2, however the schedule is accelerated by one year – so that Tier 1 becomes effective in 2018 and Tier 2 becomes effective in 2021. Scenario 3 mimics the other two in terms of EEI levels; however it introduces the two tier levels one year earlier than the second scenario – in other words, 2017 and 2020.

The energy saving potentials arising from the three policy scenarios are shown in the table below. More detail can be found in Annex F, Non-Directional Household Lamps.

Table 4-18. Projected Annual Energy Savings to 2030, Scenarios 1-3, Non-Directional Household Lamps

Scenario	2010 (TWh/yr)	2015 (TWh/yr)	2020 (TWh/yr)	2025 (TWh/yr)	2030 (TWh/yr)
Scenario 1	-	-	12.4	21.3	16.0
Scenario 2	-	0.1	18.6	22.9	17.4
Scenario 3	-	0.1	25.2	24.1	18.6

No specific additional requirements are specified in the "revision" article, Article 7. However the recitals did point to 1) the need to verify that special purpose lamps are not used for general lighting purposes; 2) taking note of the development of new technologies such as LED; 3) and an assessment the feasibility of establishing energy efficiency requirements at the 'A' class level as defined in Directive 98/11/EC. The scenarios developed for this paper integrates LED technology and are consistent with the third point regarding 'A' class level efficiency requirement as well. Attempts to promote incandescent lamps as space heating appliances (as indeed the promotion of incandescent lamps intended for industrial applications to the household market) may be mainly a matter of enforcement at the member state level, but may also raise issues of scope and definitions in the implementing measure. Finally, in a manner consistent with other regulatory measures, it would be appropriate to assess verification tolerances and the possibilities for removing or reducing some of the correction factors.

In summary for non-directional household lamps, the scope may require review as new products are entering the market and there are separate regulations for non-directional and directional household lamps and tertiary lamps and equipment. Part of the review may seek to address the integrity of the regulation in the face of attempts to circumvent the phase-out of incandescent lamps by tightening up scope/definitions. The energy label has recently been updated, and therefore does not need to be revised. It was found that there is still further potential for technological improvement for halogen, CFL and especially LED lamps. Tier 1 in all three scenarios is based on label class A (EEI of 0.24) followed by Tier 2 which adopts class A+ (EEI of 0.17). Since halogen is not able to achieve an energy efficiency class A or A+, the three scenarios are effectively phasing out halogen lamps in favour of more efficient alternatives. It is the removal of halogen from the market coupled with the projected performance improvement of LED that contributes significantly to the energy savings estimates. Across the EU, non-directional household lamps are projected to consume 89.1 TWh of electricity in 2020. The energy savings estimate from Scenario 2 is 18.6 TWh in that year, or approximately 21% of the baseline. By 2030, the baseline energy consumption is 79.6 TWh of electricity and the energy savings estimate from Scenario 2 is 17.4 TWh, or 22% of the baseline.

4.7 Looking at lighting together

Four different and partially overlapping implementing measures cover the lighting sector. The first two to be adopted were the ecodesign implementing measure EC No 244/2009 on non-directional household lamps and the ecodesign implementing measure EC No 245/2009 on tertiary lighting. The final stages of requirements for these are coming up in 2016 and 2017, respectively. There appears to be no formal requirement in either regulation to reassess all aspects of the final stages of the two regulations.[19] However, while the final stage (6) of 244/2009 may be asking for a product that is no longer available in the market, the final stage (3) of 245/2009 has requirements that appear to be too

[19] A review of the requirements for HID ballasts in the final tier of 245/2009 is discussed in paragraph (15) of the recitals: "The revision according to Article 8 should, inter alia, verify whether the performance requirement of ballasts for HID lamps in Annex III Section 2.1.C will be achievable eight years after this Regulation has entered into force."

low for HID lamps. This suggests that there would be merit in an early meeting to assess the appropriateness of the final stage for both, in light of the available data.

Two additional regulatory measures for lighting products have been adopted more recently. One is the energy labelling implementing measure EU No 874/2012 on electrical lamps and luminaires, the other is the ecodesign implementing measure EU No 1194/2012 on directional lamps, LED lamps, and related equipment.

All four implementing measures on lighting are coming up for review between April 2014 and January 2016. There are commonalities between them. Several companies manufacture or import products that are covered in all four regulations. And all of the lighting technologies covered by these regulations are experiencing competition from LED based sources. In addition, the distinction drawn between different product types in the three ecodesign implementing measures is to a certain extent artificial. While the distinction between directional and non-directional lamps would continue to be of value, the penetration of LEDs in both domestic and tertiary applications, challenges the existing categorisation of product groups under the implementing measures. There may therefore be value in bringing the reviews together rather than doing them separately. This should lead to reductions in resources needed for contribution and participation by stakeholders, Member States and the Commission.

Thus a two step approach to lighting over the next few years could be envisaged:

Step 1: Reassess the appropriateness of final stage requirements for EC No 244/2009 (non-direction household lamps) and EC No 245/2009 (tertiary lighting) with a view to potentially reducing the ambition of the former, and increasing the ambition of the latter.

Step 2: Conduct the review and revision of all four lighting implementing measures simultaneously as part of the same process to ensure synergies and reductions in overall resources required.

If this approach were to be adopted, it would be desirable to complete Step 1 by the middle of 2014 and Step 2 by the middle of 2015. In this context "completed" is intended to mean adopted by the Commission, in other words, just prior to publication in the Official Journal. The timetable will in part depend on what additional evidence base is deemed necessary in order to draw up any amendments/revisions, and the what formal requirements there are making any amendments to the final stages of EC No 244/2009 and EC No 245/2009.

4.8 Simple Set-Top Boxes

Commission Regulation (EC) No.107/2009 on the ecodesign requirements for simple set-top boxes (SSTB) entered into force on 25 February 2009. The implementing measure states that it shall be reviewed no later than five years after its entry into force (i.e. by 25 February 2014) and the results of that review shall be presented to the ecodesign consultation forum. There is no energy labelling regulation for SSTB.

In line with the ecodesign framework directive, the review of the implementing measure must assess potential future minimum performance requirements in light of technological progress. No additional issues to be integrated into the review were specified in Article 7.

The definition of SSTB Regulation 107/2009 served its purpose but is now outdated. Voluntary initiatives on complex set top boxes (CSTBs) have been developed, but these exclude certain products that are also excluded from the SSTB Regulation. This group of new products are therefore not subject to either SSTB Regulation 107/2009 or the two voluntary initiatives, and may undermine the objectives of these efforts to ensure energy-efficiency measures are designed into all set top boxes. A review should therefore carefully establish definitions and requirements that will ensure coverage of these products that are currently omitted from the SSTB and the CSTB scopes of coverage.

The shipments of SSTB in the EU are in significant decline. Shipments and thus, installed stock, are principally linked to the rate of the transition to digital terrestrial television (DTT) broadcasting in the EU. In most countries, a phased shutting down of analogue TV signal transmissions has overlapped with the introduction of DTT broadcasting. By December 2012, most countries in the EU had implemented the transition to DTT broadcast, although some delays are expected in Bulgaria, Poland, Romania and possibly Hungary.

It is expected that SSTB sales will be dominated by high feature Personal Video Recorders (PVRs) supporting multi-screen local area network programme distribution and home gateway interface functions for those households who do not wish to use subscription services. Leading European STB manufacturers predict that the basic SSTB and simple PVR SSTB will virtually disappear as a product within seven years, leaving a relatively low volume of high feature SSTB products. The table below shows the projected levels of sales and stock of SSTB and a BAU projection of energy consumption to 2030.

Table 4-19. Projected Sales, Stock and BAU Energy Consumption to 2030, Simple Set-Top Boxes

EU-27 Projection	2010	2015	2020	2025	2030
Sales (million units)	26.5	12.3	10.0	0.0	0.0
Stock (million units)	132.7	107.4	74.5	37.3	4.7
Stock annual energy consumption BAU, (TWh)	2.86	2.48	1.82	1.06	0.13

There are many technology measures that are adapted for use with SSTBs that improve their efficiency. The main opportunities for improvement in energy-efficiency include higher integration of chips; more energy efficient software development; higher power supply efficiency; and auto switch-off to standby-mode and low power standby.

To determine the energy savings potential for SSTBs, only two illustrative policy scenarios were developed that update the ecodesign regulations. These were designed around the CSTB code of conduct (version 9.0) that is being developed by the European Commission’s Joint Research Centre and experts from industry and government. For Scenario 1, it is assumed that the Tier 1 criteria of the draft CSTB CoC version 9.0 are adopted in 2016. For Scenario 2, it assumes the same efficiency requirements; however the regulation accelerates the schedule so that it takes effect in 2014 instead of 2016. In both instances, it is assumed that the energy savings estimate associated with the draft CSTB CoC version 9.0 is approximately 15% of the BAU Scenario.

Table 4-20: Two Illustrative Policy Scenarios for Simple Set Top Boxes

Scenario	EcoDesign
1	Tier 1 Criteria of draft CSTB Code of Conduct v.9.0 in 2016
2	Tier 1 Criteria of draft CSTB Code of Conduct v.9.0 in 2014

The energy saving potentials arising from the policy scenarios are shown in the table below. More detail can be found in Annex G, Simple set-top boxes.

Table 4-21. Projected Annual Energy Savings to 2030, Scenarios 1-2, Simple Set Top Boxes

Scenario	2010 (TWh/yr)	2015 (TWh/yr)	2020 (TWh/yr)	2025 (TWh/yr)	2030 (TWh/yr)
Scenario 1	-	-	0.27	0.16	0.02
Scenario 2	-	0.19	0.27	0.16	0.02

The regulation does not identify any additional issues to be integrated into the review and we did not identify any.

In summary for SSTBs, the scope of coverage may require revision as new products are entering the market that are not covered by the SSTB regulation nor by the voluntary initiatives for CSTB. On the other hand, the market forecast is for declining sales, and there is a modest amount of energy that could be saved. Across the EU, SSTB are projected to consume 1.82 TWh of electricity in 2020 and the energy savings estimate from Scenario 2 is 0.27 TWh.

5 Comparing Upcoming Revisions of Existing Measures

In this section, the assessment of the additional energy saving potential from individual implementing measures is brought together to provide an indication of which reviews and revisions are most important. This is done primarily with reference to the potential for energy savings but other factors such as scope of coverage of the implementing measure, the integrity of the measure, and the communicative effectiveness of the energy label are also integrated into the evaluation in order to ensure a more comprehensive assessment.

5.1 Energy savings potential

Table 5-1 shows the estimated annual energy savings from the existing implementing measures by 2020 as anticipated around the time of their introduction (column 2)[20]. These values are compared to the estimates of potential additional annual energy savings with updated and enhanced regulations for the same seven product groups by 2025 and 2030 (main columns 3 and 4).Although these estimates do not take into account the economic benefits associated with each scenario, they do offer an indication of potential energy savings as they are based on similar timing and levels of ambition as the previous regulatory measures.

Overall some 40-70 TWh/year can be saved from the revisions by 2030. This is in addition to the 99.5 TWh that the Commission has estimated will be saved from the existing measures by 2020. The last column of Table 5-1 rates the importance of the seven product groups based on energy savings potential (one to three stars).

Table 5-1. Overview of Additional Annual Energy Saving from Revisions, Scenarios 1-3, 2025 and 2030

Product Group with Adopted Implementing Measures	Estimated Annual Savings **in 2020** from the Ecodesign Implementing Measures adopted 2009/10 (TWh/yr)[20]	Estimated Additional Annual Energy Savings **in 2025** from revising the Ecodesign Implementing Measures (TWh/yr)			Estimated Additional Annual Energy Savings **in 2030** from revising the Ecodesign Implementing Measures (TWh/yr)			Rating
		Scen.1	Scen.2	Scen.3	Scen.1	Scen.2	Scen.3	
Refrigerating Appliances	4	3.8	7.5	11.5	5.4	11.4	18.0	***
External Power Supplies	9	1.2	1.9	2.8	1.2	1.9	2.8	**
Washing Machines	1.5	1.8	3.2	4.7	2.9	5.2	7.3	**
Dishwashers	2	0.3	1.3	2.9	1.4	3.0	5.7	**
Tertiary Lighting	38	18.5	24.3	28.8	12.1	14.8	18.3	***
Non-Directional Household Lamps	39	21.3	22.9	24.1	16.0	17.4	18.6	***
Simple Set-Top Boxes	6	0.2	0.0	0.0	0.2	0.2	0.0	*
Total:	99.5	47.0	61.1	74.7	39.1	54.0	70.7	

[20] The European Commission, DG Enterprise and Industry, Sustainable and Responsible Business Products. http://ec.europa.eu/enterprise/policies/sustainable-business/ecodesign/product-groups/index_en.htm

Our analysis indicates that the two lighting product groups still account for the overwhelming proportion of the savings potentials. Next most important would be household refrigerating appliances, followed by washing machines, external power supplies and dishwashers. The analysis suggests that comparatively modest savings could be achieved from simple set top boxes. The rating above is based on the mid-range scenario, Scenario 2. The rating would not change if Scenario 1 or Scenario 3 were used. Nor would it change if the cumulative energy savings were used instead of annual energy savings in a given year. Finally the rating is also robust in relation to which year is used: the ranking does not change whether 2020, 2025 or 2030 is used.

The table below shows the additional energy savings for each of the product groups for Scenario 2, and presents those savings in percentage of energy consumption of each product group in the years shown.

Table 5-2. Energy Savings Potential of the Seven Product Groups, Scenarios 1-3

Product	Scenario	Energy Savings 2020		Energy Savings 2025		Energy Savings 2030	
		TWh	(%)	TWh	(%)	TWh	(%)
Household Refrigerating Appliances	1	1.5	2%	3.8	6%	5.4	9%
	2	2.3	3%	7.5	12%	11.4	18%
	3	3.4	5%	11.5	18%	18.0	30%
External Power Supplies	1	1.04	14%	1.17	15%	1.17	15%
	2	1.71	23%	1.92	25%	1.93	25%
	3	2.50	33%	2.80	37%	2.82	37%
Household Washing Machines	1	0.7	2%	1.8	5%	2.9	8%
	2	1.5	4%	3.2	8%	5.2	14%
	3	2.2	5%	4.7	12%	7.3	19%
Household Dishwashers	1	0.03	0.1%	0.32	1%	1.40	3%
	2	0.56	1%	1.27	3%	3.01	7%
	3	1.15	3%	2.86	7%	5.66	13%
Tertiary Lighting	1	10.3	5%	18.5	10%	12.1	7%
	2	14.5	7%	24.3	13%	14.8	9%
	3	14.9	7%	28.8	15%	18.3	11%
Non-Directional Household Lamps	1	12.4	14%	21.3	26%	16.0	20%
	2	18.6	21%	22.9	28%	17.4	22%
	3	25.2	28%	24.1	30%	18.6	23%
Simple Set-Top Boxes	1	0.27	15%	0.16	15%	0.02	15%
	2	0.27	15%	0.16	15%	0.02	15%

5.2 Scope of Coverage

It is important that the scope of coverage of the regulation covers relevant products in the market. This is not always the case, as products can evolve over time which may cause them to fall outside of a defined scope. For this reason, the scope of coverage is an important dimension for reviews and potential revisions.

The following table presents each of the seven product group and summarises the assessment of the alignment between the scope of coverage and the market. Each product group is given a star rating based on how important the issue of scope of coverage is for that product.

Table 5-3. Adequacy of the Scope of Coverage the Seven Product Groups

Product	Observations	Rating
Household Refrigerating Appliances	Already includes all types of household refrigerating appliances apart from wine storage appliances	***[21]
External Power Supplies	Several types of EPS that are omitted from this definition, including high power, indirect operation and multiple-voltage output	***
Household Washing Machines	Scope is adequate, except it excludes products that are washer-dryer combinations, which currently represent about 2.5% of the units sold in the EU	**
Household Dishwashers	Includes all types of domestic dishwashers and therefore does not need to be extended or modified.	*
Tertiary Lighting	Scope certain HID lamps, halogen lamps and but LED products may need review	**
Non-Directional Household Lamps	Scope may require review, including addressing regulatory circumvention such as 'heatball' and industrial rough-service incandescent lamps	**
Simple Set-Top Boxes	The definition of SSTB Regulation 107/2009 served its purpose but may now require revision.	***

The lowest rating (*) is given to household dishwashers, as the scope for that product group does not need to be extended or modified. Of the products analysed, the most important one to correct in terms of the scope of coverage is SSTB where the market has moved considerably and there is no longer good alignment between the regulation and the products sold. By better defining the scope of the SSTB regulation, additional energy savings which should have resulted from the initial regulation will be realised.

It should be noted that the rating in terms of additional energy savings potential from revisions in Table 5-1 (in the previous subsection) does not take account of any additional savings that could be achieved by increasing the scope of, for example the washing machine, EPS and SSTB implementing measures. However we think it is unlikely that this would significantly affect the overall ranking of product groups in terms of additional energy savings potential from revisions.

[21] Although the scope of the implementing measures for household refrigeration appliances is otherwise adequate, there is a significant delay in assessing whether wine coolers should be included.

It seems clear that the implementing measures that would be most important to review from the point of view of energy savings are not necessarily those that would be most important to review from the point of view of adjusting the scope of coverage.

5.3 Integrity of the Regulation

The idea of assessing the "integrity of the regulation" is an attempt to capture a collection of issues which impinge on the effectiveness of a given implementing measure and may reduce the energy savings potential of the regulation. Thus, correction factors that are too generous can compromise the integrity of an implementing measure, as can definitional ambiguities. An example of the latter is the marketing of incandescent lamps as space heating products (e.g., "Heatball") or the marketing of rough-service industrial incandescent lamps for general household use. It is important to reduce such opportunities for 'gaming' the system.[22]

The following table compares the seven product group on the basis of how important integrity of the regulation is to address in each case.

Table 5-4. Integrity of the Regulation for the Seven Product Groups

Product	Observations	Rating
Household Refrigerating Appliances	Review the need for the correction factors[23]	***
External Power Supplies	No issues identified	*
Household Washing Machines	Review test standard in relation to "intelligent" appliances.	**
Household Dishwashers	No issues identified	*
Tertiary Lighting	No issues identified	*
Non-Directional Household Lamps	Review definitions (e.g., 'heatball', industrial rough service lamps)	***
Simple Set-Top Boxes	No issues identified	*

The products where the issue of the integrity of the regulation appears the most important are household refrigerating appliances and non-directional household lamps. For household refrigerating appliances, there is a question whether the correction factors are still needed as discussed in a recent

[22] Compliance continues to be an issue but is not considered here. See for example, the results of a recent EU project, ATLETE, which found that 21% of household refrigerating models tested, had declared an energy class that did not correspond to the test results. See ATLETE (Appliance Testing for Energy Label Evaluation), Publishable result-oriented report. Author: Stefano Faberi (Editing) in collaboration with Milena Presutto and Therese Kreitz, Intelligent Energy The EU (IEE), Energy Efficiency (SAVE) – September 2011. Link: http://www.atlete.eu/doc/Publishable%20Result%20Oriented%20Report.pdf

[23] Assessment of the applicability of current EC correction factors and tolerance levels for domestic refrigerating appliances; Final Report Version 1.0; Intertek; A research report completed for the Department for Environment, Food and Rural Affairs (UK), August 2012

report from the UK (see Annex A). For non-directional household lamps there is an issue with companies attempting to undermine the objective of the regulation.

The issues raised here have the potential to significantly undermine the energy savings potential if not addressed. For household refrigerating appliances, a Defra study found that most of these correction factors were no longer needed. The study estimated that the energy savings potential of removing these correction factors, which was approximately 4.56 TWh of additional annual savings for the EU by 2030.[24] These electricity savings would be in addition to the savings estimated for this product under Scenarios 1 through 3 in this paper.

For non-directional household lamps, the development and exploitation of loop-holes has the potential to undermine the implementing measure. Products such as industrial rough-service incandescent lamps are actually less efficient[25] than the standard incandescent lamps that were the original target of the regulation. This issue requires further study and should be discussed in the review.

5.4 Communicative Effectiveness of the Energy Label

For the products with energy labelling regulations, it is important to assess the trend in label classes and whether the existing scales are adequate to differentiate products and provide consumers with helpful information at the time of purchase.

The table below rates the seven product group based on which products groups the label is most in need of revision. Three stars (***) are given to the product group that is most in need of a review of the labelling classes, which in this case includes household refrigerating appliances, washing machines and dishwashers. All of these products have reached the end of their meaningful energy labelling scales, with the entire market being A-rated or better and by 2015 being potentially A+ rated or better. At the same time, there is still significant energy savings with improvement potential for these three product groups, and thus some re-scaling of the energy label would be helpful. The lowest rating (*) is given to those products for which there appear to be adequate energy label classes or for which a labelling regulation has very recently been adopted (i.e., tertiary lighting and non-directional household lamps).

[24] Assessment of the applicability of current EC correction factors and tolerance levels for domestic refrigerating appliances, Final Report Version 1.0", Intertek. A research report completed for the Department for Environment, Food and Rural Affairs, London, UK. August 2012

[25] Rough service lamps have a reinforced filament (extra lead supports) and tougher glass in order to enable them to operate in specialist applications where they are exposed to vibration and other harsh conditions. The extra reinforcing of the filament and robust construction causes these lamps to have a lower efficacy than the standard incandescent lamp covered by the regulation – the light output is approximately 30% lower for the same power consumption.

Table 5-5. Communicative Effectiveness of the Energy Label for relevant product groups

Product	Observations	Rating
Household Refrigerating Appliances	From July 2010 only four out of seven label classes available on the market (A to A+++). From July 2014, only three out of seven labelling classes available (A+ to A+++).	***
External Power Supplies	No direct EC energy labelling activity at this time.	n/a
Household Washing Machines	From December 2011 only four out of seven label classes available on the market (A to A+++). From December 2013, only three out of seven labelling classes available (A+ to A+++). The entire market is projected to reach A+ or better by 2015 under the BAU scenario.	***
Household Dishwashers	From December 2011 five out of seven labelling classes available on the market (B to A+++). Four most of the market, only four classes (A to A+++). From December 2013 class A will be eliminated for most of market leaving only three classes (A+ to A+++). The entire market is projected to reach A+ or better by 2015 under the BAU scenario.	***
Tertiary Lighting	Recent regulation (September 2012), so no update on labelling.	*
Non-Directional Household Lamps	Recent regulation (September 2012), so no update on labelling.	*
Simple Set-Top Boxes	No EC energy labelling activity at this time.	n/a

5.5 Other Factors

A few other factors were identified as shown in the table below. Unlike the other criteria, there is no relative rating associated with these other factors, rather they are just important product-specific points that need to be kept in mind when considering the reviews on these seven products.

Table 5-6. Other Factors for the Seven Product Groups

Product	Observations
Household Refrigerating Appliances	• Updating of international test method to improve the accuracy of the quantified energy performance and thus EEI calculation. • Potential to bundle wine coolers in the review, instead of conducting a separate proceeding. • The final stage of original regulation is due in July 2014.
External Power Supplies	• Harmonisation with international efforts on the energy performance mark. • The final stage of original regulation was in April 2011. • MOU with Digital Europe on universal connectors expired in December 2012.
Household Washing Machines	• The final stage of the original regulation is December 2013.
Household Dishwashers	• The final stage of the original regulation is December 2013.
Tertiary Lighting	• The final stage of the original regulation is April 2017. • Potential for looking at lighting together in relation to final stage of existing implementing measures as well as and to the review.
Non-Directional Household Lamps	• The final stage of the original regulation is September 2016. • Potential for looking at lighting together in relation to final stage of existing implementing measures as well as and to the review.
Simple Set-Top Boxes	• Shipments are significantly declining and will be virtually zero by 2030. • The final stage of the original regulation was February 2012.

6 Concluding Remarks

This paper has assessed the relative importance of upcoming reviews of existing implementing measures for seven product groups. The assessment has been made primarily with reference to the potential for energy savings but it is also relevant to integrate other (related) factors such as scope of coverage of the implementing measure, the integrity of the measure[26], and the communicative effectiveness of the energy label in order to ensure a more comprehensive assessment.

The assessment only covers the reviews that are required to take place up to the end of 2014: eleven implementing measures across the seven product groups. Several other reviews are in the pipeline.

The Commission has estimated that some 99.5 TWh per annum by 2020 could be achieved from the existing implementing measures for the seven product groups reviewed here. Our analysis has identified an *additional* 40-70 TWh per annum by 2030.

The table below summarises the rating in relation to each of the parameters discussed in the previous subsections and arrives at an overall qualitative ranking based on the discussion above.

Table 6-1. Product Group Comparison Overview

Product Group	**Energy Savings Potential**	**Scope of Coverage**	**Integrity of Regulation**	**Communicative Effectiveness**	**Overall qualitative ranking**
Household Refrigerating Appliances	***	***	***	***	***
External Power Supplies	**	***	*	n/a	**
Household Washing Machines	**	**	**	***	**
Household Dishwashers	**	*	*	***	**
Tertiary Lighting	***	**	*	*	***
Non-Directional Household Lamps	***	**	***	*	***
Simple Set-Top Boxes	*	***	*	n/a	*

We have compared the additional energy saving potential from individual implementing measures to provide an indication of which reviews and revisions are most important in terms of energy savings. The analysis indicates that the two lighting product groups still account for the overwhelming proportion of the potential for energy savings. Next most important is household refrigerating appliances, followed by washing machines, external power supplies and dishwashers. The analysis suggests that only very modest savings could be achieved from simple set top boxes.

A prioritisation of reviews based on which implementing measures are most in need of realignment of scope would be rather different to a prioritisation based on potential energy savings. The product

[26] The idea of the "integrity of the regulation" was as noted above, an attempt to capture a collection of issues which impinge on the effectiveness of a given implementing measure in terms of reducing energy consumption. Thus correction factors that are too generous can compromise the integrity of an implementing measure as can definitional ambiguities.

groups where the scope of implementing measures is most in need of realignment with the market are SSTB, EPS and refrigerators (as noted above there are significant delays in assessing whether wine coolers should be included in the ecodesign implementing measures for household refrigerating appliances).[27] Of middle importance on the basis of adequacy of scope would be household washing machines and the two lighting regulations. Finally, the scope of both implementing measures for household dishwashers appears to be adequate and thus does not require change. As the additional energy savings from increasing the scope of EPS and SSTB are likely to be modest (compared to what can be achieved from lighting and household refrigerating appliances), in the end, considering the revisions from this point of view does not alter the initial prioritisation.

A similar story emerges when considering the implementing measures of the seven product groups from the point of view of the integrity of the regulation. Here it is the implementing measures for the non-directional household lamps and household refrigerating appliances that are most in need of review. These are also among those product groups that would be most important to review from an energy savings potential. Reviewing the implementing measures for household washing machines was found to be of middle priority in this respect, whereas EPS, household dishwashers, tertiary lighting and SSTB were found to be less of a priority from this perspective.

We also considered how reviews might be prioritised based on the communicative effectiveness of the energy label, and by extension, consumer comprehension. This was not of relevance to EPS and SSTB as there are no energy labels for these products. The implementing measure establishing energy labelling for the two lighting product groups is very recent and was therefore not assessed either. This left household refrigeration appliances, household washing machines and household dishwashers. On the basis of the communicative effectiveness of the energy label, all three implementing measures would be a priority to review. The reason for this is that in all three cases, models on the market are clustered at the top end of the energy label scale, at class A or above. This lends weight to prioritising the reviews of the implementing measures for household refrigerating appliances, already important because of potential energy savings. It also suggests that there may be grounds to move household washing machines into a higher priority group.

Finally, based on the qualitative ranking of all four parameters, three clusters of product groups emerge:

1. Three product groups with three stars: the two lighting groups and household refrigerating appliances. These would, comparatively, be the most important to tackle;
2. Three product groups with two stars: household washing machines, dishwashers and EPS. These are comparatively, of middle importance. And,
3. One product group with one star: SSTB. When compared to the other six product groups coming up for review by 2014, this would be the least important.

Our point of departure has been energy saving, and we have tried to integrate a wider, but related set of criteria in an explicit way. They all have some bearing on the capacity of implementing measures to effect market transformation and improve product energy efficiency and save energy. They are not the only ones that should be taken into consideration. There may, for example, be good grounds for also dedicating some attention to EPS in the short term simply because the comparatively modest energy

[27] The inclusion of wine coolers in the indicative list of priority products under the new ecodesign working plan suggests that a comprehensive preparatory study will be carried out for this product group. Another approach would be to roll wine coolers into the review and revisions to the ecodesign measure on household refrigerating appliances. We have not explored here what would be the best way forward. Wine coolers are already part of the energy label regulation on household refrigerating appliances.

saving potential of 1.2-2.8 TWh may also be relatively easily accessible. This is because of the code of conduct on energy efficiency being developed by the JRC could easily be adopted into a revised ecodesign implementing measure. Moreover, the code is part of an attempt at international harmonisation of energy efficiency requirements for EPS. In addition, there is an easy *material resource efficiency* win to be had on this product group by extending the memorandum of understanding between the Commission and DigitalEurope on the compatibility of EPS which expired at the end of 2012, although it is not clear whether this necessarily has to be linked to a review of the implementing measure.

The Commission has set out ambitious plans for the period to 2014 in its December 2012 working plan for energy related product policy. This includes a substantial remaining workflow from the so-called "transitional period" (2005-2008) as well as from the first working plan (2009-2011). All in all, the Commission plans to adopt some 22 ecodesign measures, 9 labelling measures and recognise 4 voluntary agreements by 2014. To this should be added the review and revision of some 11 existing ecodesign and energy labelling measures adopted during the transitional period and covering some 7 product groups. Finally, a certain number of preparatory studies from the first working plan will be completed and preparatory studies on the indicative list of product groups identified in the second working plan will need to be initiated.

Given the economic, health, climate and other environmental benefits associated with energy related product policy, and the relative simplicity and effectiveness of the policy tools, it would be desirable for the EU to invest more resources to this area of work reflecting better the level of effort dedicated in other jurisdictions such as the US and China.

In order to best prioritise the effort, the analysis offered in this paper should be set against the savings potentials of the regulations still in the process of development under the transition period and the first and second working plans, additional reviews beyond 2014 and the requirement to review and potentially revise the legislative framework of energy related product policy: the ecodesign and energy labelling regulations.

The Commission has already indicated in its second ecodesign working plan that completing the work on existing measures will take priority over the new working plan. This approach has been supported by the Consultation Forum. It has also indicated that some form of fast track approach for revisions is being considered/under development. The revision to the implementing measures on televisions is an example of this.

The reviews thus have to be set against this wider context of savings potentials from products from the transitional period and first working plan still in the process of being regulated, and the priority products in the new working plan. In addition, they also have to be set against the context of the requirement to review and revise the existing legislative framework and the decision to conduct the review of the ecodesign and energy labelling directives together by the end of 2014. Would it make sense to revise not only the household refrigerating energy label, but also the washing machine and dishwasher energy label in advance of a potential change to the energy label? The answer to this question depends in part on the expected outcome of the review and revision to the energy label. Is this dilemma quite the same in relation to the revision of the ecodesign measures and the review and revision to the ecodesign directive? If the adoption of the revisions of the legislative framework gets delayed, this would delay savings from revised implementing measures (whether energy labelling, ecodesign or both) and would therefore reduce the overall cumulative savings from such revisions.

An additional consideration is the state of the evidence base in relation to each of the product groups. It may be that for some, it would be enough to update essential parts of the preparatory study in a more limited review/revision study as is the case with the review that was prepared for televisions. We hope that the analysis offered here provides some of the elements to start that work for the product groups considered in this paper.

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1 Introduction and Context

In common with the other six annexes, this annex starts by setting out the timetable and scope of the upcoming reviews. It then sets out the scope of the existing implementing measures. Having provided this context, a BAU energy consumption scenario is developed. Next an assessment of technology developments is made and this is used to develop a set of illustrative policy scenarios on the basis of which a range of energy savings potentials are defined. Finally, a set of issues of relevance in the context of upcoming reviews is outlined.

1.1 Timetable and Scope to the Upcoming Reviews

Commission Regulation 643/2009 on the ecodesign requirements for household refrigerating appliances[1] entered into force on 12 August 2009. The implementing measure states that it shall be reviewed no later than five years after its entry into force (*i.e.*, by 12 August 2014) and the results of that review shall be presented to the Ecodesign Consultation Forum. Commission Delegated Regulation 1060/2010 on the energy labelling of household refrigerating appliances[2] entered into force on 20 December 2010. The implementing measure states that it shall be reviewed no later than four years after its entry into force (*i.e.*, by 20 December 2014).

1.2 Scope of Coverage of the Implementing Measures

The ecodesign regulation and energy labelling regulations share near identical scope of coverage. This is set out in Article 1 of the implementing measures: electric mains operated household refrigeration appliances, including those sold for household use or for refrigeration of items other than foodstuffs. Build in appliances are included, as are electric mains operated household refrigeration appliances that can be battery operated. A certain number of exclusions are also set out in Article 1. The main difference in scope between the two implementing measures is that the implementing measure on ecodesign does not include wine storage appliances, whereas the energy labelling measure does.

1.3 Scope of the Upcoming Reviews

In line with the framework directives, the reviews must, respectively, assess potential future minimum performance requirements and potential reclassification of labelling categories in light of technological progress. In addition, both the ecodesign and energy labelling regulations require reviews to assess verification tolerances and the possibilities for removing or reducing the values of existing correction factors. The ecodesign revision article (7) also required the Commission to assess the need to adopt specific ecodesign requirements for wine storage appliances no later than two years after the entry into force of the regulation (i.e., 12 August 2011). This deadline has now passed and the assessment has been included into a separate work-stream under the ecodesign work plan for 2012-2014. It is, with six other product groups, on the indicative priority list. Apart from the issue of wine coolers, the scope of both implementing measures is still adequate.

[1] Commission Regulation (EC) No 643/2009 of 22 July 2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for household refrigerating appliances, OJ L 191, 23.7.2009, p. 53
[2] Commission Delegated Regulation (EU) No 1060/2010 of 28 September 2010 supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to energy labelling of household refrigerating appliances, OJ L 314, 30.11.2010, p. 17

2 Market Projection

2.1 Installed Stock and Annual Sales

The EU household refrigerating market is generally considered to be saturated. The market now, and in the future, is primarily a replacement market, except for where population and thus number of households are increasing. The number of households in the EU-27 is projected to increase by 11.6% between 2012 and 2030.[3] Under stable economic conditions domestic refrigerator sales is driven by changes in the number of households; however, according to Eurostat, sales in the EU have declined over the last few years (see Table 2-1). This decline is most probably due to the global economic crisis that began in 2008. It is unlikely that the number of domestic refrigerators per household has declined during this period, but instead people are keeping hold of their existing appliances for longer and thus effectively increasing the average refrigerator lifespan.

Table 2-1: Sales of Household Refrigerating Appliances in the EU-27 Countries

Product	2006	2007	2008	2009	2010	2011
Refrigerator-Freezer (million)	7.3	7.8	7.1	5.9	5.7	6.2
Refrigerator (million)	8.8	9.1	6.4	5.3	4.8	5.2
Freezers (million)	5.9	5.4	3.7	3.5	3.5	3.9
Total	22.0	22.3	17.2	14.7	14.1	15.3

2.2 Refrigerator Stock and Sales Projection

Given this, it is expected the recent increase in average product lifespan will soon reach a limit and that replacement sales will return to historical norms as a share of the number of households and of GDP. A projection of future sales based on returning to the historic norms is provided in Table 2-2. This projection is based on a weighting of GDP and population growth projection for the EU-27 taken from Eurostat.

Table 2-2: Projected Sales of Household Refrigerating Appliances in the EU-27

Product	2015	2020	2025	2030
Refrigerator-Freezer (million)	7.3	7.9	8.6	9.4
Refrigerator (million)	7.6	8.2	8.9	9.7
Freezers (million)	5.4	5.8	6.3	6.9
Total	20.3	22.0	23.8	25.9

These sales figures are consistent with a fluctuating mean product lifespan that temporarily increases and then returns back to a long term average value of 14 years for refrigerators and 17 years for freezers. Adding these sales into a stock model produces a trend in the European household refrigerator stock as shown in Table 2-3.

[3] EUROSTAT Population Projections for EU-27, accessed in October 2012, see weblink: http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&init=1&plugin=1&language=en&pcode=tps00002

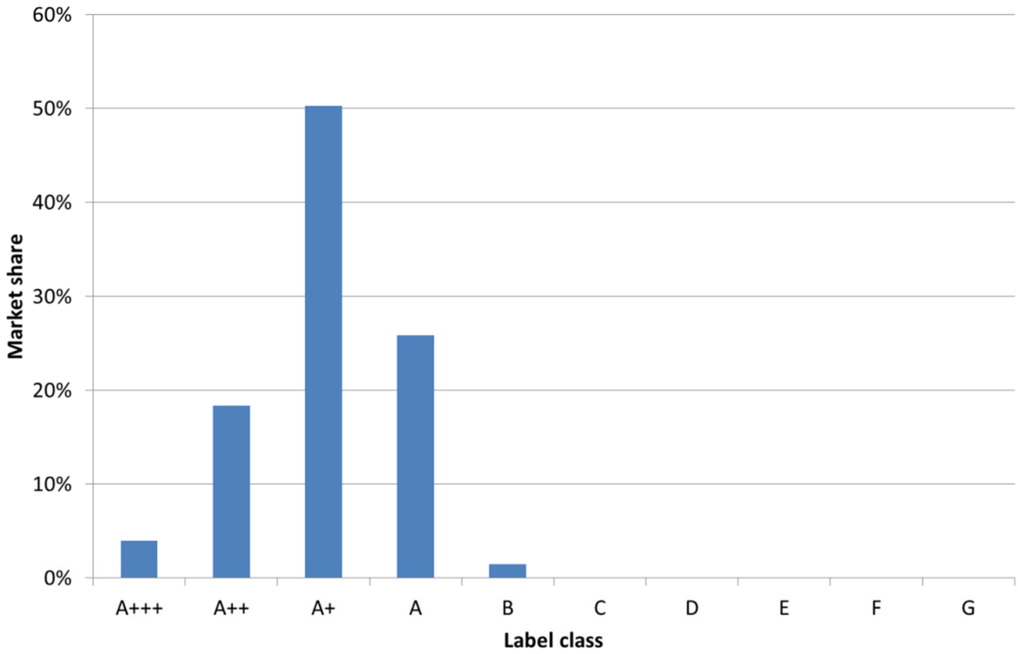
Table 2-3: Projected Stock of Household Refrigerating Appliances in the EU-27

Product	2015	2020	2025	2030
Refrigerator-Freezer (million)	104.9	108.5	111.8	114.9
Refrigerator (million)	108.7	112.5	116.0	119.1
Freezers (million)	76.8	79.5	81.9	84.1
Total	290.4	300.5	309.7	318.1

2.3 Projected Energy Consumption

At the time energy labelling for household refrigerating appliances was first developed in the EU (the GEA study of 1993), the average appliance was on the class D and E threshold and had an EEI of 100. Despite the implementation of Ecodesign MEPS set at the energy label class A level (EEI = 55) in 2010 there continues to be a large difference between the highest and least efficient refrigerating appliances. A+++ units (EEI=22), which appear to account for about 4% of models available for sale on the EU market (Figure 2-1), are 60% more energy efficient than a class A refrigerators (appearing to account for roughly 25% of those available for sale).[4]

Figure 2-1: Share of EU Household Refrigerator Sales by Label Class, Internet Survey 2012



These figures suggest that, if the EEI is taken at face value and the influence of the correction factors is not taken into account, there has been an improvement of approximately 60% in the energy efficiency

[4] Percentages based on a limited Internet survey of 200 models on sale in six different EU countries in September 2012 and hence may not be representative of the EU market as a whole.

of European refrigerators over the last 19 years. If this trend were to continue in the same manner into the future, by the time a new EU Ecodesign regulation is developed and effective (in say 2016) the average EEI would have moved on from today's market average 41 to 32 i.e. to the A++ level. This is some 22% more efficient than today's apparent average based on a limited survey of 200 models in six EU countries, as shown in Figure 2-1.

In order to estimate the energy savings potential of any revised ecodesign regulation and energy labelling regulation, the stock projections discussed earlier are multiplied by a base case average unit energy consumption projection to estimate future energy consumption for household refrigerating appliances. This projection is referred to as the 'Business as Usual' (BAU) scenario which takes into account the fact that energy efficiency of refrigerators will continue to improve in the coming years, even without further minimum energy performance requirements. The BAU scenario also takes into account the fact that the effectiveness of the label will slowly decline as saturation occurs in the top three label classes (i.e., A+ through A+++).

Table 2-4: BAU Energy Consumption of Household Refrigerating Appliances

Basecase Energy Consumption	2005	2010	2015	2020	2025	2030
Total Household Refrigerating Appliances (TWh)	103.8	92.1	79.7	70.6	65.0	62.3

3 Technology Assessment

The technologies used in refrigerators have evolved steadily over the last decade rather than undergone any dramatic revolution. The use of electronic controls which allow better regulation of the compartment temperatures and better control of the refrigeration cycle itself have become relatively standard. Better compressors continue to evolve and the best have now attained efficiency levels thought to be near the technological limit of some early studies.[5] Evaporators and condensers have been refined and insulation techniques improved allowing more efficient heat transfer and refrigeration cycles operating closer to the ideal refrigeration thermodynamic cycle on the one level and reducing heat losses on the other. The deployment of electronically regulated valve technology has enabled separate and more efficient operation of the fresh-food compartment refrigeration cycle and the frozen food compartment refrigeration cycle. Computer aided design and related energy simulation techniques have also evolved which has facilitated the adoption of more efficient design options by manufacturers. Vacuum insulation panels and variable speed compressors are high-efficiency design options, but they have yet to be adopted widely in the EU market.

3.1 Production Cost and Economic Developments

Economies of scale are one reason why the incremental cost to manufacture more efficient products is likely to have fallen but another is increased flexibility in manufacturing machinery and processes that allow for design changes without setting up a new assembly line or requiring new machinery (especially mouldings) for each production run. The household refrigerating appliances preparatory study did not include a techno-economic energy engineering analysis, i.e., one that used simulation software coupled with economic analysis to analyse the impact of potential higher efficiency design changes on energy efficiency and cost. Rather the approach taken was to consider the impact of design changes in a simplified tabular form that articulated views of how much could be saved by applying a given design option. Its starting point was often the detailed findings of the 2000 Cold II study conducted in support of the first energy label revision.

The results of the Cold II study are now over 12 years old and the input data that the analysis relied on regarding costs and efficiency options are even older. The cost to manufacture efficient products has declined sharply since that time and it is thus likely that the lifecycle cost (LCC) minimum value now occurs at a significantly higher efficiency level. Recent analyses conducted for the US DOE on learning curves show sharp declines in the real price of appliances have continued despite substantial, regulation driven, improvements in energy efficiency[6]. This conclusion is also supported from the findings of earlier work by the IEA[7], Lane and Harrington[8], and others.[9]

Thus, while the Cold II study concluded, 12 years ago, that the LCC minimums occurred for EEI levels of between A and A+, and the ecodesign regulatory process settled on the class A boundary as the regulatory minimum, it is expected that the minimum will now have advanced to a higher efficiency (lower EEI) level through the combined effect of (1) progressive improvements in the energy efficiency

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[5] Cold II (2000) COLD II The revision of energy labelling and minimum energy efficiency standards for domestic refrigeration appliances, ADEME and PW Consulting, for the European Commission, Directorate-General for Transport and Energy, Contract no: XVII/4.1031/Z/98-269, December.

[6] "Incorporating experience curves in appliance standards analysis" by Louis-Benoit Desroches; Karina Garbesi; Colleen Kantner; Robert Van Buskirk; Hung-Chia Yang; Energy Policy (January 2013), vol 52, pg. 402-416

[7] *Experience with Energy Efficiency Requirements for Electrical Equipment*, IEA, 2007, www.iea.org

[8] Evaluation of Energy Efficiency Policy Measures for Household Refrigeration in Australia An assessment of energy savings since 1986, prepared by Energy Efficient Strategies, E3 Report no 2010/10, December 2010.

[9] Weiss, M., Patel, M.K., Junginger, M., Blok, K., 2010b. Analyzing price and efficiency dynamics of large appliances with the experience curve approach. *Energy Policy* 38, 770-783.

of refrigeration technology and (2) progressive and possibly quite sharp declines in the real cost of manufacturing efficient refrigerator designs.

This is supported by evidence from the household refrigerating appliances preparatory study (Lot 13, 2007) that average EU refrigerating appliance prices have not increased and may have even decreased despite having much higher average efficiency levels, more features and greater average volumes than in the past.

4 Energy Savings Potential

The purpose of this section is to provide an estimate of the potential for additional energy savings from revised regulations in the context of different levels of ambition. After briefly setting out the requirements of existing regulations, a high, medium and low ambition illustrative policy scenario is presented based on the preceding assessment of technological development. These policy scenarios provide an indicative estimate of the energy savings potential, based on updated regulatory requirements.

4.1 Existing Regulations

4.1.1 Ecodesign

Annex II of ecodesign regulation EU No 643/2009 established the following performance requirements for household refrigerating appliances:

Table 4-1. Requirements for Household Refrigeration Appliances Under the Ecodesign Regulation

Type	Application Date	Energy Efficiency Index (EEI)
Compression-type refrigerating appliances	1 July 2010	EEI < 55
	1 July 2012	EEI < 44
	1 July 2014	EEI < 42
Absorption-type and other-type refrigerating appliances	1 July 2010	EEI < 150
	1 July 2012	EEI < 125
	1 July 2015	EEI < 110

This applies to household refrigeration appliances with a storage volume equal to or higher than 10 litres. It does not apply to wine storage appliances, absorption appliances, or certain appliances set out in Annex IV.

4.1.2 Energy label

The energy labelling regulation No. 1060/2010, which applies from 20 December 2011, specifies ten energy efficiency classes from G (least efficient) to A+++ (most efficient). A second set of energy classes applies from 1 July 2014 which changes the threshold value between A and A+ from an EEI of 44 to 42. This adjustment to the threshold of A+ requires that models in this class will have to be slightly more efficient than they were prior to the change. Both sets of energy labels are shown in the table below.

Table 4-2. Energy Classes for Household Refrigeration Appliances Under the Energy Labelling Regulation

Energy Efficiency Class	Energy Efficiency Index (until 30 June 2014)	Energy Efficiency Index (from 1 July 2014)
A+++ (most efficient)	EEI < 22	EEI < 22
A++	22 ≤ EEI < 33	22 ≤ EEI < 33
A+	33 ≤ EEI < **44**	33 ≤ EEI < **42**
A	**44** ≤ EEI < 55	**42** ≤ EEI < 55
B	55 ≤ EEI < 75	55 ≤ EEI < 75
C	75 ≤ EEI < 95	75 ≤ EEI < 95
D	95 ≤ EEI < 110	95 ≤ EEI < 110
E	110 ≤ EEI < 125	110 ≤ EEI < 125
F	125 ≤ EEI < 150	125 ≤ EEI < 150
G (least efficient)	EEI ≥ 150	EEI ≥ 150

The ecodesign regulation has removed models less efficient than A from the market in July 2010. This means that the current labelling classification is from A to A+++, and the household refrigerating appliances energy label has had only four classes. In July 2014, the ecodesign regulation will remove models less efficient than A+ (EEI of 42) from the market, retaining only three classes.

Emerging evidence from a forthcoming CLASP study on consumer comprehension of the new energy label suggests that consumers do not understand that classes still appearing on the A-G scale a no longer available in the market and that the extended A scale does not have as strong motivational effect as the A-G scale. This suggests that there is a need to revise the energy label to retain its effectiveness.

4.2 Illustrative Policy Scenarios

Three illustrative policy scenarios were developed for household refrigerating appliances. These are presented in the table below. The levels and timing associated with the different tiers are based on the magnitude of step increases and timing of the existing ecodesign and energy labelling requirements. These policy scenarios provide an indicative estimate of energy savings, based on possible technology improvements for this product group.

Table 4-3: Three Illustrative Policy Scenarios for Household Refrigerating Appliances

Scenario	EcoDesign	Energy Label
1	Tier 1 at EEI ≤ 38 from 2016 Tier 2 at EEI ≤ 35 from 2019	HELC[10] in 2016 at EEI ≤ 15
2	Tier 1 at EEI ≤ 36 from 2016 Tier 2 at EEI ≤ 28 from 2019	$HELC_{-1}$ in 2016 at EEI ≤ 18 HELC in 2018 at EEI ≤ 14
3	Tier 1 at EEI ≤ 33 from 2016 Tier 2 at EEI ≤ 22 from 2019	$HELC_{-1}$ in 2016 at EEI ≤ 18 HELC in 2018 at EEI ≤ 14

The first scenario assumes that new ecodesign regulations come into effect in two steps – a Tier 1 requirement with an EEI of 38 from 2016 and a Tier 2 requirement with an EEI of 35 from 2019. The scenario also assumes that a new energy label class is introduced in 2016 having a new, higher energy label class with an EEI of 15.

The second scenario assumes a new ecodesign Regulation with two tiers, the first from 2016 at an EEI of 36 and the second from 2019 with an EEI of 28. This scenario also considers two new energy label classes are introduced, one with an EEI threshold of 18 and the other with an EEI threshold of 14.

The third scenario also assumes a new ecodesign regulations would come into effect in two steps – an EEI of 33 from 2016 and an EEI of 22 from 2019. In addition, this scenario assumes two new energy label classes, one with an EEI of 18 and one with an EEI of 14.

The efficiency of the hypothetical new label classes has not yet been attained by any appliance of the EU market and hence is beyond best available technology (BAT); however, exactly the same circumstance applied when the current A+++ threshold was set and in 2012, approximately 4% of models meet this threshold.

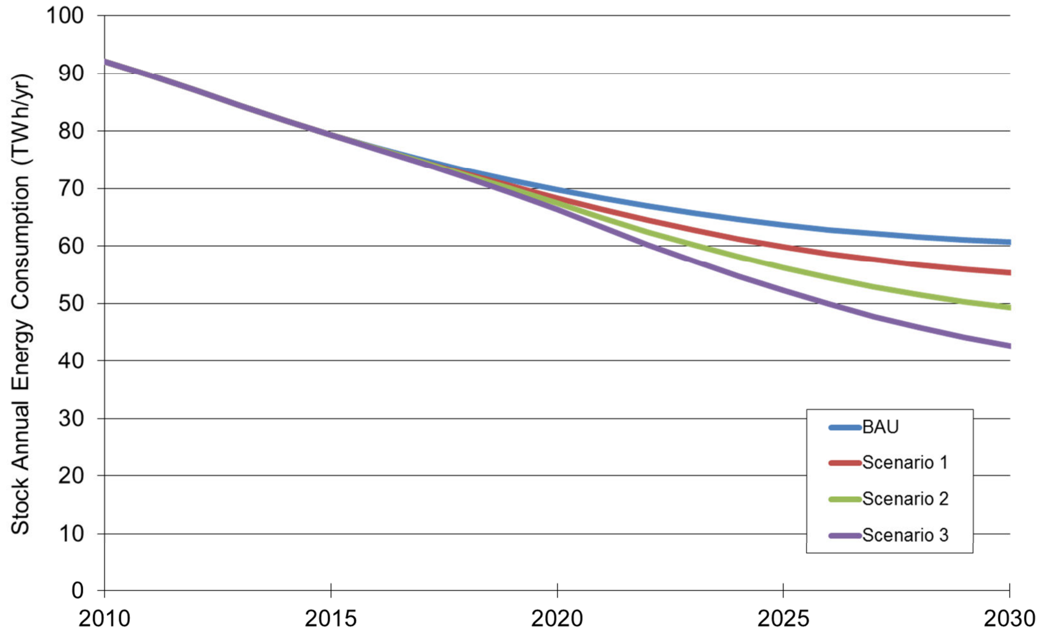
It is expected that the design of new high efficiency models would take less than 12 months to complete and that implementation in production would be a rapid process. With modern production methods retooling is often not required to produce modified products; however, the timeframe set out in the scenarios above would allow industry several years to adapt their production and stocks to comply with the requirements.

4.3 Energy Saving Potential

As more energy-efficient household refrigerating appliances are sold into the market each year, the fleet average efficiency improves. The effect of the three illustrative policy scenarios on the total energy consumption across the EU-27 relative to the BAU scenario is shown in the figure below.

[10] Highest Energy Labelling Class (HELC). Illustrative new next highest classes are represented with sub-scripts in this table.

Figure 4-1: Energy Savings Potential for Household Refrigerating Appliances



The table below presents the difference between the projected energy consumption for household refrigerating appliances for the three illustrative policy scenarios compared with the BAU scenario.

Table 4-4: Projected Annual Energy Savings to 2030, Scenarios 1-3, Household Refrigerating Appliances

Scenarios Modelled[11]	2015 (TWh/yr)	2020 (TWh/yr)	2025 (TWh/yr)	2030 (TWh/yr)
Scenario 1	0.00	1.46	3.79	5.36
Scenario 2	0.00	2.33	7.48	11.44
Scenario 3	0.00	3.42	11.48	17.99

[11] A more complete description of the three scenarios can be found in Table 4-3.

5 Additional Issues

In line with the framework directives, the reviews must, respectively, assess potential future minimum performance requirements and potential reclassification of labelling categories in light of technological progress. Above we have provided three illustrative policy scenarios in support of this. Further, implementing measures often require additional issues to be assessed in connection with the review. Finally, it may be that some issues have come to light since the development of the implementing measure and while not specified, could be relevant to include in a review. Below we consider both types of issues.

5.1 Additional Issues Required by the Implementing Measures

Both the ecodesign and energy labelling regulation require reviews to assess verification tolerances and the possibilities for removing or reducing the values of existing correction factors. In addition the inclusion of wine storage appliances must be assessed for the ecodesign implementing measure. While important to address in the review we do not discuss verification tolerances here.

5.1.1 Assess the Possibilities for Removing or Reducing Existing Correction Factors

Correction factors provide an allowance for additional energy consumption in the reference energy consumption used to calculate the EEI. There are three main types of such correction factors: for frost free appliances, for climate class (tropical and subtropical appliances), and for built-in appliances. The table below presents the correction factors that appear in both the ecodesign and energy labelling regulations. In addition to the correction factors specified in the table, an allowance of an extra 50 kWh/year is also made for any model with a chiller compartment ≥15 litres capacity.

Table 5-1: Correction Factors Applied to Household Refrigerating Appliances

Distinction	Correction Factor	Conditions
Frost-free	1.2	For frost-free frozen-food storage compartments
	1	Otherwise
Climate class	1.2	For T class (tropical) appliances
	1.1	For ST class (subtropical) appliances
	1	Otherwise
Built-in	1.2	For built-in appliances under 58 cm in width
	1	Otherwise

In effect models, to which a correction factor can be applied, are permitted to use more energy than their more standard counterparts on the basis that they provide more service or a different service to the consumer which justify such additional energy consumption. Correction factors can make a substantial difference to an appliance's EEI rating. For example, for a typical refrigerator-freezer applying the frost-free correction factor leads to a 9% improvement in the EEI, adding the built-in factor creates a 17% improvement in EEI and adding in the Tropical climate class adjustment leads to a 26% improvement in EEI. This means that while the overall energy consumption of e.g., a frost free model is greater than the standard counterpart, the labelling class will signal that the product is equally energy efficient.

This may give manufacturers an additional incentive to select features that are associated with correction factors, rather than the development and incorporation of (new) energy savings technologies.

A recent study published by the UK Department for Environment, Food and Rural Affairs (Defra), found that the frost-free correction factor should be reduced and the climate class, built-in and chill compartment factors should be removed.[12] The Defra study quantified the energy savings potential of removing correction factors for the UK. It found the savings would be approximately 0.29 TWh per year by 2030; which when scaled up to the EU, would equate to about 4.56 TWh.

5.1.2 Scope of Coverage: Ecodesign Requirements for Wine Storage Appliances

As noted above, the ecodesign implementing measure also required the Commission to assess the need to adopt specific ecodesign requirements for wine storage appliances by August 2011. While delayed, the assessment is now included as a separate work-stream under the new ecodesign working plan. This suggests that wine coolers will be subject to a full preparatory study. It would be worth considering whether wine storage appliances are best regulated separately and if not whether they might be assessed within the context of a revision study for household refrigeration appliances as a whole on the basis that this latter option would reduce the amount of resources required. In this context it might be worthwhile examining the practices of other jurisdictions such as the United States[13] and Canada.[14] We have not assessed the additional energy savings potential for wine storage appliances. At present, they remain a luxury item and we would therefore not expect to have a high level of household penetration, like other refrigerating appliances. The display aspect of wine storage appliances requiring at least a glass door means that they are, all other things being equal, less efficient than other household refrigerating appliances.

5.2 Additional Issues Not Anticipated in the Implementing Measures

5.2.1 Performance Requirements that Increase More than Proportionally with Volume

At present the implementation measures on household refrigerating appliances address the energy performance but not the overall energy consumption of models. Indeed, the correction factors referred to above, give an allowance for certain types of service which result in additional energy consumption. There is little in the current implementing measures to help steer the consumer towards *smaller*, as well as more efficient models. The only aspect of the current implementing measures that help steer the consumer towards a model that uses less energy is the inclusion of annual energy consumption on the energy label. It would be desirable to consider whether it is now time to introduce performance requirements that increase *more than proportionally* with volume (as recommended in the Cold II study). Again, in this context it would be worth investigating the practices of other jurisdictions. It appears for example that Australia has changed energy labelling requirements in this direction.

[12] "Assessment of the applicability of current EC correction factors and tolerance levels for domestic refrigerating appliances, Final Report Version 1.0", Intertek, A research report completed for the Department for Environment, Food and Rural Affairs, London, UK. August 2012
[13] US DOE website for residential refrigeration equipment: http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/43
[14] Natural Resources Canada website for residential refrigeration equipment, including wine chillers: http://oee.nrcan.gc.ca/regulations/products/12831

5.2.2 New IEC Test Method

The IEC will shortly adopt a revised version of its test method (IEC 62552). The new test method will incorporate a number of changes in relation to the previous IEC test method which together mean that the new test method will:

- Better capture the actual energy performance of refrigerating appliances that in practice operate under varying ambient temperatures and variable loads;
- Enhance the reproducibility of test results (*i.e.*, that different labs testing the same appliance should produce the same test result);
- Create a globally acceptable test procedure that can be adopted by all the major economies and hence facilitate direct comparison of energy performance tests results and policy thresholds (which is currently almost impossible due to the differences in test procedures around the world); and
- Capture controls that impact the actual energy performance and are not detectable under the current EU test method (EN 153).

The European regulations for household refrigerating appliances are tested under EN 153 which is aligned with the existing version of the IEC test method. The implications of the new IEC test method for a revision to the energy labelling and ecodesign implementing measures should be considered as part of the review.

5.2.3 Allowances for Alternative Refrigerants with a Lower Global Warming Potential

Under the new ecodesign regulation for air conditioners and comfort fans (Regulation EU No 206/2012 the Commission, models which use alternative refrigerants with a lower global warming potential are given an allowance which mean that they can use more energy than comparable standard models and retain the same EEI. The lessons of this emerging practice and its potential implications for the revised household refrigeration implementing measures should be considered in the review.

Annex B. External Power Supplies

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1 Introduction and Context

In common with the other six annexes, this annex starts by setting out the timetable and scope of the upcoming reviews. It then sets out the scope of the existing implementing measures. Having provided this context, a BAU energy consumption scenario is developed. Next an assessment of technology developments is made and this is used to develop a set of illustrative policy scenarios on the basis of which a range of energy savings potentials are defined. Finally, a set of issues of relevance in the context of upcoming reviews is outlined.

1.1 Timetable and Scope of the Upcoming Review

Commission Regulation (EC) No 278/2009 of 6 April 2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for no-load condition electric power consumption and average active efficiency of external power supplies (EPS)[1] entered into force on 26 April 2009. The implementing measure states that no later than four years after the entry into force (i.e., 26 April 2013), the Commission must review the regulation in light of technological progress and present the result of this review to the Consultation Forum. No additional issues to be integrated into the review are specified.

There is no energy labelling Regulation for EPS.

1.2 Scope of Coverage of the Implementing Measure

Article 1 of the regulation on EPS introduces the scope of the regulation by stating that the requirements are related to electric power consumption in no-load condition and average active efficiency of EPS.

Article 2 defines EPS in some detail as devices that meet the following criteria:

(a) it is designed to convert alternating current (AC) power input from the mains power source input into lower voltage direct current (DC) or AC output;
(b) it is able to convert to only one DC or AC output voltage at a time;
(c) it is intended to be used with a separate device that constitutes the primary load;
(d) it is contained in a physical enclosure separate from the device that constitutes the primary load;
(e) it is connected to the device that constitutes the primary load via a removable or hard-wired male/-female electrical connection, cable, cord or other wiring;
(f) it has nameplate output power not exceeding 250 Watts;
(g) it is intended for use with electrical and electronic household and office equipment as referred to in Article 2(1) of Regulation (EC) No 1275/2008;[2]

[1] Commission Regulation (EC) No 278/2009 of 6 April 2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for no-load condition electric power consumption and average active efficiency of external power supplies, OJ L 93, 7.4.2009, p. 3

[2] Article 2(1) of Regulation (EC) No. 1275/2008: Article 2(1). 'electrical and electronic household and office equipment' (hereafter referred to as 'equipment'), means any energy using product which: (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; (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, also when marketed for non-household or non-office use; OJ L 339, 17.12.2008, p. 45.

The second part of Article 1 names those products that are excluded from the scope of the regulation:

(a) voltage converters;
(b) uninterruptible power supplies;
(c) battery chargers;
(d) halogen lighting converters;
(e) external power supplies for medical devices;
(f) external power supplies placed on the market no later than 30 June 2015 as a service part or spare part for an identical external power supply which was placed on the market not later than one year after this Regulation (EC No 278/2009 of 6 April 2009) has come into force, under the condition that the service part or spare part, or its packaging, clearly indicates the primary load product(s) for which the spare part or service part is intended to be used with.

2 Market Projection

2.1 Installed Stock and Annual Sales

The EPS market is projected to grow in the coming years, adopting new power architectures, smaller form factors, more efficient designs and improved power management technology. The applications that will contribute to this growth include communications, computers, consumer electronics, and many other products. The consumer market is offering new applications that were not considered in the 2007 preparatory study[3], such as tablet computers, smart phones, and gaming devices, that require higher wattage EPS than simple mobile phones. The communications segment is projected to maintain the largest unit market and will be dominated by the mobile phone industry, which uses inexpensive, commoditised low-wattage power supplies. The largest number of EPS units sold is presently, and is projected to be in the future, the lower wattage categories.

2.2 EPS Stock and Sales Projection

In order to prepare an estimate the energy savings potential that remains in the EPS product group, a simple European market model was developed. This model relies primarily on data published recently by the US DOE on the North American EPS market. From that detailed market study, the market assessment for Europe is scaled taking into account the relative GDP, population and the Universal Charging Solution Memorandum of Understanding between the European Commission and Digital Europe. The purpose of the universal charging solution (UCS) memorandum of understanding (MOU) is to improve user convenience and improve material resource efficiency by reducing the number of chargers for portable electronics and hand-held devices through improving their compatibility. The agreement expired at the end of 2012. However, to facilitate the modelling of the BAU scenario, it is has been assumed that the agreement will be extended.

The US DOE market assessment was used because it offered detailed data and forecasts of the volume, wattage and product trends for the North American market, which has a similar product offering to that of Europe. The DOE analysis was adapted by taking the six highest volume products[4] from the shipment forecast and scaling them according to GDP and population.

- GDP adjustment – GDP per capita is higher for a US citizen when compared to a European citizen. To account for this, the US EPS shipments were scaled down by the same ratio of GDP per capita, reflecting the wealth of individuals and their ability to purchase products that use EPSs. The ratio used to adjust shipments was 1.00::1.47 for Europe::US.

- Population adjustment – the population of Europe is larger than the US, so there are more potential consumers of products that use EPS, necessitating an increase in the scalar. The ratio of population adjustment was 1.62::1.00 for Europe::US.

The US DOE market assessment was scaled to approximate European shipments by combining these two adjustment factors into one scalar that estimates European shipments to be 1.102, which resulted in a shipment projection that is larger than the US market.

[3] Preparatory Studies for Eco-design Requirements of EuPs, Lot 7: Battery chargers & external power supplies. BIOS, January 2007.
[4] These top six products modelled represent 44% of total EPS shipments in the US market.

The European shipments were then projected to grow at the same rate as the EU-27 population, which has an annual growth rate of 0.29% in 2010 gradually reducing to 0.12% in 2030. The projection assumes no change in the mix of products, nor in any relative proportions of products sold.

Table 2-1: Shipments of External Power Supplies in the EU-27 (millions of units)

EPS Product Applications	2010	2015	2020	2025	2030
Mobile Phones	52	53	53	54	54
Notebooks	31	31	32	32	32
Smartphones	23	23	23	24	24
Video Game Consoles	21	22	22	22	22
LAN Equipment	21	21	21	21	21
Answering Machines	19	19	19	19	19
Total EU-27, top six products	166	169	171	172	173
Total, scaled to all EPS models	381	387	391	395	397

Table 2-2 presents the stock of EPS in Europe, based on the aforementioned shipments and compounding those shipments taking into account the operating lifetime of the products. Please note that for mobile phones, the typical lifetime is 2 years, however the stock model assumes we created assumes that EPS will last four years (equivalent to the lifetime of two phones) as a result of the UCS MOU. The assumed average product lifetimes used in the stock model are:

Mobile Phones: 4.0 years (adjusted from 2 years due to UCS)
Notebooks: 3.3 years
Smartphones: 4.0 years
Video Game Consoles: 5.0 years
LAN Equipment: 4.0 years
Answering Machines: 5.2 years

The bottom row of the following table scales up the stock estimates of these six high volume products (representing 44% of the market) to the total inventory of EPSs in Europe.

Table 2-2: Stock of External Power Supplies in the EU-27 (millions of units)

Product	2010	2015	2020	2025	2030
Mobile Phones	233	237	240	242	244
Notebooks	118	119	121	122	123
Smartphones	102	104	105	106	107
Video Game Consoles	116	118	119	120	121
LAN Equipment	92	93	95	96	96
Answering Machines	106	107	109	110	111
Total EU-27, top six products	766	778	788	796	802
Total, scaled to all EPS models	1,758	1,784	1,807	1,826	1,840

The estimated stock of EPS in 2010 was approximately 1.76 billion units. This stock estimate is lower than the preparatory study estimate of 2.0 billion units in 2005, however the preparatory study[5] estimate included battery chargers as well as EPS, so although these two figures are not directly comparable, the above estimates for EPS excluding battery chargers is reasonable compared to the preparatory study projection.

Eurostat estimates that in 2010, there were 208 million households across the EU-27, so this estimate of 1.76 billion EPSs equates to 8.4 EPS per household, or roughly 3.5 EPS per person. That number of EPS per household and per capita is consistent with other national market studies such as Australia.[6]

2.3 Projected Energy Consumption of EPS in Europe

Due to the fact that the regulatory requirements for EPS are generally harmonised between Europe and the US, the energy consumption estimation for the European stock of EPS is based on the recent (March 2012) DOE analysis of the North American market. The DOE analysis takes into account nine different types of EPS which span the broad range of EPS products (see Table 2-3) and estimates the relative stock volume and average kilowatt hours per year of electricity consumption for the typical usage profiles of these product groups. These nine product classes are then combined to determine the weighted-average energy consumption in kWh/year across all EPS models used in the US. As shown in the table below, the average annual energy consumption is 4.16 kilowatt-hours per year.

[5] Preparatory Studies for Eco-design Requirements of EuPs, Lot 7: Battery chargers & external power supplies. BIOS, January 2007, p.II-5.
[6] See the preparatory study.

Table 2-3: US DOE Market Analysis of Stock-Weighted Power Consumption

Product Class	Stock Volume	kWh/year per EPS
EPS Product Class: A1, Rep Unit A	138,409,533	2.06
EPS Product Class: A1, Rep Unit B	64,299,147	7.37
EPS Product Class: A1, Rep Unit C	34,137,868	6.20
EPS Product Class: A1, Rep Unit D	6,650,258	10.89
EPS Product Class: A2	104,007,663	1.58
EPS Product Class: A3	15,495,255	8.34
EPS Product Class: A4	3,344,109	2.48
EPS Product Class: Multiple Voltage	1,919,133	97.34
EPS Product Class: High Power	15,000	145.69
TOTAL:	368,277,965	4.16

By applying this stock-weighted average energy consumption for all EPS and to the earlier estimate of EU-27 stock, it is estimated that all EPS in Europe consume approximately 7.43 TWh of electricity. The table below presents the projected business as usual (BAU) energy consumption of EPS in Europe, which assumes no further updates to the ecodesign regulation.

Table 2-4: Stock and Energy Consumption of External Power Supplies in the EU-27

	2015	2020	2025	2030
Stock of all EPS models (millions)	1,784	1,807	1,826	1,840
Total energy consumption (TWh)	7.43	7.52	7.60	7.66

The energy consumption for the BAU scenario is reflective of the point in time when the 2009 ecodesign regulation is fully phased in (Tier 2 took effect in April 2011). The estimate of European EPS energy consumption aligns reasonably well with that published in the preparatory study. In that study, it was estimated that there were 2 billion EPS and battery chargers installed, and that they consumed 17.3 TWh in 2005. It was then estimated that the 2009 implementing measure would reduce the power consumption of EPSs and Battery Chargers by approximately 9.0 TWh/year by 2020 compared with a BAU case. If 9.0 TWh is deducted from 17.3 TWh, the preparatory study is projecting an estimated 8.3 TWh of consumption under the regulatory measures by 2020. This estimate is slightly higher than the estimate presented in Table 2-4, however the 17.3 TWh estimate includes the energy consumption of battery chargers whereas the values in Table 2-4 are only EPS. Thus, the approach of scaling European energy consumption from the weighted average of EPSs in North America produces a result that seems reasonable.

3 Technology Assessment

The technologies used in EPS have improved significantly over the last decade. A movement from simple transformers to electronic architecture, mainly driven by copper and iron laminate cost as well as weight and size savings, was the first step. Electronic architecture enabled the design of a single product to have a wide range of input voltages enabling the mass production of a small number of models, which could then be operated on different voltages and frequencies around the world. This has resulted in improvements in the utility and portability of the products while simultaneously improving efficiency, reducing size and lowering cost. There is little brand differentiation in this market.

There are further technological improvements that could be exploited to bring additional reductions in energy consumption while not compromising product performance. Advances in power semiconductor technology have contributed to the largest performance improvements, followed by gains made in magnetic materials and capacitors. In addition, design engineers are encouraged to reduce size without compromising performance, which leads to incremental improvements in every aspect of the design, both electrical and mechanical.

Some of the technology options being used to improve the efficiency of EPS today are briefly identified below (US DOE, 2012):

- **Improved Transformers**: in line-frequency EPS products, the transformer has the largest effect on efficiency. Transformer efficiency can be improved by upgrading the transformer cores and windings to lower-loss material or adding extra material.

- **Switched-Mode Power Supply**: line-frequency EPS may use linear regulators to maintain a constant output voltage. By using a switched-mode circuit architecture, a designer can limit losses associated with both the transformer and the regulator.

- **Low-Power Integrated Circuits**: EPS efficiency can be further improved by incorporating low-power integrated circuit (IC) controllers into the design. These controllers can switch more efficiently in active mode and reduce power consumption in no-load mode. For instance, the IC can turn off its start-up current (sourced from the primary side of the power supply) once the output voltage is stable. In addition, when in no-load mode, the IC can turn off the switching transistor for extended periods of time to save energy (termed "cycle-skipping").

- **Schottky Diodes and Synchronous Rectification**: both line-frequency EPS and the switched-mode EPSs use diodes to rectify output voltage. Schottky diodes and synchronous rectification can replace standard diodes to reduce rectification losses, which are increasingly significant at low voltage. Schottky diodes have a voltage drop of 0.3– 0.4 volts, compared to approximately 0.6 volts for standard diodes. Synchronous rectification (used primarily in switched-mode EPS) further reduces losses by substituting transistors for diodes. The voltage drop across the drain-to-source resistance of transistor is much lower than that across even a Schottky diode, leading to lower overall losses from the output rectifier.

- **Low-Loss Transistors**: the switching transistor dissipates energy due to its drain-to-source resistance (R_{DS_ON}) when the current flows through the transistor to the transformer. Using transistors with low R_{DS_ON} can reduce this loss.

- **Resonant Switching**: in addition to reducing the R_{DS_ON} of the transistor, power consumption can be reduced further through the use of an IC controller decreasing switching transients through zero-voltage or zero-current switching. The power consumption of the transistor is influenced by the voltage across the R_{DS_ON} and the current flowing through it. An integrated circuit (IC) can control the switching to minimize that voltage or current and save energy, although some parts in addition to the IC may also be needed.

- **Resonant ("Lossless") Snubbers**: in a switched-mode EPS, a common snubber protects the switching transistor from the high voltage spike that occurs after a transistor turns off by dissipating that power as heat. A resonant or lossless snubber recycles that energy rather than dissipating it.

In all EPS designs, one of the most important constraints is the thermal performance because excessive generation of heat can compromise the service life of the components. For these products, it is important to develop innovative and creative mechanical designs that eliminate hot spots and ensure the best possible air flow around the primary heat-emitting components. Combining the best of proven design technologies with creative mechanical design has led recently to the introduction of power supplies that can reach up to 95% efficiency, a figure thought impossible only a few years ago.[7]

[7] "Drive Your AC-DC Power-Supply Efficiency Even Higher", by Peter Blyth, Electronic design magazine; February 11, 2011. http://electronicdesign.com/content/topic/drive-your-ac-dc-power-supply-efficiency-even-higher/catpath/components

4 Energy Savings Potential

The purpose of this section is to provide an estimate of the potential for additional energy savings from revised regulations in the context of different levels of ambition. After briefly setting out the requirements of existing regulations, a high, medium and low ambition illustrative policy scenario is presented based on the preceding assessment of technological development. These policy scenarios provide an indicative estimate of the energy savings potential, based on updated regulatory requirements.

4.1 Existing Regulation

The Ecodesign minimum energy efficiency performance requirements issued in regulation 278/2009 established a level that was consistent with the now dormant ENERGY STAR version 2.0. The following table presents these requirements that became effective in April 2010 (Tier 1) and April 2011 (Tier 2). For Tier 2, the regulation established specific (both no-load and active mode) requirements for low-voltage EPS, which are defined in Article 2 of the regulation as “an external power supply with a nameplate output voltage of less than 6 volts and a nameplate output current greater than or equal to 550 milliamperes”.

Table 4-1: Existing Ecodesign Regulation for External Power Supplies

Tier 1 Ecodesign Regulations Effective 26 April 2010			
No-load Power (W)	**Average Active Efficiency (%)**		
Shall not exceed 0.50W	$P_o < 1.0$ W	$0.5 \times P_o$	
	$1.0 \text{ W} \leq P_o \leq 51.0$ W	$0.090 \times \ln(P_o) + 0.5$	
	$P_o > 51.0$ W	0.85	
Tier 2 Ecodesign Regulations Effective 26 April 2011			
No-load Power (not exceed Wattage)			
	AC-AC EPS, except low voltage EPS	AC-DC EPS except low voltage EPS	Low Voltage EPS
$P_o \leq 51.0$ W	0.50 W	0.30 W	0.30 W
$P_o > 51.0$ W	0.50 W	0.50 W	n/a
Average Active Efficiency (not less than %)			
	AC-AC and AC-DC EPS, except low voltage EPS		Low Voltage EPS
$P_o \leq 1.0$ W	$0.480 \times P_o + 0.140$		$0.497 \times P_o + 0.067$
$1.0 \text{ W} < P_o \leq 51.0$ W	$0.063 \times \ln(P_o) + 0.622$		$0.075 \times \ln(P_o) + 0.561$
$P_o > 51.0$ W	0.870		0.860

4.2 Voluntary EU and Mandatory US Energy Performance Requirements Under Development

The US DOE has proposed revised efficiency requirements for EPS. These include products that are not included in the existing EU regulations (see section 5.2.1 which discusses the scope of the EU regulations). In Europe, the JRC has been working to revise an existing Code of Conduct (CoC)[8] for the energy performance of EPS. The latter looks set to contain levels very similar to those proposed by the US DOE and the two developments may well result in harmonised efficiency levels across jurisdictions.[9] However, while the DOE standards will be mandatory, the JRC CoC is a voluntary measure. In the two tables that follow, the DOE proposals as of March 2012 and the JRC draft CoC as of September 2012 are set out in turn.

Table 4-2: US DOE Proposed Regulations for External Power Supplies, March 2012

No-load Power (not to exceed Wattage)		
Nameplate Output Power (P_{no})	Standard Voltage	Low Voltage[10]
$P_{no} < 50$ W	≤ 0.100 W	≤ 0.100 W
50 W < $P_{no} \leq 250$ W	≤ 0.210 W	≤ 0.210 W
250 W < P_{no}	≤ 0.500 W	≤ 0.500 W
Average Active Efficiency (not less than %)		
Nameplate Output Power (P_{no})	Standard Voltage	Low Voltage
$P_{no} \leq 1.0$ W	$\geq 0.5 \times P_{no} + 0.16$	$\geq 0.517 \times P_{no} + 0.087$
1.0 W < $P_{no} \leq 49.0$ W	$\geq 0.071 \times \ln(P_{no}) - 0.0014 \times P_{no} + 0.67$	$\geq 0.0834 \times \ln(P_{no}) - 0.0014 \times P_{no} + 0.609$
49 W < $P_{no} \leq 250$ W	≥ 0.880	≥ 0.870
250 W < P_{no}	0.875	0.875

The draft European proposals would entail measuring energy performance in two different ways. Models would have to meet both of these requirements:

1. Development of a four point average efficiency, measured at 25%, 50%, 75% and 100% of rated output current; and
2. Measurement of the efficiency of the EPS at 10% of rated output current.

[8] European Commission, Directorate-General JRC, Joint Research Centre, Institute for Energy, Renewable Energy Unit, Ispra, 8 April 2009: "Code of Conduct on Energy Efficiency of External Power Supplies: Version 4"; http://www.phihong.com/assets/pdf/Code_of_Conduct__EPS_Ver4__March_09.pdf

[9] A CoC meeting was held in Ispra on the 13th September 2012 and it focused on discussing possible new efficiency levels (tiers) for a new version of the CoC and dates of entry into force. There is agreement on the effective dates of the two tier levels under consideration – Tier 1 will take effect on 1 January 2014 and Tier 2 will take effect on 1 January 2016. It was in the meeting that the new CoC should be more ambitious and/or come into effect before other influential mandatory measures (i.e., a revision of the ecodesign regulation or the implementation of US DOE requirements).

[10] The requirements for low-voltage EPS apply to models that have an output voltage of less than 6 volts and a nameplate output current greater than or equal to 550 milliamperes.

Table 4-3: Draft JRC Code of Conduct for External Power Supplies, September 2012

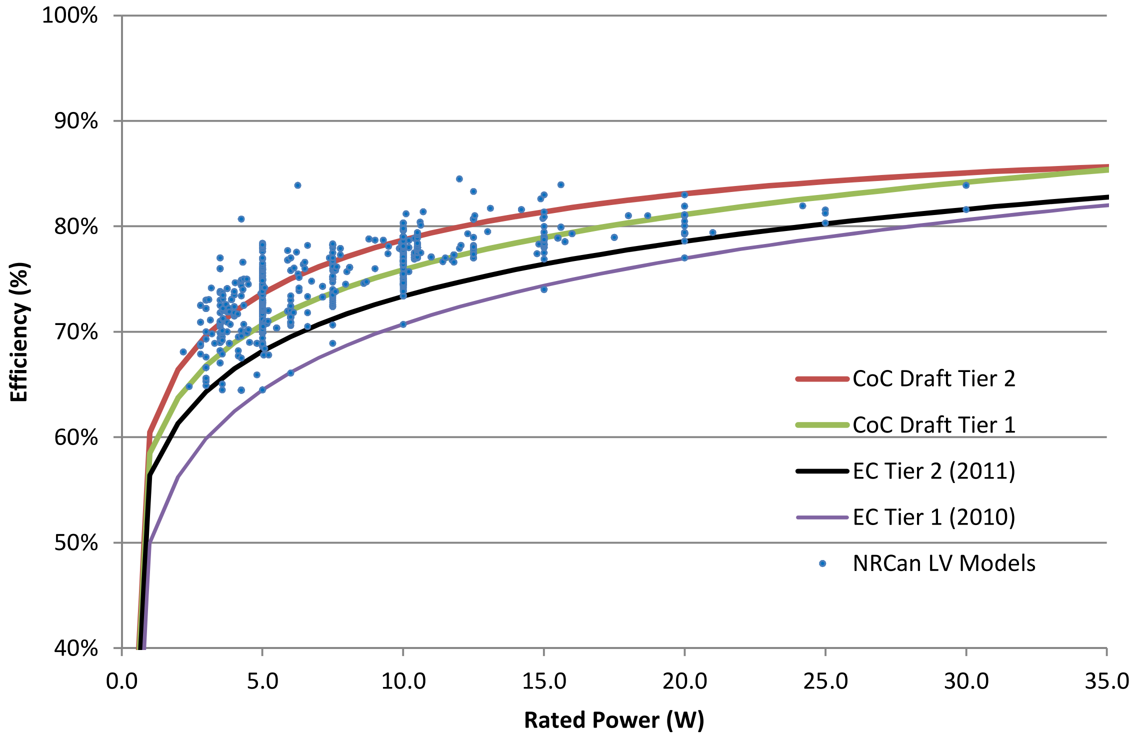
No-Load Power (not exceed Wattage)			
	Rated Output Power (P_{no})	Tier 1	Tier 2
	$0.3\ W \leq P_{no} < 49\ W$	$\leq 0.150\ W$	$\leq 0.075\ W$
	$49\ W \leq P_{no} < 250\ W$	$\leq 0.250\ W$	$\leq 0.150\ W$
	Mobile handheld battery driven and < 8 W	$\leq 0.075\ W$	$\leq 0.075\ W$
Average Active Efficiency (not less than %)			
Excluding low-voltage four-point avg. Efficiency	**Rated Output Power (P_{no})**	**Tier 1**	**Tier 2**
	$P_{no} \leq 1.0\ W$	$\geq 0.5 \times P_{no} + 0.145$	$\geq 0.5 \times P_{no} + 0.16$
	$1.0\ W < P_{no} \leq 49.0\ W$	$\geq 0.0626 \times \ln(P_{no}) + 0.645$	$\geq 0.071 \times \ln(P_{no}) - 0.0014 \times P_{no} + 0.670$
	$49\ W < P_{no} \leq 250\ W$	≥ 0.890	≥ 0.890
Excluding low-voltage 10% load efficiency	**Rated Output Power (P_{no})**	**Tier 1**	**Tier 2**
	$P_{no} \leq 1.0\ W$	$\geq 0.5 \times P_{no} + 0.045$	$\geq 0.5 \times P_{no} + 0.060$
	$1.0\ W < P_{no} \leq 49.0\ W$	$\geq 0.0626 \times \ln(P_{no}) + 0.545$	$\geq 0.071 \times \ln(P_{no}) - 0.0014 \times P_{no} + 0.570$
	$49\ W < P_{no} \leq 250\ W$	≥ 0.790	≥ 0.790
Low-voltage four-point avg. Efficiency	**Rated Output Power (P_{no})**	**Tier 1**	**Tier 2**
	$P_{no} \leq 1.0\ W$	$\geq 0.5 \times P_{no} + 0.085$	$\geq 0.517 \times P_{no} + 0.087$
	$1.0\ W < P_{no} \leq 49.0\ W$	$\geq 0.0755 \times \ln(P_{no}) + 0.585$	$\geq 0.0834 \times \ln(P_{no}) - 0.0014 \times P_{no} + 0.609$
	$49\ W < P_{no} \leq 250\ W$	≥ 0.880	≥ 0.880
Low-voltage 10% load efficiency	**Rated Output Power (P_{no})**	**Tier 1**	**Tier 2**
	$P_{no} \leq 1.0\ W$	$\geq 0.5 \times P_{no}$	$\geq 0.517 \times P_{no}$
	$1.0\ W < P_{no} \leq 49.0\ W$	$\geq 0.0755 \times \ln(P_{no}) + 0.485$	$\geq 0.0834 \times \ln(P_{no}) - 0.0014 \times P_{no} + 0.509$
	$49\ W < P_{no} \leq 250\ W$	≥ 0.780	≥ 0.780

Figures 4.1 and 4.2 illustrate how the draft JRC CoC might affect the market and how this relates to the existing EU ecodesign implementing measure. North American EPS performance data was used from published test results of over 6,000 models of EPS. Models from this database that did not comply with current EU regulations were removed. For each compliant model, the efficiency of EPS

tested according to the four point average efficiency value (i.e., 25%, 50%, 75% and 100% of rated current) is shown.[11]

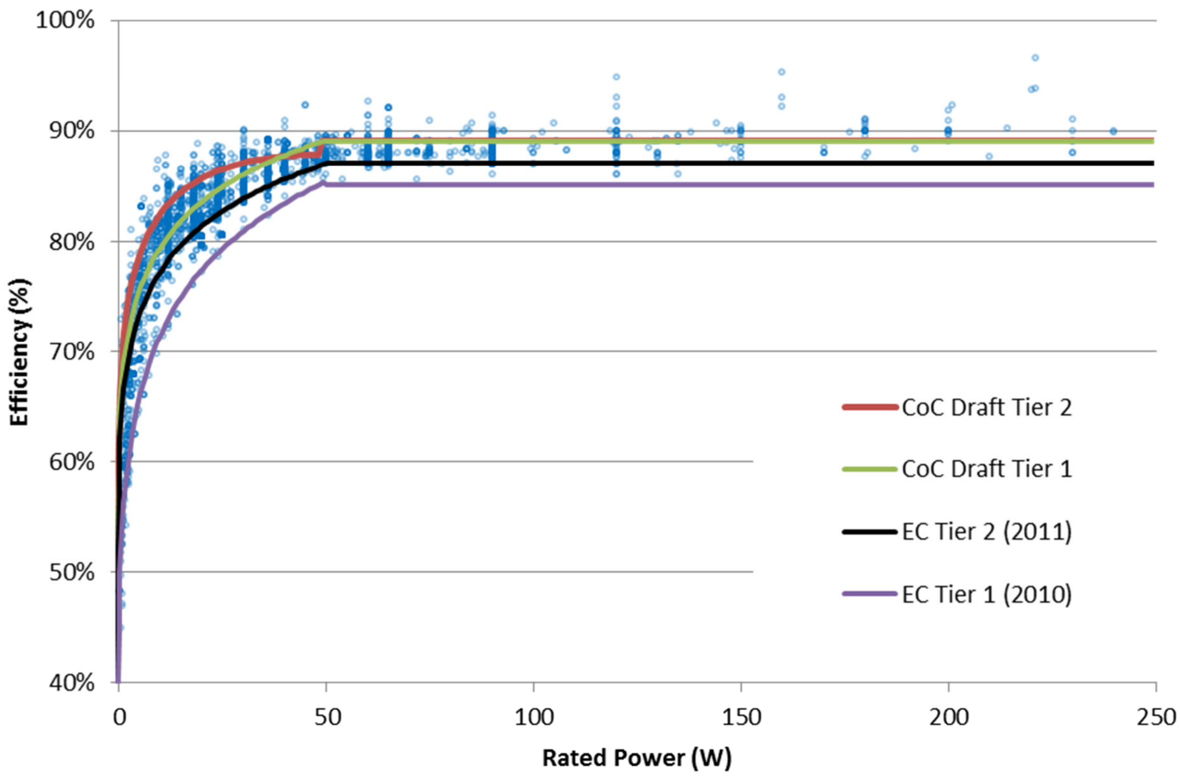
Figure 4-1 presents the scatter plot and MEPS levels for low-voltage models and Figure 4-2 presents all the other units in the database (i.e., all the models that are not low-voltage). From the figure below, it can be seen that all the products examined already comply with EC 278/2009 Tier 1 (2010) and almost all at EC 278/2009 Tier 2 (2011). In fact most products already reach CoC draft Tier 1, and around half reach Tier 2.

Figure 4-1. Low-Voltage External Power Supplies and Efficiency Curves



[11] It should be noted that the draft CoC also contains a "Minimum Average Efficiency in Active Mode at 10% of load of full rated output current" which requires the efficiency to meet or exceed a certain value at 10% of rated output. This additional requirement is not analysed in this study because the performance of these products at that loading point is not known.

Figure 4-2. Standard Voltage External Power Supplies and Efficiency Curves



To put the efficiency requirements from the draft CoC Tier 1 and Tier 2 levels into perspective, the following table presents the requirements for active mode and no-load power consumption for a few common wattages. The proposed US DOE values and the best models from the North American dataset are also presented, for comparative purposes.

Table 4-4: Comparison of MEPS Requirements for Selected EPS Power Ratings

Rating (P_{no})	EC No 278/2009 Tier 2	CoC Draft Tier 1	CoC Draft Tier 2	US DOE 2012 Proposal	Best of North American Database
	Active Mode Efficiency				
$1W_{low\ voltage}$	56.4 %	58.5%	60.4%	60.4 %	--
$1W_{standard\ voltage}$	62.0 %	64.5%	66.0%	66.0 %	70.9%[B]
$5W_{low\ voltage}$	68.2 %	70.6%	73.6%	73.6 %	78.4%
$5W_{standard\ voltage}$	72.3 %	74.6%	77.7%	77.7 %	83.1%[B]
$20W_{standard\ voltage}$	81.0 %	83.3%	85.5%	85.5 %	87.0%
$60W_{standard\ voltage}$	87.0 %	89.0 %	89.0 %	88.0 %	92.6%
	No-Load Power Consumption				
< 50 W	≤ 0.3W / 0.15W	≤ 0.15W[A]	≤ 0.075W[A]	≤ 0.100W	0.03W[C]
50W – 250W	≤ 0.5W	≤ 0.25W[A]	≤ 0.15W[A]	≤ 0.210W	0.06W[D]

[A] The requirements in the draft CoC Tier levels are for <49W and then ≥49W
[B] The models considered are within 10% of the rated power (e.g., 0.9 – 1.1W for the 1.0W model)
[C] The minimum no-load power selected from models rated between 45-49W
[D] The minimum no-load power selected is from models rated between 200-250W

4.3 Illustrative Policy Scenarios

To determine the energy savings potential for EPS, three illustrative policy scenarios were developed with updates to the ecodesign regulations. These policy scenarios provide an indicative estimate of energy savings, based on technology improvements for this product group. The three scenarios have differing levels of ambition, with Scenario 2 being the mid-range scenario. The three scenarios were based on the JRC draft CoC on Energy Efficiency of External Power Supplies [12] under development in late 2012. [13] The assumptions about the level and timing of new ecodesign and labelling requirements in the three scenarios are shown in the table below.

[12] DRAFT Code of Conduct on Energy Efficiency of External Power Supplies, Version 5, the European Commission, Directorate-General JRC, Joint Research Centre, Institute for Energy, Renewable Energy Unit; 19 September 2012.
[13] Note that due to a lack of data, this paper did not consider the CoC's 10% loading efficiency requirement or the more stringent no-load power requirements for mobile handheld battery driven devices rated less than 8 watts.

Table 4-5: Three Illustrative Policy Scenarios for External Power Supplies

Scenario	Tier 1	Tier 2
1	CoC Tier 1 from 2015 (see Table 4-3)	CoC Tier 2 from 2016 (see Table 4-3)
2	CoC Tier 1 from 2014 (see Table 4-3)	Modified CoC Tier 2 (Tier 2+) from 2016, no-load ÷ 1.025; efficiency x 1.025
3	Modified CoC Tier 1 (Tier 1+) from 2014 no-load ÷ 1.025; efficiency x 1.025	Modified CoC Tier 2 (Tier 2++) from 2016, no-load ÷ 1.05; efficiency x 1.05

For Scenario 1, the CoC Tier 1 level is introduced in 2015 and the CoC Tier 2 level in 2016. These years were selected on the basis that the previous ecodesign requirements were introduced in 2010 and 2011. Thus, the timing associated with the two tiers is based on a similar magnitude of step increases and timing of the existing ecodesign and energy labelling requirements.

For Scenario 2, the CoC Tier 1 level is introduced in 2014 (i.e., one year earlier) and a slightly more ambitious requirement based on the CoC Tier 2 level is introduced in 2016. This two year gap is created between the two tiers because the level of ambition for the Tier 2 requirement is more stringent than the CoC Tier 2 level. The requirements – both the no-load power and the average active efficiency were increased by 2.5%. The no-load maximum power ratings were divided by 1.025 and the average active efficiency percentages were multiplied by 1.025. This has the effect of shifting both requirements, making each slightly more stringent but maintaining the overall shape and timing of the curve that had been developed by the JRC's working group.

For Scenario 3, the schedule of 2014 for Tier 1 and 2016 for Tier 2 is maintained, but the level of ambition is increased for both Tier 1 and Tier 2. The CoC Tier 1 equations are adjusted in exactly the same way that the CoC Tier 2 equations were adjusted for Scenario 2 Tier 2 - both the no-load power and the average active efficiency were increased by 2.5%. The no-load maximum power ratings were divided by 1.025 and the average active efficiency percentages were multiplied by 1.025. At the Tier 2 level, the CoC Tier 2 equations are adjusted by 5% rather than 2.5%, thus maintaining the overall shape of the curves but increasing the level of ambition.

To better visualise the shape and level of ambition of the curves, Figure 4-3 illustrates the normal voltage CoC Tier 1 and modified CoC Tier 1 levels (labelled Tier 1+). Figure 4-4 illustrates the normal voltage CoC Tier 2, and the two modified CoC Tier 2 levels (labelled Tier 2+ and Tier 2++). To demonstrate that these levels are within the performance of today's commercially available products, the background of both plots is a scatter plot of the 4600 models in the North American database that are compliant with the final level of EC No 278/2009.

Figure 4-3. Normal Voltage CoC Tier 1 and Tier 1+ Efficiency Curves

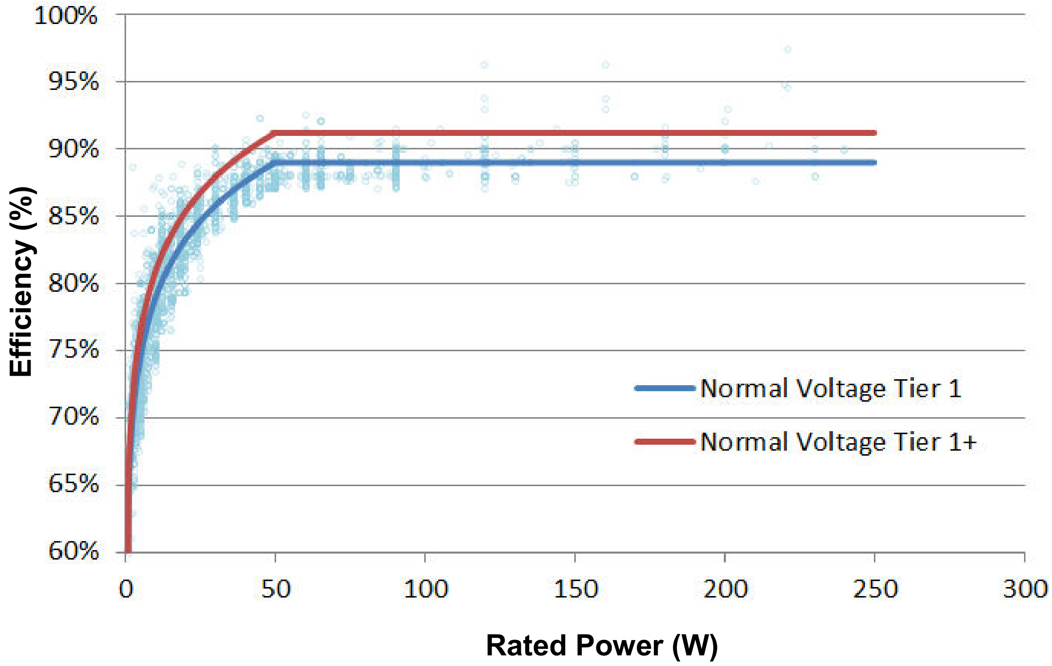
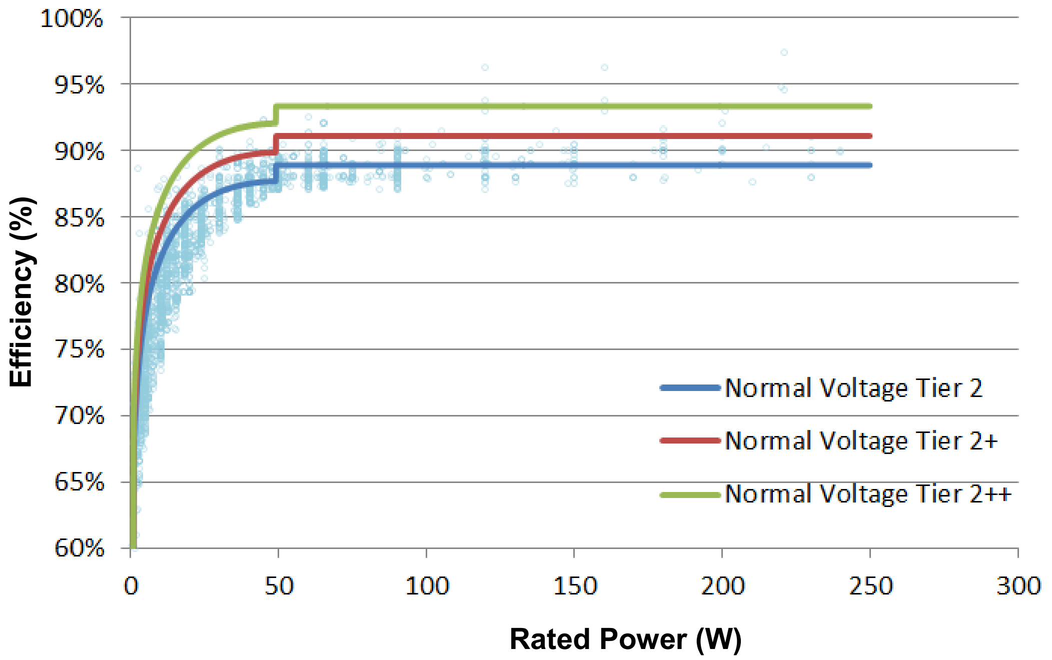


Figure 4-4. Normal Voltage CoC Tier 2, Tier 2+ and Tier 2++ Efficiency Curves



4.4 Energy Savings Potential

An estimate of the energy savings potential from these three scenarios was prepared using the North American database as an indicator of the distribution of efficiencies in the market. Due to the fact that this database is only a model database (i.e., not sales-weighted), the energy-savings potential from this calculation is only an approximation. As a first step, all models that did not comply with the Tier 2 regulation that took effect in April 2011 in Europe (i.e., 278/2009) were removed from the database, leaving approximately 4600 models that are compliant.

The average energy consumption of the models in this database were correlated to the weighted average of the US DOE market assessment average installed stock of 4.16 kWh/year (see section 2.2). Three scenarios were then applied to this database, with any models that failed to meet the new regulation being adjusted to match the minimum requirements of the regulation. A new average annual installed stock energy consumption value was then calculated, and from this value it was possible to estimate the total savings from the scenario for the EU-27.

The table below presents the estimated impact on the kWh/year for the baseline model and the more energy-efficient models. It should be noted that in all instances, there were still designs in the database that met or exceeded the regulatory scenarios being considered in this analysis, although in Scenario 3, Tier 2 there were only 76 designs in the 2012 database that met this requirement.

Table 4-6. Impact on Annual Power Consumption of the Potential Tier Levels

Energy Using Scenario		Average Annual Power Consumption	Number of Compliant Models in 2012 Database
Business As Usual (BAU)		4.164 kWh/yr	n = 4608
Scenario 1	Tier 1 (CoC Tier 1)	3.974 kWh/yr	n = 2214
	Tier 2 (CoC Tier 2)	3.526 kWh/yr	n = 333
Scenario 2	Tier 1 (CoC Tier 1)	3.974 kWh/yr	n = 2214
	Tier 2 (CoC Tier 2+)	3.112 kWh/yr	n = 165
Scenario 3	Tier 1 (CoC Tier 1+)	3.635 kWh/yr	n = 737
	Tier 2 (CoC Tier 2++)	2.629 kWh/yr	n = 76

For Scenario 1, Tier 1, 48% of the models in the 2012 North American database were found to be compliant with the level, thus approximately 52% of the models were subject to redesign to meet the minimum requirements, resulting in energy savings. At the Tier 2 level, approximately 7% of the models would comply and 93% of those in the database would need to be redesigned. The impact on the average annual power consumption is evident, as it reduces by 5% and 15% relative to the BAU at Tier 1 and Tier 2 respectively.

For Scenario 2, the Tier 1 requirement is the same as Scenario 1 Tier 1, however it is brought forward one year. The Tier 2 requirement adopts a modified CoC Tier 2 level, resulting in a more ambitious requirement. For Tier 2, 4% of models in the 2012 database are compliant and the others would require re-design. The impact on the average annual power consumption is slightly greater, with a reduction of 25% relative to the BAU scenario.

In Scenario 3, the Tier 1 requirement and the Tier 2 requirement are both more ambitious than the CoC levels, and there is a further reduction in the number of compliant products in the 2012 database. In Scenario 3, Tier 1 approximately 16% of the models are compliant while at Tier 2 it drops to 2% (i.e., 76 out of 4608 models). While this sounds very low, it is worth noting that these are models that are commercially available in 2012 and which already meet ambitious requirements that would take effect in four years. The reduction in average annual power consumption of an EPS is reduced by 13% and 37% relative to the BAU at Tier 1 and Tier 2 respectively.

Using the sales and stock levels presented earlier, and the energy consumption values above, the EU-27 stock energy consumption values under different scenarios were estimated. The table below illustrates the impact on the total annual energy consumption of EPS in Europe under the BAU and the three illustrative policy scenarios.

Table 4-7. Projected Annual Energy Consumption of EPS for BAU and Scenarios 1-3

EU-27 Projection	2010 (TWh/yr)	2015 (TWh/yr)	2020 (TWh/yr)	2025 (TWh/yr)	2030 (TWh/yr)
Business As Usual	7.32	7.43	7.52	7.60	7.66
Scenario 1	7.32	7.33	6.49	6.44	6.49
Scenario 2	7.32	7.22	5.81	5.68	5.73
Scenario 3	7.32	6.86	5.03	4.80	4.84

The energy savings potential from these three scenarios is presented in the table below, where the energy savings ranges from 1.2 to 2.8 TWh of savings in 2025.

Table 4-8. Projected Annual Energy Savings to 2030, Scenarios 1-3, External Power Supplies

EU-27 Projection	2010 (TWh/yr)	2015 (TWh/yr)	2020 (TWh/yr)	2025 (TWh/yr)	2030 (TWh/yr)
Scenario 1	-	0.10	1.04	1.17	1.17
Scenario 2	-	0.20	1.71	1.92	1.93
Scenario 3	-	0.57	2.50	2.80	2.82

5 Additional Issues

In line with the framework directive on ecodesign reviews must assess potential future minimum performance requirements in light of technological progress. Above we have provided three illustrative policy scenarios in support of this. Further, implementing measures often require additional issues to be assessed in connection with the review. It may be that some issues are not anticipated in implementing measures, but could be relevant to include in a review. Below we consider both types of additional issues.

5.1 Additional Issues Required by the Implementing Measure

The ecodesign implementing measure on EPS does not point to any additional issues that should be included as part of a review.

5.2 Additional Issues Not Anticipated in the Implementing Measure

5.2.1 Scope of Coverage of the Implementing Measure

Overall, the current EPS regulation still covers and regulates the highest volume products in the market. However, it would nevertheless be appropriate to revisit the scope of coverage as recently proposed new regulations from the US includes some EPS not currently included in the scope of the EU regulation.[14] The relationship between the existing scope of coverage of the EU regulation and the proposed new regulations in the US are set out in the table below.

Table 5-1: Comparison of Proposed US DOE rule on External Power Supplies to EU Ecodesign Scope

US DOE Class	Description	Covered in Europe?
B	AC or DC Output, Basic-Voltage, ≤ 250W	Yes
C	DC Output, Low-Voltage (output < 6V, current > 550mA)	Yes
D	AC Output, Basic-Voltage	Yes
E	AC Output, Low-Voltage	Yes
H	High-Power (>250W)	No
N	Indirect Operation (cannot operate device without a battery installed)	(No)
X	Multiple-Voltage Output	No

There does appear to be some ambiguity in the scope of the ecodesign regulation such that it is not clear whether power supplies sold as accessories of products are in fact covered by the regulation. It would be desirable to eliminate such ambiguities in the context of the review.

5.2.2 Opportunity for Material Resource Efficiency Gains by Renewing the UCS MOU

The Universal Charging Solution (UCS) memorandum of understanding (MOU) between the Commission and Digital Europe expired at the end of 2012.[15] The MOU defines measures to be taken by the signatories to allow mobile phones to be charged through a common charger interface agreed by signatories. The MOU facilitates user convenience and a reduction in the environmental impact of (redundant) chargers which are discarded with mobile phones well before the end of their service life. It is not clear whether the renewal of the MOU has to be linked to a review, or whether this is something that could be done separately and potentially ahead of a review. However it is clear that there are significant *resource efficiency* gains to be had through renewing this MOU, as well as reducing costs for consumers and suppliers of products that use EPS covered by the UCS.

5.2.3 Power Factor With No-load

Power factor[16] is included in the energy performance criteria for EPS on full load in the existing implementing measure and in the JRC draft code of conduct. However, it may be appropriate to consider power factor in the context of requirements for EPSs with no-load. For an individual household, the energy losses in the AC wiring mains due to EPSs with a poor power factor with no load are not significant. The cumulative effect of EPS with a poor power factor with no-load from hundreds of households fed from a common AC mains sub-station is also negligible since the difference in reactance of each household's combination of EPS does not result in a simple addition of power factor, because cancellation will occur. However, in a commercial environment (e.g., hotels, offices, large retail stores) where hundreds of identical EPS are operating (e.g., equipment and lighting) the cumulative effect on the building wiring system adds up and poor power factor at low loading/standby will introduce substantial energy losses in the building wiring. It should be noted that these poor power factor energy losses generated by the commercial building electrical load are usually not extended outside the building to the medium to high voltage AC mains distribution networks of European conurbations because poor power factor is usually corrected at the mains power input (i.e., mains riser) of large commercial premises.

[15] MoU regarding Harmonisation of a Charging Capability for Mobile Phones June 5, 2009. See: http://ec.europa.eu/enterprise/sectors/rtte/files/chargers/chargers_mou_en.pdf

[16] Power Factor is defined as the ratio of real power to apparent power. Power factor is a simple way to describe how much of the current contributes to real power in the load. A power factor of one (unity or 1.00) indicates that 100% of the current is contributing to power in the load while a power factor of zero indicates that none of the current contributes to power in the load. However the current carried to and returning from a load with poor (close to zero) power factor can typically be tens of times higher than that current value suggested by a real power measurement at the load. It is this current that generates heat and consequent energy wastage in the mains distribution wiring feeding the load.

Annex C. Household Washing Machines

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1 Introduction and Context

In common with the other six annexes, this annex starts by setting out the timetable and scope of the upcoming reviews. It then sets out the scope of the existing implementing measures. Having provided this context, a BAU energy consumption scenario is developed. Next an assessment of technology developments is made and this is used to develop a set of illustrative policy scenarios on the basis of which a range of energy savings potentials are defined. Finally, a set of issues of relevance in the context of upcoming reviews is outlined.

1.1 Timetable and Scope of Coverage of the Upcoming Reviews

Commission Regulation EU No 1015/2010 on the ecodesign requirements for household washing machines states that it shall be reviewed no later than four years after its entry into force, i.e., by 1 December 2014 and the results of that review shall be presented to the Ecodesign Consultation Forum. The review shall in particular assess the verification tolerances, the opportunity of setting requirements on rinsing and spin-drying efficiency and the potential for a hot water inlet.

Commission Delegated Regulation EU No 1061/2010 on the energy labelling of household washing machines states that it shall be reviewed no later than four years after entry into force, *i.e.*, by 20 December 2014. The review shall in particular assess the verification tolerances set out in Annex V.

1.2 Scope of Coverage of the Implementing Measures

The ecodesign regulation[1] and energy labelling regulation[2] share the same scope of coverage, which is given in Article 1 in each of the published regulations. Both cover electric mains-operated household washing machines and electric mains-operated household washing machines that can also be powered by batteries. This includes those sold for non-household use and built-in household washing machines. The regulation does not cover household combined washer-driers.

[1] Commission Regulation (EU) No 1015/2010 of 10 November (Ecodesign requirements), in: Official Journal of the European Union, 11.11.2010.
[2] Commission Delegated Regulation (EU) No 1061/2010 of 28 September 2010 supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to energy labelling of household washing machines, in: Official journal of the European Union, 30.11.2010.

2 Market Projection

2.1 Installed Stock and Annual Sales

The European washing machine market is generally considered to be saturated. In the future, the washing machine market is expected to be driven primarily by the replacement of old appliances.

The replacement market has dominated sales in the EU-15 countries for several years now, where household ownership reached a level of approximately 90% in 2000.[3] A slight increase in the percentage of household ownership may occur, but it is unlikely to ever reach 100% due to the practice of some households and apartment blocks using collective laundry rooms. By 2005, it was estimated that approximately 10% of new washing machine sales in the EU-15 were contributing to increasing the stock while 90% were replacing existing appliances. In this saturated market, the future sales percentage going into increases in the net stock will largely depend on the growth rate of households across the EU-15.

There are less reliable data are available for the twelve New Member States (NMS-12). In these countries, household washing machine ownership reached a rate of around 70% by 2000. It has since grown to 90%, as in the EU-15 countries.[4] Taking into account the respective growth rates of EU-15 and NMS-12, Table 2-1 estimates the annual sales and installed stock of washing machines in Europe between 2007 and 2011. Total washing machine sales in 2011 were approximately 13.9 million units.

Table 2-1. Sales and Installed Stock of Washing Machines in the EU-27 Countries

EU-27 data	2007	2008	2009	2010	2011
Sales (million units)	13.4	13.5	13.7	13.8	13.9
Stock (million units)	182	184	187	189	191

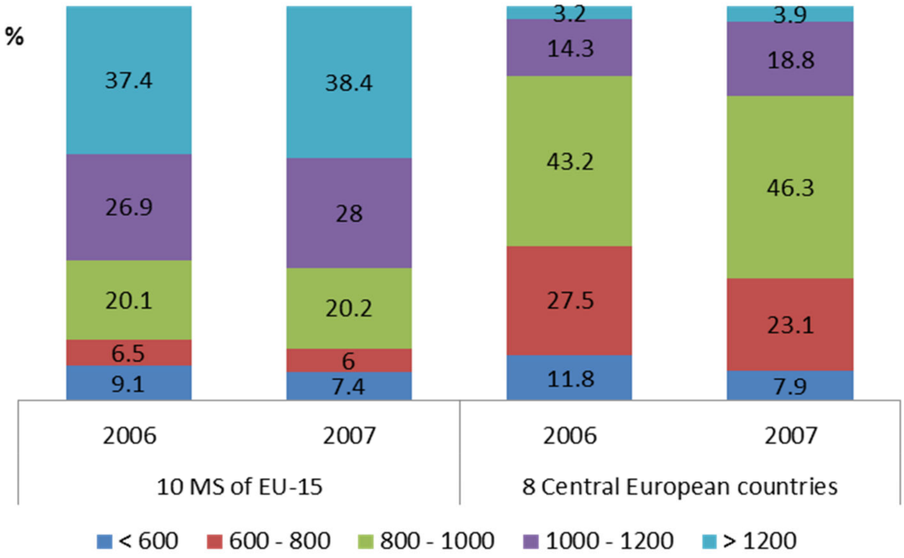
Washing machine sales show that consumers have a preference for higher spin speeds – a development that has been observed for several years. The fast spin speed (> 800 rpm) washing machines market share used to be higher in the EU-15 than in NMS-12, but it has been increasing in the NMS-12 (see figure below which is based on data from eight Central European countries).[5]

[3] Lot 14 (2007) Preparatory Studies for Eco-design Requirements of EuPs (Tender TREN/D1/40-2005) LOT 14: Domestic Washing Machines and Dishwashers, Final Report

[4] Bertoldi, Atanasiu, (EC Joint Research Centre, Institute for Energy), 'Electricity Consumption and Efficiency Trends in European Union', Status Report 2009.

[5] M. Soregaroli, 'Latest Trends in Major Domestic Appliances in CEE. Focus on energy consumption', proceedings of the 6th JRC annual workshop on: "Energy Efficiency in Buildings: Policies and Financial Instruments", 3/5 June 2008, Ljubljana, Slovenia. See: http://re.jrc.ec.europa.eu/energyefficiency/pdf/ProceedingsLjubljana2008/33%20Soregaroli.pdf

Figure 2-1. Washing Machine Sales: Spin-Speed Distribution in 2006 and 2007



2.2 Washing Machine Stock and Sales Projection

As discussed above, the household ownership rate of washing machines has reached 90% in all EU-27 countries, and is unlikely to ever reach 100%. The development of future sales and stock will therefore be driven primarily by the expected growth rate of the number of households in the EU-27. According to Eurostat, the population of the European Union is projected to increase by approximately 4% between now through 2030,[6] with the number of households growing slightly faster as the number of persons per household is forecast to decline. Introducing the Eurostat projections and an assumed product lifespan of 15 years (consistent with the estimate used in the 2007 Preparatory Study), a projected future sales estimate and total installed stock of washing machines has been calculated (Table 2.2).

Table 2-2. Projected Washing Machine Sales and Stock in EU-27 Countries

EU-27 projection	2010	2015	2020	2025	2030
Population (million)	501.5	508.2	514.4	519.1	522.3
Sales (million units)	13.8	14.4	15.1	15.7	16.4
Stock (million units)	189	200	209	219	229

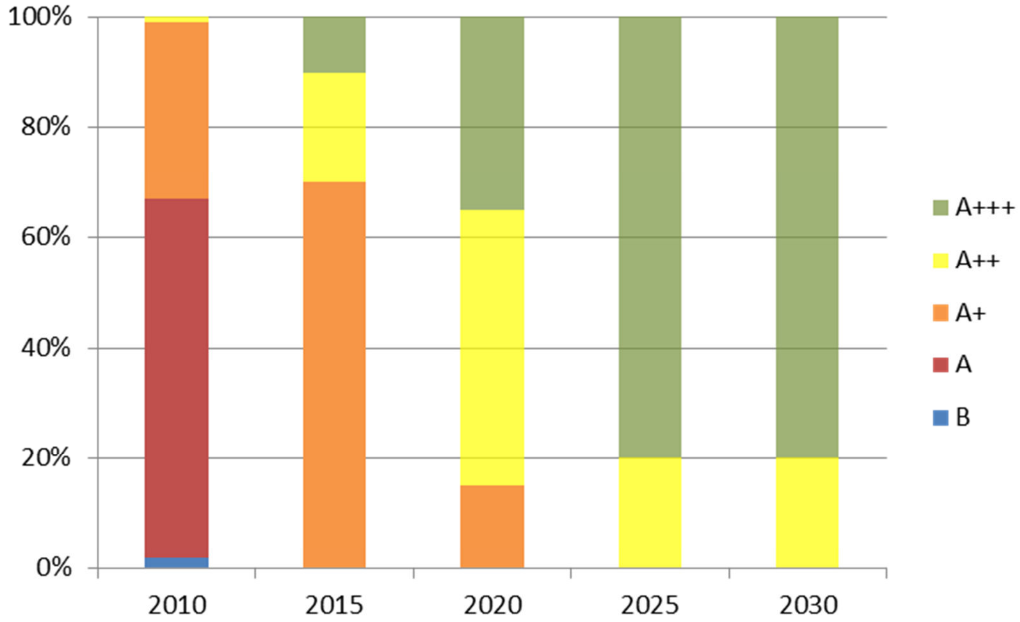
2.3 Projected Energy Consumption

The base case energy consumption projection prepared for this paper reflects the on-going influence of the current ecodesign and energy labelling measures, but assumes that no new policy instruments are introduced. This projection is referred to as the 'Business as Usual' (BAU) scenario and assumes that the

[6] EUROSTAT Population Forecast, 2012 (v2.9.12-20120730-4869-PROD_EUROBASE). ; available at: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=proj_10c2150p&lang=en

effectiveness of the label will slowly decline as saturation of the top label classes occurs (as shown in the figure below). The figures for 2010 are based on GfK.[7]

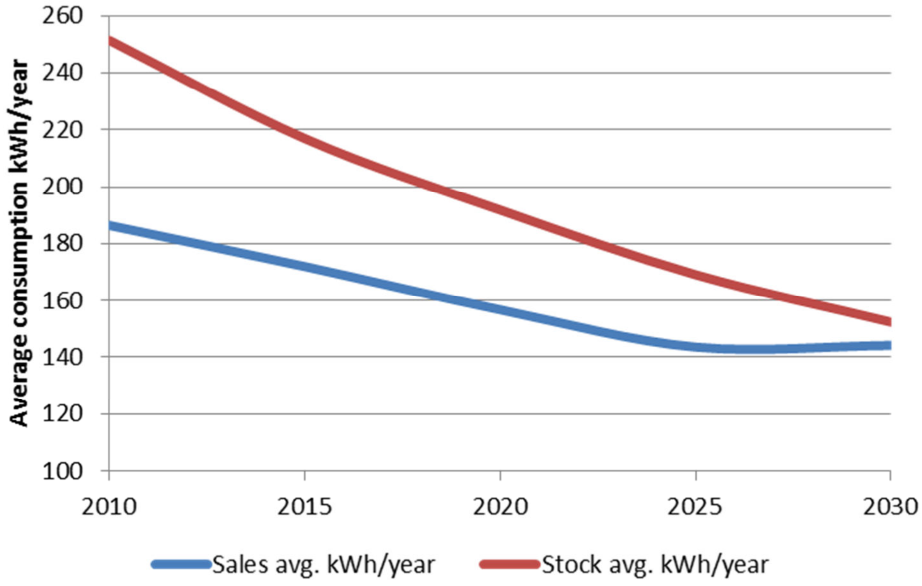
Figure 2-2. Estimated Sales by Energy Efficiency Class, BAU Scenario EU-27



As the new, more energy-efficient products are installed into the stock of washing machines in Europe and the least energy-efficient products are retired from the market, the efficiency of the stock will gradually increase as the older (less efficient) units are replaced. The figure below illustrates this effect for the BAU Scenario showing annual energy consumption of new units versus the stock average energy consumption.

[7] GfK Presentation: Latest Trends in Major Domestic Appliances Efficiency in Europe, Russia, and Ukraine, Oksana Shvedyuk, GfK Ukraine, 6 July 2011. Note: the presentation contains the data for both refrigerators and washing machines, and the sales plots for these two appliances were apparently swapped. This error becomes apparent when comparing the sales by energy label class to the 2008 GfK presentation.

Figure 2-3. Stock and Sales Average Annual Energy Consumption, BAU Scenario, EU-27



"*Annual energy consumption*" is defined in the ecodesign and energy labelling regulations. It is based on the assumption of 220 wash cycles per year. The "*weighted energy consumption*" per cycle is calculated on the basis of measured consumption figures for cycles at 60°C full loaded, 60°C half loaded and 40°C half loaded. The "*weighted energy consumption*" represents the total energy consumption of these wash cycles in addition to the "*left-on*" or "*off*" modes for which power consumption is also measured. The sum of all of these equals the annual energy consumption in kilowatt-hours.

The table below provides an estimate of the energy consumption for the BAU scenario, multiplying the projected energy consumption per unit by the forecasted stock estimates.

Table 2-3. EU-27 Stock Washing Machine Energy Consumption BAU Scenario

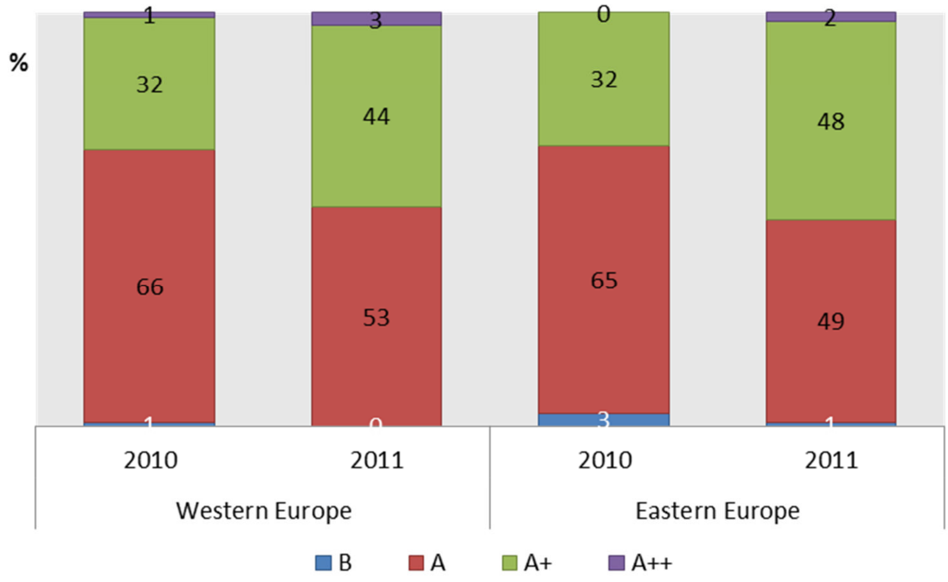
EU-27 projection	2010 (TWh/yr)	2015 (TWh/yr)	2020 (TWh/yr)	2025 (TWh/yr)	2030 (TWh/yr)
Stock annual energy consumption, BAU	47.5	43.3	40.8	38.9	37.7

3 Technology Assessment

The most significant environmental aspects of washing machines are energy and water consumption in the use phase. Regarding energy, the influence of the power consumption in low power modes such as left-on mode and off mode are of secondary importance.

Energy labelling of washing machines was first introduced in 1995.[8] By 2007, close to 100% of the sales were top class A.[9] By 2010, more than 30% of sales in Western and Eastern Europe exceeded the class A threshold requirements, achieving the equivalent of A+ and A++.[10]

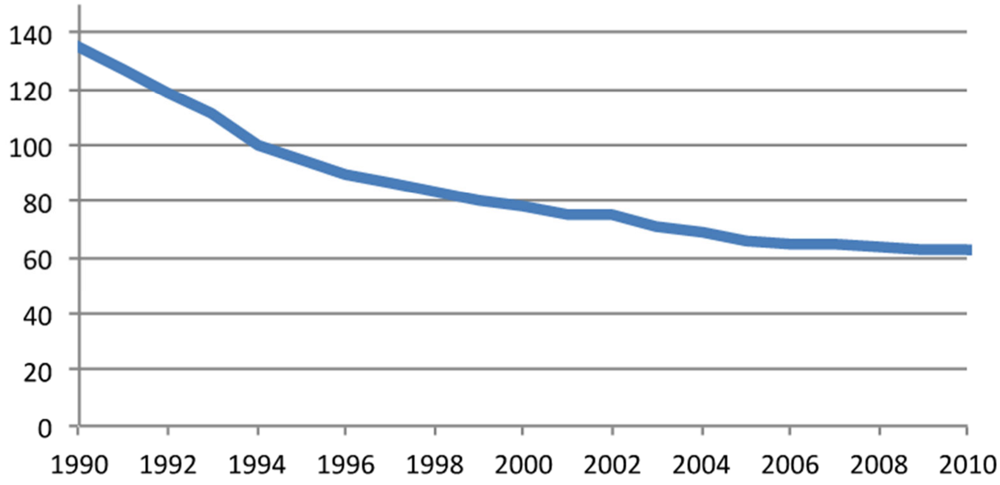
Figure 3-1. Washing Machine Sales: Energy Label Classes, 2010-2011



The metric used to determine the “energy efficiency class” (labelling class) of a given washing machine model was not the same in Directive 95/12/EC (the old washing machine energy label) and Delegated Regulation EU No 1061/2010 (the new label). In Directive 95/12/EC, washing machines were classified according to the kilowatt-hours of energy consumption per kilogram of clothes washed in a standard 60°C cotton cycle. In the new regulation, the energy consumption of the machine is taken as an average across seven different washes: two part-load at 40°C, two part-load at 60°C and three full-load at 60°C. Because the test methods are different, the energy metrics developed and used to classify washing machines under these two regulations is not straight forward. However, by using an empirical average relationship developed by testing washing machines under both test methods, a conversion factor that allows for the development of an indicative trend in EEI from 1990 to 2010 can be established, as shown in the figure below.

[8] European Commission. Commission Directive 95/12/EC of 23 May 1995 implementing Council Directive 92/75/EEC with regard to energy labelling of household washing machines, published in the Official Journal of the European Union, L 136 , 21/06/1995.
[9] GfK Presentation, Latest Trends in Major Domestic Appliances in CEE – June 2008. GfK Retail and Technology Group, 3 July 2008.
[10] GfK Presentation, Latest Trends in Major Domestic Appliances Efficiency in Europe, Russia, and Ukraine, Oksana Shvedyuk, GfK Ukraine, 6 July 2011. Note: the presentation contains the data for both refrigerators and washing machines, and the sales plots for these two appliances were apparently swapped. This error becomes apparent when comparing the sales by energy label class to the 2008 GfK presentation.

Figure 3-2. EEI Trend for Washing Machine Sales, European Market, 1990-2010



The 2012 average EEI of a washing machine is approximately 60, and the most efficient models on the European market have an EEI of 42.[11]

3.1 Design Options Related to Energy Efficiency

Areas of possible technology improvement were discussed in the GEA study[12] and reviewed in the WASH-2[13] as well as the EuP Lot 14 2007 Preparatory Study. These options include improved motor efficiency, temperature-time trade-off, improved mechanical action in the wetting phase, sophisticated electronic process controls and sophisticated electronic water and temperature controls. Overall, the technological improvements using these options have resulted in close to a 40% reduction in average energy consumption per wash (kWh per kg under test conditions) between 1995 and today. Further improvements are still possible in all five of these areas, and if exploited would result in further reduction in energy consumption.

The three most relevant elements with potential to further reduce the energy consumption in the future are motor efficiency, the trade-off between wash-time and temperature, and improved sensors.

3.1.1 Motor Efficiency

According to the Preparatory Study, most washing machines marketed in Europe use AC phase controlled motors. Compared to these motors, brushless DC motors are more energy efficient, largely due to the motor's speed being determined by the frequency at which the electricity is switched, not the voltage. Additional efficiency gains are realised due to the absence of brushes in the motor, alleviating some of the frictional loss. Apart from motor efficiency, a better motor enables the engineers to enter other efficient design options. Improvement in motor efficiency alone, i.e. moving from AC phase controlled to brushless DC, can result in a reduction of around 50 Wh/cycle. This corresponds to 11 kWh per year (assuming 220 cycles per year as in current ecodesign and labelling

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[11] Top Ten website, washing machine section, see: http://www.topten.eu/

[12] Group for Efficient Appliance (GEA), Study for the Commission of the European Communities on 'Washing Machines, Dryers and Dishwashers', Final Report, June 1995

[13] WASH-2 study, NOVEM, 'Second study on washing machines' for DG TREN, 2000

regulations). That amount of electricity represents approximately 3.6 EEI points, such as the difference between an EEI of 60 and an EEI of 56.4. Motor efficiency is therefore a design element with limited contribution to the overall performance, but is of growing importance as energy consumption per cycle decreases.

3.1.2 Temperature-Time Trade-Off

In a household washing machine, there are four factors that contribute to the textile cleaning process: (1) mechanical action on the textiles, (2) chemistry of the detergents, (3) temperature to activate the chemistry and (4) duration of the wash cycle. Trade-offs can be made between the different factors to improve or reduce the cleaning contribution from any one of these four factors. Generally, cleaning effectiveness will increase with more vigorous mechanical action, more detergent, higher water temperatures, and longer wash cycles. These four factors contributing to cleaning are referred to as the "Sinner's circle".[14]

Chemistry is a constant in the efficiency and performance test of washing machines, and applying mechanical action and high temperatures consume energy. The majority of electrical energy is used to heat the water, therefore a cost efficient way to reduce the energy consumption is to lower the temperature, i.e. the maximum temperature in the main wash, and compensate for the reduction in cleaning effectiveness by increasing the wash cycle duration. Extensive use of this temperature-time trade-off has lead both to substantially more energy efficient European washing machines with long wash cycle durations. This temperature-time trade-off is one of the most important options for reducing energy consumption while maintaining wash performance as the most important performance metric for consumers.

3.1.3 Sensors, Automatic Load Detection, Sophisticated Controls

Another approach for reducing average energy consumption per cycle involves using sensors that automatically detect the load size and sophisticated controls that intelligently adjust water quantities, agitation and other parameters of the wash cycle. Up until now, these design features which reduce energy and water consumption in use were not detected and not credited because machines were only required to be tested with full load for the labelling directive. However, the new testing standard for washing machines includes measurement of equipment performance and energy consumption for half-loads which will better represent actual usage and enable the EEI to reflect (and reward) 'intelligent' wash cycle controls such as those described above.

3.2 Other Technology Trends

Further development of washing machine technology will target other important consumer performance aspects such as:

- Special programmes - normal 40°C and 60°C cotton wash cycles still represent the cycles predominantly used by consumers, however a growing number of washing machines offer a wide range of special programmes designed to give an optimised balance between required wash performance, fabric care and energy and water consumption. For example, programmes for

[14] The term, Sinner's circle, was coined in 1959 by Dr Herbert Sinner of the German detergent supplier Henkel. It conveys the idea that that the reduction of one factor (e.g. using less detergent) can be compensated for by any of the three other factors: time, mechanical energy or temperature. Recent research suggests that the picture is more complex. For instance, enzyme activity is can be ruined when using water at too high a temperature.

delicates, sportswear, iron-free garments and hand wash programmes may use less mechanical agitation than normal cotton wash cycles and lower water temperatures.

- Intensive programmes – these programmes may be used to clean heavily soiled garments such as work wear with programmes that are optimised for wash performance but may require more resources (i.e., energy or water) than normal cotton wash cycle programmes.

- Half/small load programmes – despite the trend toward higher capacities of new washing machines, consumers may still use the machines to wash a small amount of laundry. These partial loads can be adequately cleaned with less energy and less water. Having specific small load programmes are a less expensive alternative to sensors detecting the actual load size and adjusting the wash cycle accordingly.

- Shorter programme duration - as mentioned above, longer cycle durations combined with lower wash temperature in the normal cotton wash programmes substantially improve the energy-efficiency of the wash cycle. However, consumers may wish to have shorter programmes available that operate with higher wash temperatures to ensure satisfactory cleaning performance.

- Low temperature programmes – in response to trends toward lower wash temperatures, detergent manufacturers have developed new detergents optimised to work at low temperature cycles. Consumers expect energy-efficient washing machines to offer effective wash programmes at low water temperatures such as 15°C or 20°C.

- Hygiene programmes - the growing trend towards lower wash temperatures and the increased usage of liquid detergent not containing bleach components (that have some germ reduction potential) have resulted in some discussion about good hygiene in domestic washing machines. Some machines are already marketed with claims regarding germ reduction despite the fact that test methods to verify these claims are not yet fully developed.

4 Energy Savings Potential

The purpose of this section is to provide an estimate of the potential for additional energy savings from revised regulations in the context of different levels of ambition. After briefly setting out the requirements of existing regulations, a high, medium and low ambition illustrative policy scenario is presented based on the preceding assessment of technological development. These policy scenarios provide an indicative estimate of the energy savings potential, based on updated regulatory requirements.

4.1 Existing Regulations

4.1.1 Ecodesign

Annex I of ecodesign regulation EU No 1015/2010 established the following performance requirements for washing machines:

2. SPECIFIC ECODESIGN REQUIREMENTS

Household washing machines shall comply with the following requirements:

(1) From 1 December 2011:

— *for all household washing machines, the Energy Efficiency Index (EEI) shall be less than 68,*

— *for household washing machines with a rated capacity higher than 3 kg, the Washing Efficiency Index (I_w) shall be greater than 1,03,*

— *for household washing machines with a rated capacity equal to or lower than 3 kg, the Washing Efficiency Index (I_w) shall be greater than 1,00,*

— *for all household washing machines, the Water Consumption (W_t) shall be:*

$$W_t \leq 5 \times c + 35$$

where c is the household washing machine's rated capacity for the standard 60 °C cotton programme at full load or for the standard 40 °C cotton programme at full load, whichever is the lower.

(2) From 1 December 2013:

— *for household washing machines with a rated capacity equal to or higher than 4 kg, the Energy Efficiency Index (EEI) shall be less than 59,*

— *for all household washing machines, the water consumption shall be,*

$$W_t \leq 5 \times c_{½} + 35$$

where $c_{½}$ is the household washing machine's rated capacity for the standard 60 °C cotton programme at partial load or for the standard 40 °C cotton programme at partial load, whichever is the lower.

The Energy Efficiency Index (EEI), the Washing Efficiency Index (I_w) and the Water Consumption (W_t) are calculated in accordance with Annex II.

4.1.2 Energy Label

The energy labelling regulation EU No 1061/2010 establishes seven energy efficiency classes from D (least efficient) to A+++ (most efficient). According to the implementing measure, most articles in the regulation applied from 20 December 2011, including the responsibility of suppliers to provide a printed label in the format and containing information set out in Annex I of the energy labelling regulation. The other articles became applicable on 20 April 2012, including for example the requirement that any advertisement for a specific model of household washing machine contain the energy efficiency class if the advertisement discloses information on the energy consumption or price.

Table 4-1. Energy Classes from Washing Machine Labelling Regulation EU No 1061/2010

Energy Efficiency Class	Energy Efficiency Index
A+++ (most efficient)	EEI < 46
A++	46 ≤ EEI < 52
A+	52 ≤ EEI < 59
A	59 ≤ EEI < 68
B	68 ≤ EEI < 77
C	77 ≤ EEI < 87
D (least efficient)	EEI ≥ 87

The Energy Efficiency Index (EEI) of a household washing machine is calculated in accordance with Annex II of the ecodesign regulation or with point 1 of Annex VII of the energy labelling regulation. However, the ecodesign regulation requirements do not allow classes B, C and D anymore, also class A will no longer be allowed for machines with a rated capacity ≥ 4 kg with Tier 2 after 1 December 2013.

4.2 Illustrative Policy Scenarios

Energy savings estimates have been prepared for each of the seven products scheduled for review. These savings estimates were based on three illustrative policy scenarios including updated ecodesign requirements and energy labelling categories. The scale of increases and timing of new requirements were informed by the scale of increases and timing in the existing implementing measures in addition to the assessment of technological progress. These policy scenarios provide an indicative estimate of energy savings, based on possible technology improvements for this product group. The three illustrative policy scenarios developed for washing machines are presented in the following table.

Table 4-2: Three Illustrative Policy Scenarios for Washing Machines

Scenario	Ecodesign	Energy Label
1	Tier 1 at EEI ≤ 52 from 2018 Tier 2 at EEI ≤ 46 from 2022	HELC[15] in 2016 at EEI ≤ 41
2	Tier 1 at EEI ≤ 52 from 2017 Tier 2 at EEI ≤ 46 from 2020	$HELC_{-1}$ in 2016 at EEI ≤ 41 HELC in 2016 at EEI ≤ 37
3	Tier 1 at EEI ≤ 52 from 2016 Tier 2 at EEI ≤ 46 from 2018	$HELC_{-2}$ in 2016 at EEI ≤ 41 $HELC_{-1}$ in 2016 at EEI ≤ 37 HELC in 2016 at EEI ≤ 33

The first scenario assumes that new ecodesign regulations come into effect in two steps – a Tier 1 requirement with an EEI of 52 from 2018 and a Tier 2 requirement with an EEI of 46 from 2022. The scenario also assumes that a new energy label class is introduced in 2016 having a new, higher energy label class with an EEI of 41.

The second scenario assumes a new ecodesign regulation with two tiers, the first from 2017 at an EEI of 52 and the second from 2020 with an EEI of 46. This represents the same requirements as Scenario 1; however the schedule is slightly accelerated. This scenario also considers two new energy label classes are introduced in 2016, one with an EEI threshold of 41 and the other with an EEI threshold of 37.

The third scenario assumes a new ecodesign regulations would come into effect in two steps – an EEI of 52 from 2016 and an EEI of 46 from 2018. This also represents the same requirements as the previous two scenarios, but they take effect much sooner. In addition, this scenario assumes three new energy label classes are introduced in 2016, one with an EEI of 41, one with an EEI of 37 and a third one with an EEI of 33.

The three scenarios have implications for the range of energy classes on the label. By 2018, or 2022 at the latest, all models would have to have at least EEI of 46 (A+++). This is the lower boundary of the A+++ category and would mean that there would only be one class of models left on the market, A+++. Given that the best available models on the market today are at EEI 42, and given the scope for technology improvement highlighted earlier in this Annex, there seems room to introduce more ambitious labelling categories beyond A+++.

The table below presents how the sales-weighted average EEI might evolve in the EU-27 under these three scenarios.

[15] Highest Energy Labelling Class (HELC). Illustrative new next highest classes are represented with sub-scripts in this table.

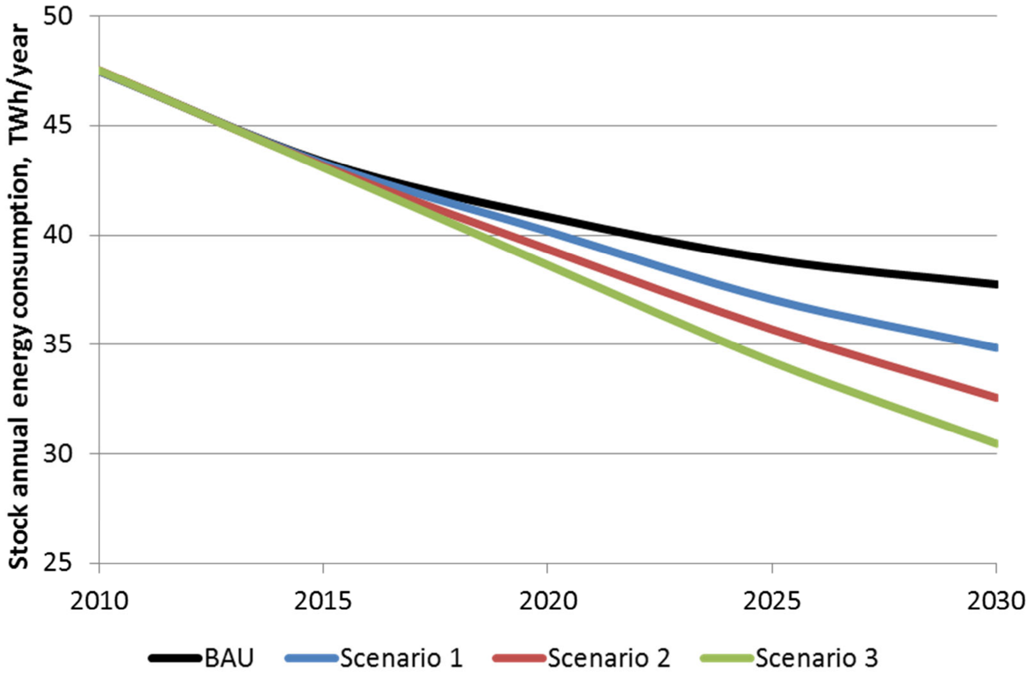
Table 4-3. Projected Estimate of Sales-Weighted Average EEI for Washing Machines

EU-27 Projection	2010	2015	2020	2025	2030
Projected new sales avg. EEI, BAU	61	56	51	47	47
Projected new sales avg. EEI, Scenario 1	61	55	48	42	42
Projected new sales avg. EEI, Scenario 2	61	54	44	39	37
Projected new sales avg. EEI, Scenario 3	61	52	41	36	34

4.3 Energy Savings Potential

As more energy efficient washing machines are sold into the market each year, the fleet or stock average efficiency improves. The effect of the three illustrative policy scenarios on total energy consumption of across the EU-27 relative to the BAU scenario is shown in the figure below.

Figure 4-1. Projected Stock Energy Consumption for BAU and Scenarios, EU-27

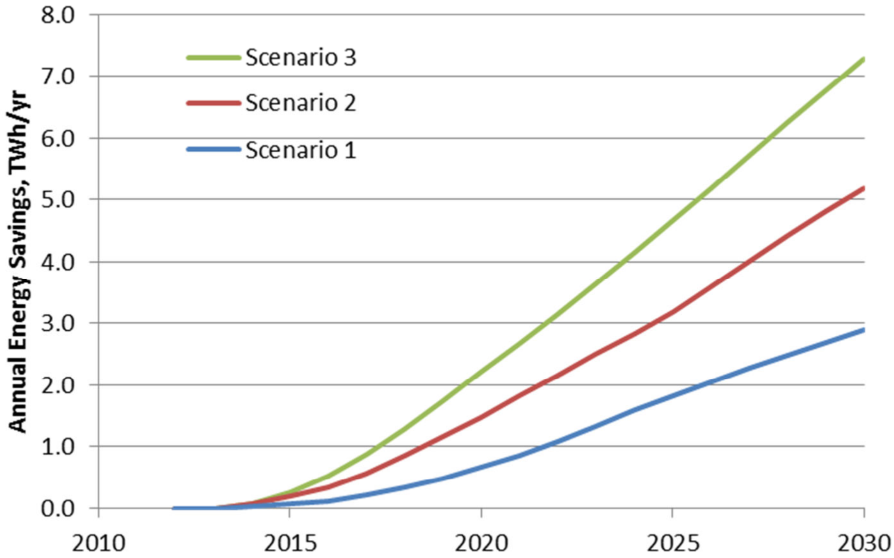


By 2030, the energy savings potential of the three illustrative policy scenarios would be between 2.9 and 7.3 TWh of electricity saved per annum. The savings estimates are presented in the table and figure below.

Table 4-4. Estimated Energy Savings Potential of Efficient Policy Scenarios, EU-27

EU-27 Projection	2010 (TWh/yr)	2015 (TWh/yr)	2020 (TWh/yr)	2025 (TWh/yr)	2030 (TWh/yr)
Scenario 1	0.0	0.1	0.6	1.8	2.9
Scenario 2	0.0	0.2	1.5	3.2	5.2
Scenario 3	0.0	0.3	2.2	4.7	7.3

Figure 4-2. Projected Energy Savings for Washing Machines for 3 Policy Scenarios



Across the EU, washing machines are projected to consume 40.8 TWh of electricity in 2020. The electricity savings estimate from Scenario 2 is 1.5 TWh in that year, or approximately 3.7% of the estimated baseline scenario electricity consumption. By 2030, the electricity savings estimate from Scenario 2 is 5.2 TWh, or 13.8% of the projected baseline.

5 Additional Issues

In line with the framework directives, the reviews must, respectively, assess potential future minimum performance requirements and potential reclassification of labelling categories in light of technological progress. Above we have provided three illustrative policy scenarios in support of this. Further, implementing measures often require additional issues to be assessed in connection with the review. Finally, it may be that some issues have come to light since the development of the implementing measure and while not specified, could be relevant to include in a review. Below we consider both types of issues.

5.1 Additional Issues Required by the Implementing Measures

Both the ecodesign and energy labelling regulation require reviews to assess verification tolerances. In addition, the ecodesign implementing measure requires an assessment of the opportunities for setting requirements on rinsing and spin-drying efficiency and the potential for a hot water inlet. We do not discuss the potential for a hot water inlet here.

5.1.1 Verification Tolerances

With the steady improvement of energy efficiency of washing machines, the measured absolute energy consumption figures decrease and the relative uncertainty may increase respectively. Standardisation groups are constantly aiming at improving reproducibility – however, the actual remaining uncertainty of energy data measured according to the test standard should to be taken into consideration whenever requirements for verification tolerances or 'width' of efficiency classes are reviewed.

5.1.2 Setting Requirements for Rinsing Efficiency

The existing method for assessing rinsing efficiency specified in EN 60456 is known to have unsatisfactory reproducibility. Working groups on European and International levels are working on developing a sufficiently reliable method that may finally be used for ecodesign and energy labelling requirement.

5.1.3 Spinning Efficiency

Spinning efficiency is a relevant parameter when assessing the overall energy consumption of the laundry process as high spinning efficiency leads to less energy needed for drying - which directly affects the energy consumption of appliances used in the laundry process if a dryer is used. This explains why options for setting spinning efficiency requirements for ecodesign shall be explored in the next review of the regulation. The current performance test standard EN 60456 specifies the assessment of spinning efficiency, but discussions in the IEC and CENELEC working groups indicate that test results may be measurably affected by the 'history' of the used test loads. Options for reducing this effect are being discussed.

5.2 Additional Issues Not Anticipated in the Implementing Measures

5.2.1 Scope of Coverage: Ecodesign Requirements for Household Washer-Dryers

Washer-dryers are labelled according to EU directive 96/60/EC, but there are no ecodesign requirements for such products. Nor are they included in the scope of the proposed regulation for laundry dryers (EuP lot 16). The question therefore is whether washer-dryers should be included as a special product category subgroup within a revised regulation for washing machines, whether they should be regulated separately, or some other solution should be found. Washer-dryers only account for approximately 2.5% of total washing machine sales in Europe, at the same time, the products would not fit easily into the ecodesign regulation for washing machines or the ecodesign regulation for laundry dryers under development.[16]

5.2.2 Potential Consumer Confusion Regarding Temperature – Time Trade-off

One of the principal methods for reducing energy consumption in the wash process is to reduce the wash temperature – which then needs to be compensated for by longer programme time to maintain the same level of wash performance. However, consumers may wrongly assume that a short programme has lower energy consumption than the longer programme.

5.2.3 Minimum Wash Temperature Requirement for Testing

The temperature – time trade-off can in principle be used by ‘intelligent’ appliances to recognise the standard test conditions. One option to prevent this happening may be to require minimum values for the actual wash temperature reached by any programme used for testing.

5.2.4 Water Efficiency

The ecodesign requirements for household washing machines address both water and electricity consumption in the use phase, as two significant environmental impacts of this product group. The labelling regulation also sets requirements for the total annual water consumption of washing machines placed on the EU market. According to the 2009 Preparatory Study laundry is responsible for approximately 15-40% of water consumption in a typical household, thus replacing current stock with more efficient products would contribute to considerable water savings from washing machines.

While the values presented on the washing machine energy label represent the energy and water usage for a normal wash cycle, the actual energy and water usage may change from those given on the energy label depending on the characteristic of actual programme selected by the user. Innovative washing machines are equipped with a number of cycle choices, providing consumer with option to match a cycle to the type of load, thus increasing efficiency of both cleaning and resource use.

The issue of water efficiency as it relates to washing machines is a topic that warrants further analysis in the review of this product. New technologies are being developed and applied by manufacturers that not only improve the energy efficiency of the appliance, but also its water efficiency, and thus the overall environmental impact per wash is being reduced.

[16] Household combined washer-dryers have distinct characteristics, and can be used for washing or drying only, but their main specific characteristic is the combination of both processes into one cycle. The energy consumption of a full washing/drying cycle is different from that of single washing or drying cycles; and the rated capacity for washing/drying cycle may be different from the capacity for washing only. To measure these performance characteristics, washer-dryers have their own performance test standard (EN 50229) that is independent of the separate test standards for washers (EN 60456) and dryers (EN 61121).

Annex D. Household Dishwashers

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1 Introduction and Context

In common with the other six annexes, this annex starts by setting out the timetable and scope of the upcoming reviews. It then sets out the scope of the existing implementing measures. Having provided this context, a BAU energy consumption scenario is developed. Next an assessment of technology developments is made and this is used to develop a set of illustrative policy scenarios on the basis of which a range of energy savings potentials are defined. Finally, a set of issues of relevance in the context of upcoming reviews is outlined.

1.1 Timetable and Scope of the Upcoming Reviews

Commission Regulation EU No 1016/2010 on the ecodesign requirements for household dishwashers[1] states that it shall be reviewed no later than 4 years after its entry into force, i.e., by 1 December 2014, and the result of that review shall be presented to the Ecodesign Consultation Forum. The review shall in particular assess the verification tolerances set out in Annex III of the regulation, the possibilities for setting requirements with regard to the water consumption of household dishwashers and the potential for hot water inlet.

Commission Delegated Regulation EU No 1059/2010 on the energy labelling of household dishwashers[2] states that the Commission shall review this regulation no later than four years after its entry into force, i.e., by 20 December 2014. The review shall in particular assess the verification tolerances set out in Annex V of the regulation.

1.2 Scope of Coverage of the Implementing Measures

The ecodesign regulation and energy labelling delegated regulation share the same scope of coverage, which is given in Article 1 in each of the published regulations. It states that the respective regulations establish requirements for:

> "*electric mains-operated household dishwashers and electric mains-operated household dishwashers that can also be powered by batteries, including those sold for non-household use and built-in household dishwashers*"

The scope of coverage of the ecodesign and energy labelling implementing still includes all types of domestic dishwashers and therefore does not appear to need to be extended or modified.

[1] Commission Regulation (EU) No 1016/2010 of 10 November 2010 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for household dishwashers, in: Official Journal of the European Union, 11.11.2010. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:293:0031:0040:EN:PDF

[2] Commission Delegated Regulation (EU) No 1059/2010 of 28 September 2010 supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to energy labelling of household dishwashers, in: Official Journal of the European Union, 30.11.2010. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:314:0001:0016:EN:PDF

2 Market Projection

2.1 Installed Stock and Annual Sales

Dishwashers have a lower saturation level than other household appliances such as refrigerators and washing machines. Even within the EU-15, ownership rates differ significantly from country to country and are estimated to be approximately 60% of households for those countries with the highest level of market penetration.[3] The EU-15 dishwasher stock in the residential sector is estimated at around 72 million units based on an updated stock model using input data from the 2007 Preparatory Study.[2]

The sales for dishwashers in the EU-15 are approximately 7 million units per year, increasing in the last few years. However, the majority of units sold are replacing units in the existing stock, thus the penetration level per household has not grown significantly in the last few years.

There are less reliable data available for the twelve New Member States (NMS-12). In these countries, market penetration so far only reached approximately 10%, but the stock growth rate is higher than in the EU-15 countries. Dishwasher sales grew significantly recently (see Table 2-1), with total sales in 2011 estimated to be approximately 7.8 million units.

Table 2-1. Sales and Installed Stock of Dishwashers in the EU-27 Countries

EU-27 data	2007	2008	2009	2010	2011
Sales (million units)	6.4	6.7	7.0	7.4	7.8
Stock (million units)	74	76	78	81	84

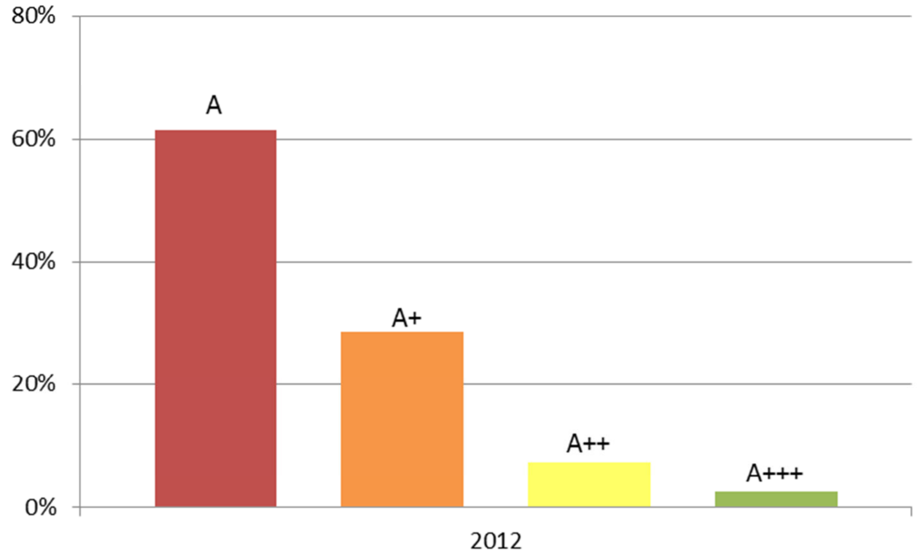
The dishwasher market has migrated towards higher energy efficiency and lower water consumption. There has also been a trend toward consumers purchasing larger machines (as well as manufacturers improving the dishware capacity of trays) to accommodate a larger number of place settings. The market has also seen an increased number of dishwashers that incorporate an ‘automatic’ cycle which uses soil sensors to continuously evaluate the degree of soiling and applies intelligent management of water consumption and duration of the wash cycles. Finally, there has been a trend toward less noise emission and an increased number of special cycles such as intensive wash (e.g., for pots and pans) or gentle cycles (e.g. for plastic toys).

In Switzerland, all of the dishwashers sold in 2010 were labelled energy class A.[4] Higher energy classes of A+ through A+++ were introduced at the end of 2011. The following figure presents an estimate of the 2012 market for the EU-27 based on a TopTen study of the dishwasher market for Switzerland in 2010 and an evaluation of energy classes of dishwashers for sale in November 2012, less than twelve months after the new energy label classes became mandatory. Since the products sold in the Swiss market tend to be more efficient than the EU-27 average, by making this the business as usual reference case will ensure that any savings calculated relative to this reference will be conservative (i.e., not overstate the energy savings potential).

[3] Lot 14 (2007) Preparatory Studies for Eco-design Requirements of EuPs (Tender TREN/D1/40-2005) LOT 14: Domestic Washing Machines and Dishwashers, Final Report. http://www.eceee.org/Eco_design/products/domestic_dishwashers/Final_Report_Lot14

[4] Michel et al., ‘Swiss appliance sales data, 2004 – 2011: Analysis and conclusions for EU market monitoring’ Topten International Services, www.topten.eu, August 2012

Figure 2-1. Estimate of 2012 Dishwasher Sales in EU-27 by Energy Label Class



2.2 Dishwasher Stock and Sales Projection

In 2012, the ownership rate of dishwashers reached approximately 40% of the households in the EU-27. Penetration rates vary widely between different countries and the penetration is substantially lower in the NMS-12 than in the EU-15. It is expected that there will be moderate increases in the household penetration level for the EU-15, but faster growth in the NMS-12 market, reaching an overall EU-27 average household penetration level of just over 60% in 2030.

According to EUROSTAT, the population of the EU-27 is projected to increase by approximately 4% between now and 2030.[5] The number of households is projected to grow at a slightly faster rate, as the number of persons per household is projected to decline slightly. Using these EUROSTAT projections and the assumption that the product lifespan will remain at its long term average of 15 years,[6] estimates of future sales and total installed stock of dishwashers were calculated, as shown below.

Table 2-2. Projected Dishwasher Sales and Installed Stock in EU-27 Countries

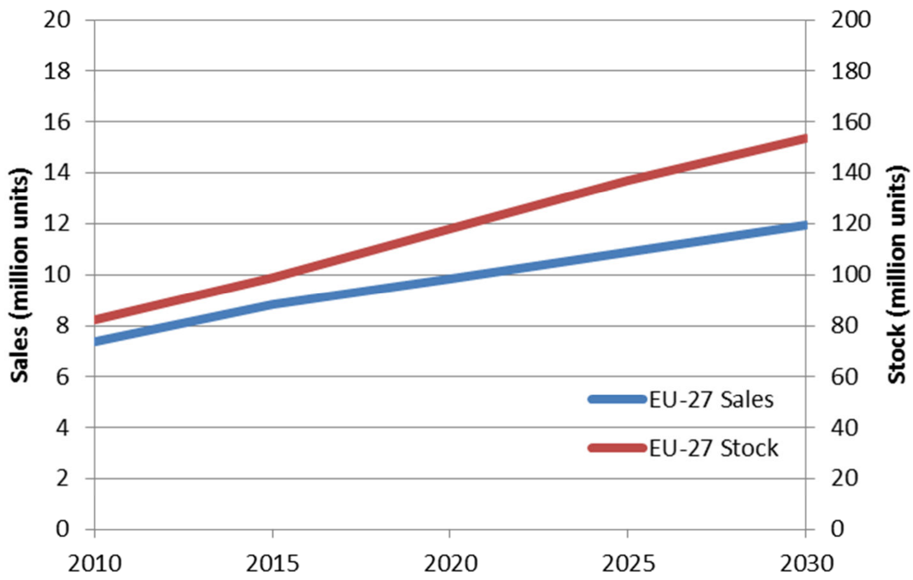
EU-27 Projection	2010	2015	2020	2025	2030
Population (million)	501.5	508.2	514.4	519.1	522.3
Sales (million units)	7.4	8.8	9.8	10.9	11.9
Stock (million units)	82.2	99.1	118.2	137.0	153.4

In the figure below, the blue line represents the annual sales (left hand axis) and the red line represents the stock (right hand axis).

[5] EUROSTAT Population Forecast (v2.9.12-20120730-4869-PROD_EUROBASE). Viewed 30 October 2012, see: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=proj_10c2150p&lang=en

[6] Lot 14 (2007) Preparatory Studies for Eco-design Requirements of EuPs (Tender TREN/D1/40-2005) LOT 14: Domestic Washing Machines and Dishwashers, Final Report

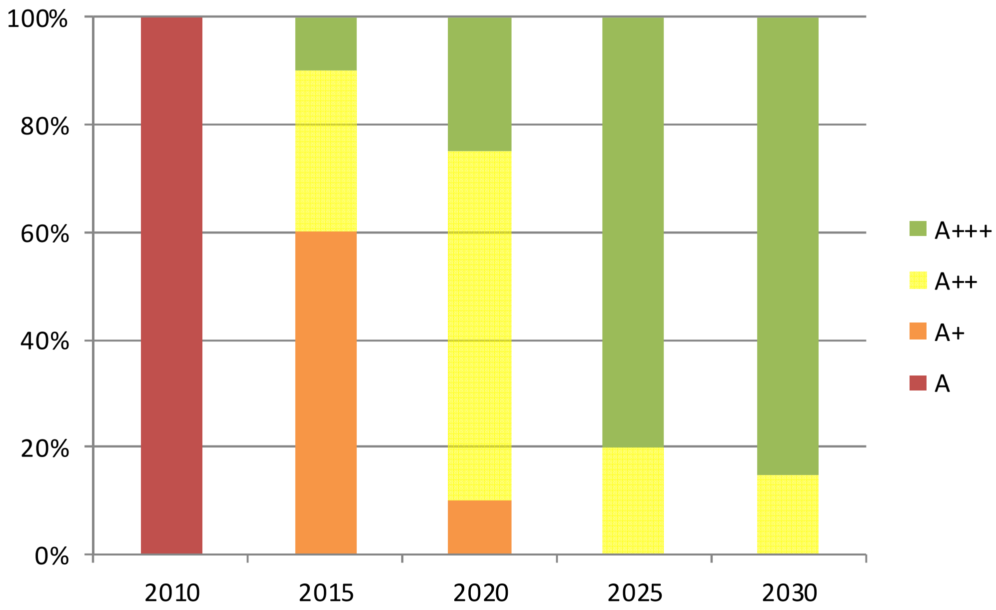
Figure 2-2. Projected Dishwasher Sales and Stock in EU-27



2.3 Projected Energy Consumption

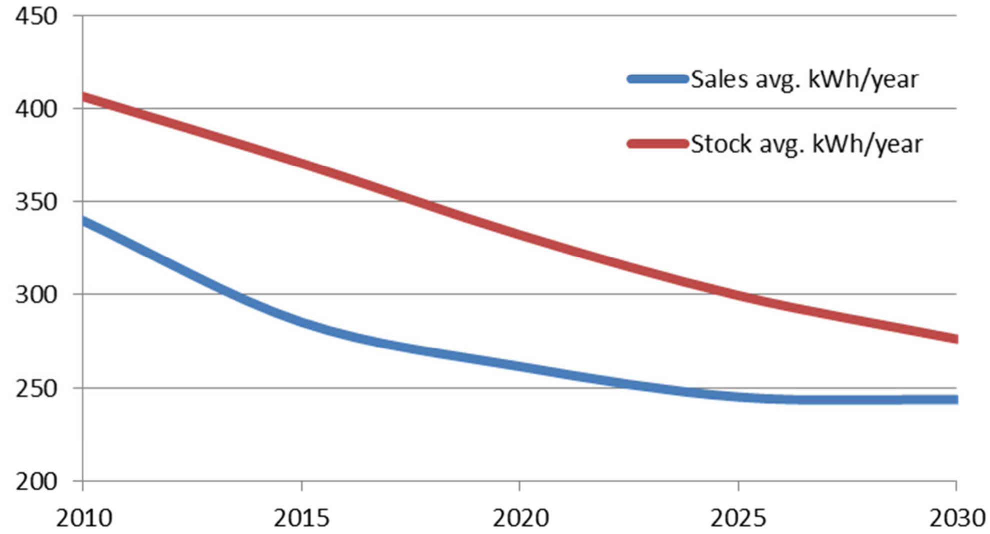
A base case energy consumption projection was developed to reflect the on-going influence of the current ecodesign and energy labelling measures, but assumes that no new policy instruments are introduced. This projection is referred to as the 'Business as Usual' (BAU) scenario and assumes that the effectiveness of the label will slowly decline over the projected period as market saturation occurs in the top label classes as shown in the figure for the EU-27 market below.

Figure 2-3. Estimated Proportion of Sales by Energy Efficiency Class, BAU Projection



The improvement in the energy-efficiency of units sold will affect the energy-efficiency of the overall stock as the older least energy-efficient products are retired from the market. Figure 2-4 illustrates this effect for the BAU scenario, plotting the annual average energy consumption of new units versus the stock average.

Figure 2-4. Stock and Sales Average Annual Energy Consumption, BAU Scenario, EU-27



"*Annual energy consumption*" is defined in the ecodesign and energy labelling regulations, and is based on 280 cycles per year[7] with the energy consumed by a standard wash cycle. The "*energy consumption for the standard cycle*" represents the energy consumption in use, the remaining time per year the appliance is assumed to be either "*left-on*" or "*off*", two modes that are also measured and their contribution added to the consumption in use for the time between the 280 cycles.

Multiplying this baseline assumption of per unit energy consumption by the aforementioned estimated EU-27 stock of dishwashers, the BAU energy consumption for all of Europe can be calculated. The table below presents the estimated annual energy consumption of dishwashers for the BAU scenario.

Table 2-3. EU-27 Stock Dishwasher Energy Consumption BAU Scenario

EU-27 projection	2010 (TWh/yr)	2015 (TWh/yr)	2020 (TWh/yr)	2025 (TWh/yr)	2030 (TWh/yr)
Stock annual energy consumption BAU scenario	33.4	36.7	39.3	41.1	42.4

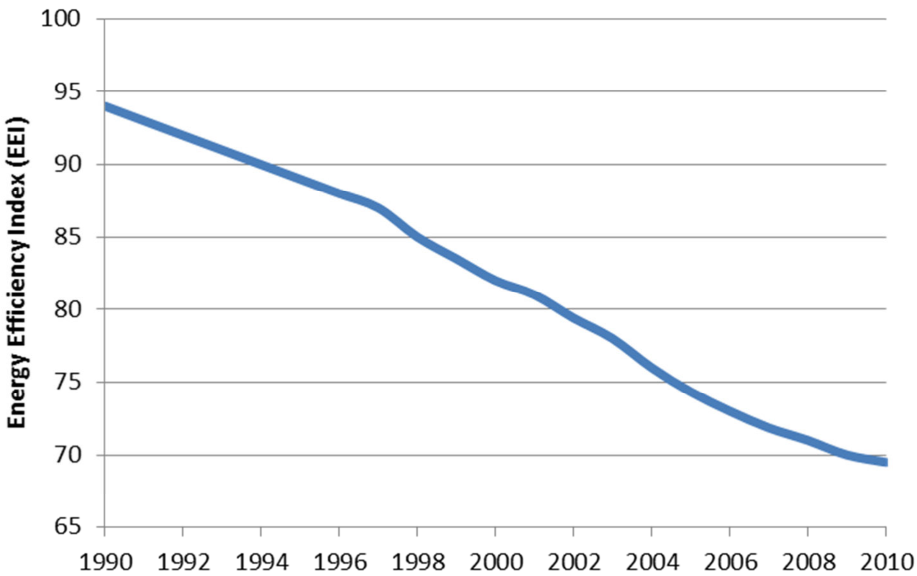
[7] The lot 14 Preparatory Study (2007) based the calculation of the annual energy consumption on the assumption of 208 cycles per year in task 2 (as did earlier publications) but on 280 cycles per year in task 7 in the description of 'BAU' and 'New Policy' scenarios. This paper uses the 280 cycles assumption that was decided to be the basis for the current Ecodesign and Labelling regulations, and assumes this remains constant to 2030.

3 Technology Assessment

The most significant environmental impacts associated with the life-cycle of dishwashers are energy and water consumption in the use phase. Regarding energy, the influence of the power consumption in low power modes such as left-on mode and off mode are of secondary importance.

The metric used to determine the energy efficiency class (labelling class) of a given dishwasher model was not the same in the previous Energy Labelling regulation and the current energy label. In the current regulations, an Energy Efficiency Index (EEI) is used in both the ecodesign and energy labelling regulations and is based on calculating the annual energy consumption during usage and including low power modes (i.e., left-on and off) and its relation to a standard annual energy consumption which varies with the number of place settings of the machine under test. For this reason, direct comparison of the old measure of specific energy consumption and the new EEI values is difficult, however by using the empirical average relationship developed by testing dishwashers under both test methods, a conversion factor that allows for the development of an indicative trend in EEI from 1990 to 2010 can be established, as shown in the figure below.

Figure 3-1. EEI Trend for Dishwasher Sales, European Market 1990-2010



By 2012, the average EEI of dishwasher sales is approximately 67, while the most efficient models in the European market have an EEI of 49.[8]

3.1 Design Options Related to Energy Efficiency

The design options that are related to improving the energy-efficiency of dishwashers include improved pump and motor efficiency, temperature-time trade-off, improved water spraying, sophisticated electronic process controls and sophisticated electronic water and temperature controls.[9,10] Overall,

[8] Top-Ten website, dishwasher sales. See: www.topten.eu

[9] Group for Efficient Appliances (GEA), Study for the Commission of the European Communities on 'Washing Machines, Dryers and Dishwashers', Final Report, June 1995.

these technological improvements resulted in a reduction in the average energy consumption of 25% between 1997 and 2010. Further improvements in these areas are still possible, including additional design options like adsorption drying systems that were recently introduced into the market.

The design options with the greatest potential to further reduce the energy consumption are temperature-time trade-off, sensors and innovative drying systems. Each of these options is discussed in more detail in the following subsections.

3.1.1 Temperature-Time Trade-Off

Similar to a washing machine, a dishwasher has four factors that all contribute to the cleaning process: (1) mechanical action of water striking the surfaces of the dishes and glassware, (2) chemistry of the detergents, (3) temperature of the wash cycle and (4) duration of the wash cycle. Generally, the dishwasher's effectiveness cleaning will increase with more vigorous mechanical action, more detergent, higher water temperatures, and longer wash cycles. These four factors contributing to cleaning are referred to as "Sinner's circle".[11]

A large proportion of the total electrical energy consumed by a dishwasher is used heating the water used in the cleaning phase. The electrical energy consumed can be reduced by lowering the water temperature and compensating for the reduction in cleaning effectiveness by increasing the wash cycle duration. This design option benefits from new dishwasher detergents that are formulated to offer improved performance at lower wash cycle temperatures. The application of this design option has contributed to improved energy-efficiency with very long wash cycle durations for European dishwashers. This temperature-time trade-off is one of the most important options for reducing energy consumption while maintaining cleaning performance.

3.1.2 Sensors, Automatic Load and Soil Detection, Sophisticated Controls

Another approach for reducing energy consumption per wash cycle involves using sensors that automatically detect the load size and soil level, and then intelligently adjust the quantity of water, the spraying and other parameters of the wash cycle. These sensors and controls represent another option for reducing the average energy consumption per cycle – however, the standard performance test would not detect these design option improvements because this test only measures the washing machine with a full load and a defined soiling level.

3.1.3 Innovative Drying Process

A conventional dishwashing cycle typically has two heating phases, the first for heating water during the cleaning stage and the second for heating water at the beginning of the drying cycle to heat up the dishes. During the drying phase, the dishes are heated up and evaporate the water that remains on the surface of the dishes. The introduction of an open cycle adsorption technology would allow designers to omit the second heating phase. If this new technology is used, then the dishes are dried by a hot air flow, circulated through a packed bed of microporous adsorbents such as zeolites, removing the

[10] Lot 14 (2007) Preparatory Studies for Eco-design Requirements of EuPs (Tender TREN/D1/40-2005) LOT 14: Domestic Washing Machines and Dishwashers, Final Report.

[11] The term, Sinner's circle was coined in 1959 by Dr Herbert Sinner of the German detergent supplier Henkel. It conveys the idea that that the reduction of one factor (e.g., using less detergent) can be compensated for by any of the three other factors: time, mechanical energy or temperature. Recent research suggests that the picture is more complex. For instance, enzyme activity can be ruined when using water at too high a temperature.

moisture from the air and heating it up. Using such technologies could reduce energy consumption by as much as 20%[12] while providing excellent drying performance, especially of dishes that have low heat capacity, such as plastic items.

3.2 Other Technology Trends

Some other areas of dishwasher technology that are being developed address other performance aspects that meet other market demands, including special programmes, shorter cycle durations and hygiene washes. Although the ‘normal’ or ‘eco’ programmes still represent the wash cycles predominantly used by consumers, a growing number of dishwashers are offering a wide range of special programmes designed to give an optimised balance between required cleaning performance and energy and water consumption.

- Intensive wash programmes - these cycles are designed for very dirty pots, pans and dishes that would normally need soaking. They tend to use more energy and water than the normal wash programmes, but should prevent the items needing a second wash cycle by addressing the baked-on food in one cycle.

- Half/small load programmes - despite the trend toward dishwashers with higher capacities, in a household kitchen, the washers may still be used to clean smaller loads. Such partial loads can be adequately cleaned with less energy and water consumption. Small load programmes are one alternative to sensors that detect the load size and soil level in the water and manage the wash cycle accordingly.

- Automatic programmes - in automatic programmes, dishwashers use sensors to detect the soil level of the water in the machine and then set the water temperature, wash duration and/or other wash cycle parameters to minimise the use of energy and water while ensuring adequate cleaning.

- Shorter duration programmes - as discussed above, longer cycle durations in the normal and eco-programmes substantially improve the energy-efficiency of the wash cycle. However, consumers may wish to have the option to use a shorter wash programme that uses a higher wash cycle temperature to ensure satisfactory cleaning performance.

- Hygiene programme – new machines are also now shipping with a special cycle that addresses optimum hygiene for special items such as baby bottles and chopping boards. These cycles are more energy intensive, and operate at a very high temperature to sanitise the wash load. This wash cycle can also be used as a self-cleaning programme to avoid the risk of bacteria and mildew growth inside the machine, and the formation of a biofilm.

[12] Heissler, Lävemann, ‘Large Energy Savings by Sorption-assisted Dishwasher’, EEDAL conference Berlin 2009

4 Energy Savings Potential

The purpose of this section is to provide an estimate of the potential for additional energy savings from revised regulations in the context of different levels of ambition. After briefly setting out the requirements of existing regulations, a high, medium and low ambition illustrative policy scenario is presented based on the preceding assessment of technological development. These policy scenarios provide an indicative estimate of the energy savings potential, based on updated regulatory requirements.

4.1 Existing Regulations

4.1.1 Ecodesign

Annex I of ecodesign regulation EU No 1016/2010 established the following performance requirements for dishwashers:

2. SPECIFIC ECODESIGN REQUIREMENTS

Household dishwashers shall comply with the following requirements:

(1) From 1 December 2011:

- *(a) for all household dishwashers, except household dishwashers with a rated capacity of 10 place settings and a width equal to or less than 45 cm, the Energy Efficiency Index (EEI) shall be less than 71;*
- *(b) for household dishwashers with a rated capacity of 10 place settings and a width equal to or less than 45 cm, the Energy Efficiency Index (EEI) shall be less than 80;*
- *(c) for all household dishwashers, the Cleaning Efficiency Index (I_C) shall be greater than 1,12.*

(2) From 1 December 2013:

- *(a) for household dishwashers with a rated capacity equal to or higher than 11 place settings and household dishwashers with a rated capacity of 10 place settings and a width higher than 45 cm, the Energy Efficiency Index (EEI) shall be less than 63;*
- *(b) for household dishwashers with a rated capacity of 10 place settings and a width equal to or less than 45 cm, the Energy Efficiency Index (EEI) shall be less than 71;*
- *(c) for household dishwashers with a rated capacity equal to or higher than 8 place settings, the Drying Efficiency Index (I_D) shall be greater than 1,08;*
- *(d) for household dishwashers with a rated capacity equal to or less than 7 place settings, the Drying Efficiency Index (I_D) shall be greater than 0,86.*

(3) From 1 December 2016:

- *(a) for household dishwashers with a rated capacity of 8 and 9 place settings and household dishwashers with a rated capacity of 10 place settings and a width equal to or less than 45 cm, the Energy Efficiency Index (EEI) shall be less than 63.*

The Energy Efficiency Index (EEI), the Cleaning Efficiency Index (I_C) and the Drying Efficiency Index (I_D) of household dishwashers are calculated in accordance with Annex II.

4.1.2 Energy label

The energy labelling regulation EU No 1059/2010 specifies seven energy efficiency classes from D (least efficient) to A+++ (most efficient), as shown in the table below. According to the implementing measure, most articles in the regulation applied from 20 December 2011, including the responsibility of suppliers to provide a printed label in the format and containing information set out in Annex I of the energy labelling regulation. The other articles became applicable on 20 April 2012, including for example the requirement that any advertisement for a specific model of household dishwasher contain the energy efficiency class if the advertisement discloses information on the energy consumption or price.

Table 4-1. Energy Classes from Dishwasher Labelling Regulation EU No 1059/2010

Energy Efficiency Class	Energy Efficiency Index
A+++ (most efficient)	EEI < 50
A++	50 ≤ EEI < 56
A+	56 ≤ EEI < 63
A	63 ≤ EEI < 71
B	71 ≤ EEI < 80
C	80 ≤ EEI < 90
D (least efficient)	EEI ≥ 90

The Energy Efficiency Index (EEI) of a household dishwasher is calculated in accordance with point 1 of Annex II of the ecodesign regulation or with point 1 of Annex VII of the energy labelling regulation.

The Tier 1 ecodesign requirements that became effective on 1 December 2011 do not allow energy efficiency classes C and D anymore and they only allow class B for machines with a capacity of 10 place settings and a width of 45 cm or less. After 1 December 2013, the Tier 2 requirements will come into force eliminating class A for all machines with a rated capacity of 11 or more place settings and machines with a rated capacity of 10 place settings and a width higher than 45 cm.

4.2 Illustrative Policy Scenarios

Energy savings estimates have been prepared for each of the seven products scheduled for review. These savings estimates are based on three illustrative potential policy scenarios that incorporate revised ecodesign requirements and energy labelling categories. The scale of increases and timing of new requirements were informed by the scale of increases and timing in the existing implementing measures in addition to the assessment of technological progress. These policy scenarios provide an indicative estimate of energy savings, based on possible technology improvements for this product group. The three policy scenarios developed for dishwashers are presented in the following table.

Table 4-2: Three Illustrative Scenarios for Dishwashers

Scenario	Ecodesign	Energy Label
1	Tier 1 from 2019 with EEI ≤ 56 for machines with 11 place settings and EEI ≤ 63 for 10 place settings or less	HELC[13] in 2016 at EEI ≤ 45
2	Tier 1 from 2017 with EEI ≤ 56 for machines with 11 place settings and EEI ≤ 63 for 10 place settings or less	$HELC_{-1}$ in 2016 at EEI ≤ 45 HELC in 2016 at EEI ≤ 40
3	Tier 1 from 2016 with EEI ≤ 56 for machines with 11 place settings and EEI ≤ 63 for 10 place settings or less Tier 2 from 2019 with EEI ≤ 50 for machines with 11 place settings and EEI ≤ 56 for 10 place settings or less	$HELC_{-2}$ in 2016 at EEI ≤ 45 $HELC_{-1}$ in 2016 at EEI ≤ 40 HELC in 2016 at EEI ≤ 36

The first scenario assumes that new ecodesign regulations come into effect from 2019 at an EEI of 56 for machines with 11 or more place settings and an EEI of 63 (i.e., one class more ambitious) for machines with 10 place settings or less. This scenario also assumes a new energy label is introduced in 2016 having a new, higher energy label class with an EEI of 45.

The second scenario assumes a new ecodesign regulation that enters into effect from 2017 at an EEI of 56 for machines with 11 or more place settings and an EEI of 63 (i.e., one class more ambitious) for machines with 10 place settings or less. This scenario also includes two new energy label classes are introduced in 2016, one with an EEI threshold of 45 and the other with an EEI threshold of 40.

The third scenario assumes a new ecodesign regulation comes into effect in two steps – an EEI of 56 from 2016 and an EEI of 50 from 2019 for machines with 11 or more place setting and levels one class more ambitious for machines with 10 place settings or less. This scenario also includes three new energy label classes are introduced in 2016, one with an EEI of 45, one with an EEI of 40 and a third one with an EEI of 36.

The three scenarios have implications for the spread of energy classes on the label. By 2016, or 2019 at the latest, all models would have to have at least EEI of 56. This is the current lower boundary of the A++ category and would mean that there would only be two classes of models left on the market, A++ and A+++. Given that the best available models on the market today are at EEI 49, and given the scope for technology improvement highlighted above, there seems room to introduce more ambitious labelling categories beyond A++ and A+++. This would seem to require the redrawing of the label in order to avoid a scale entirely made up of As.

The table below presents how the sales-weighted average EEI might evolve in the EU-27 under these three scenarios.

[13] Highest Energy Labelling Class (HELC). Illustrative new next highest classes are represented with sub-scripts in this table.

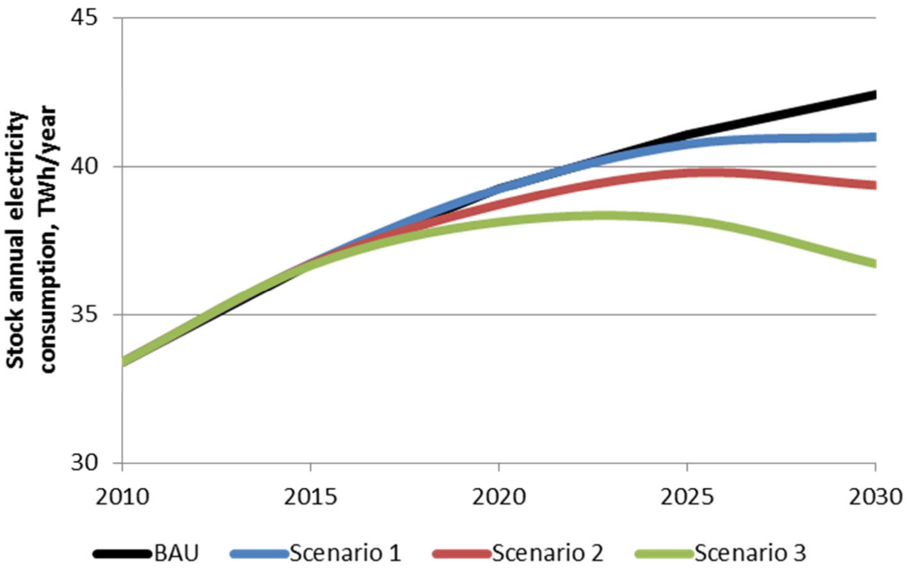
Table 4-3. Projected Estimate of Sales-Weighted Average EEI for Stock of Dishwashers

EU-27 Projection	2010	2015	2020	2025	2030
BAU (average EEI)	71	60	55	51	51
Scenario 1 (average EEI)	71	60	54	49	47
Scenario 2 (average EEI)	71	59	52	48	43
Scenario 3 (average EEI)	71	58	49	43	40

4.3 Energy Savings Potential

As more energy efficient dishwashers are sold into the market each year, the fleet average efficiency improves and reduces the total energy consumption of dishwashers across the EU-27 as compared to the BAU scenario. The effect of the three illustrative policy scenarios on total energy consumption of across the EU-27 relative to the BAU scenario is shown in the figure below.

Figure 4-1. Projected Stock Energy Consumption for BAU and Scenarios, EU-27

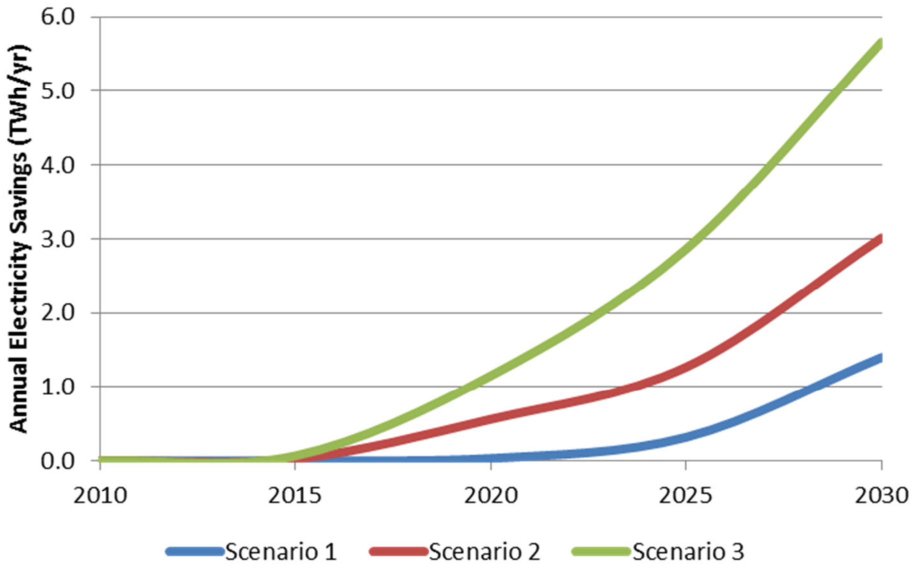


By 2030, the energy savings potential of the three illustrative policy scenarios would be between 1.4 and 5.7 TWh of electricity saved per annum. This is shown in the table and figure below.

Table 4-4. Projected Annual Energy Savings to 2030, Scenarios 1-3, Household Dishwashers

EU-27 Projection	2010 (TWh/yr)	2015 (TWh/yr)	2020 (TWh/yr)	2025 (TWh/yr)	2030 (TWh/yr)
Scenario 1	0	0	0.03	0.32	1.40
Scenario 2	0	0.02	0.56	1.27	3.01
Scenario 3	0	0.07	1.15	2.86	5.66

Figure 4-2. Projected Energy Savings for Dishwashers, Three Policy Scenarios



Across the EU, dishwashers are projected to consume 39.3 TWh of electricity in 2020. The electricity savings estimate from Scenario 2 is 0.56 TWh in that year, or approximately 1.4% of the baseline electricity consumption estimate in that year. By 2030, the electricity savings estimate from Scenario 2 is 3.0 TWh, or 7.1% of the baseline.

5 Additional Issues

In line with the framework directives, the reviews must, respectively, assess potential future minimum performance requirements and potential reclassification of labelling categories in light of technological progress. Above we have provided three illustrative policy scenarios in support of this. Further, implementing measures often require additional issues to be assessed in connection with the review. Finally, it may be that some issues have come to light since the development of the implementing measure and while not specified, could be relevant to include in a review. Below we consider both types of issues.

5.1 Additional Issues Required by the Implementing Measures

Both implementing measures require reviews to assess verification tolerances. The opportunity for setting requirements with regard to the water consumption of household dishwashers and the potential for hot water inlet are not discussed in this paper.

5.1.1 Verification Tolerances

Test standard measurements are a critical part of any regulatory programme. It is worth noting that with the steady improvement of energy efficiency of dishwashers, the measured energy consumption decreases and the relative uncertainty around that measurement could increase. Test method standardisation groups are constantly aiming at improving reproducibility – however, the actual remaining uncertainty of energy data measured according to the test standard must to be taken into consideration whenever requirements for verification tolerances around the new energy classes are discussed.

5.2 Additional Issues Not Anticipated in the Implementing Measure

5.2.1 Potential Consumer Confusion Regarding Temperature – Time Trade-off

One of the principal methods for reducing energy consumption in the wash cycle is to reduce the wash temperature – which then needs to be compensated for by longer programme time to maintain the same level of cleaning performance. However, consumers may wrongly assume that a short programme has lower energy consumption than the longer programme, or may simply choose the short programme for convenience and thereby end up using more energy per wash than they expected.

5.2.2 Water Efficiency

Although the regulations do not specify water usage requirements, manufacturers of household dishwashers are required to provide information about water consumption of the main wash programmes. And, the regulations also indicate the benchmarks for best-performing products and technology available on the market addressing water consumption, among other factors.

According to the preparatory study, the average automatic dishwashing frequency is 4.1 cycles per week. At this frequency of use, dishwashers are estimated to use between 6 and 14% of water consumption in an average European household. The study found that replacing the current stock with more efficient products would result in a water saving potential of 55%, or between 3% and 7% of total annual household consumption of water.

The EU Topten programme maintains a website that is constantly updated with new and improved products representing the best available technology in the market. For dishwashers, this website was accessed[14] and the best performing units on the European market are set in the table below. All of the models listed meet or have lower water consumption than the ecodesign benchmark value of 2,800 litres consumption per year (*i.e.*, 10 litres of water per wash cycle) for dishwashers with more than nine place settings. It is also worth noting that they all incorporate a hot water inlet.

Table 5-1. TopTen Study Identifying Best Performing Dishwashers on the European Market

Brand	Model	Energy & water costs*	Place settings	Water Use (l/year)	Hot water supply	Energy Label Class	Energy Use (kWh/year)
Built-in							
Bosch	SMV69U70EU	€ 1,201	13	1,960	yes	A+++/A	194
Siemens	SX56V594EU	€ 1,201	13	1,960	yes	A+++/A	194
Siemens	SN66M036CH	€ 1,512	13	2,660	yes	A+++/A	211
Bosch	SMV69M70EU	€ 1,519	14	2,660	yes	A+++/A	214
Bosch	SMV69U60EU	€ 1,519	14	2,660	yes	A+++/A	214
Siemens	SN66M097EU	€ 1,519	14	2,660	yes	A+++/A	214
V-ZUG	Adora GS 60 SL-di	€ 1,614	13	2,800	yes	A+++/A	232
Gaggenau	DF 260	€ 1,618	13	2,800	yes	A+++/A	234
Miele	G 25705-60 Sci	€ 1,627	14	2,800	yes	A+++/A	238
Miele	G 15830-60 SCi	€ 1,627	14	2,800	yes	A+++/A	238
Freestanding							
Bosch	SMS58N52EU	€ 1,245	13	1,680	yes	A++/A	262
Siemens	SN25N280EU	€ 1,245	13	1,680	yes	A++/A	262
Bosch	SPS69T22EU	€ 1,458	10	2,520	yes	A++/A	211
Blomberg	GSN 9583 XB 630	€ 1,571	13	2,800	yes	A+++/A	213
Hoover	DDY 189 T	€ 1,632	15	2,800	yes	A++/A	240
Siemens	SN25L230EU	€ 1,673	12	2,800	yes	A++/A	258
BEKO	DFN-6632	€ 1,682	13	2,800	yes	A++/A	262
Bosch	SMS58N12	€ 1,691	14	2,800	yes	A++/A	266
Miele	G 15141-60 SC	€ 1,691	14	2,800	yes	A++/A	266

* Operating costs for water and electricity in Euros over 15 years.

While these values represent the energy and water usage for a normal wash cycle, the actual energy and water usage may change from those given on the energy label depending on the characteristic of actual programme selected by the user. Innovative dishwashers are equipped with a number of cycle

[14] TopTen.eu Best Products of Europe – Dishwashers. Website accessed 29 January 2013. Built-in dishwashers: http://www.topten.eu/english/household/dishwasherss/built-in-2.html and Free-standing dishwashers: http://www.topten.eu/english/household/dishwasherss/freestanding-2.html

choices, providing consumer with option to match a cycle to the type of load, thus increasing efficiency of both cleaning and resource use.

The issue of water efficiency as it relates to dishwasher wash cycles is a topic that warrants further analysis in the review of this product. Clearly, new technologies are being developed and applied by manufacturers that not only improve the energy efficiency of the appliance, but also its water efficiency, and thus the overall environmental impact per wash is being reduced.

Annex E. Tertiary Lighting

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1 Introduction and context

In common with the other six annexes, this annex starts by setting out the timetable and scope of the upcoming reviews. It then sets out the scope of the existing implementing measures. Having provided this context, a BAU energy consumption scenario is developed. Next an assessment of technology developments is made and this is used to develop a set of illustrative policy scenarios on the basis of which a range of energy savings potentials are defined. Finally, a set of issues of relevance in the context of upcoming reviews is outlined.

1.1 Timetable and Scope of the Upcoming Review

Commission Regulation EC No 245/2009[1] on tertiary lighting states in Article 8 that it shall be reviewed no later than five years after its entry into force i.e. by 13 April 2014 and the results of that review shall be presented to the Ecodesign Consultation Forum. There are no special requirements for that review, only that it should be conducted “in light of technological progress.”

1.2 Scope of Coverage of the Implementing Measure

Ecodesign regulation EC No 245/2009, Article 1 states which lamps are included in the regulation:

> *“This Regulation establishes ecodesign requirements for the placing on the market of fluorescent lamps without integrated ballast, of high intensity discharge lamps, and of ballasts and luminaires able to operate such lamps as defined in Article 2, even when they are integrated into other energy-using products.*
>
> *This Regulation also provides indicative benchmarks for products intended for use in office lighting and public street lighting.*
>
> *The products listed in Annex I shall be exempt from the requirements set out in this Regulation.”*

Thus, the scope of coverage for regulation EC No 245/2009 relates to lamp types and components that are primarily used in highway, office, and industrial lighting applications. Fluorescent lamps without an integrated ballast (single- and double-ended lamps) include: rod-shaped fluorescent lamps, compact fluorescent lamps, circular lamps and U-shaped lamps. High intensity discharge (HID) lamps are often used in street lighting, and outdoor and indoor sports lighting and industrial area lighting. The most common HID-lamps are metal halide lamps, high- pressure sodium lamps and high pressure mercury lamps. The scope also includes ballasts that are used to operate fluorescent and HID lamps as well as luminaires for these lamps.

[1] Commission Regulation (EC) No 245/2009 of 18 March 2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for fluorescent lamps without integrated ballast, for high intensity discharge lamps, and for ballasts and luminaires able to operate such lamps, and repealing Directive 2000/55/EC of the European Parliament and of the Council.

2 Market Projection

2.1 Tertiary Lighting Stock and Sales Projection

Many products are covered under the regulation EC No 245/2009. These include fluorescent lamps – both single and double-ended, HID lamps, operating ballasts and luminaires. Modelling all of these products accurately, taking into account differential growth in commercial and industrial buildings and roadways, typical fixtures and lighting levels, and accounting for replacements of ballast and fixtures would be a complex task. Indeed, the impact assessment[2] did not attempt to prepare a detailed model in quantifying the estimated energy savings potential. Instead, the impact assessment presents a projection of lamp shipments to 2020 looking at sales, stock and turnover of affected lamps. The model presented in this Annex follows this same approach, calibrating the projections of shipments, energy consumption and energy savings to the impact assessment.

There is, however, an important difference between the impact assessment[3] and the model presented here. The impact assessment was prepared when LED technology was in its nascent stage of commercialisation, i.e., just entering the market. There were few applications using LED technology, particularly in general illumination. Therefore, LED technology was excluded from the market forecasts and modelling efforts in preparation for the regulation. In 2013, omitting LED technology would be a less reasonable assumption as LED lighting is beginning to compete directly with fluorescent and HID sources covered under EC No 245/2009.

Therefore, the BAU scenario presented here assumes the following: (1) all stages of regulation EC No 245/2009 are implemented and (2) LED technology penetrates the market at the rate forecast in a 2012 US DOE study[4].

The model presented in this Annex is a simplified version of the actual tertiary lighting market which, as noted above, would be very complex to characterise. The methodology followed here is meant to provide a reasonably sound estimate of European energy consumption to 2030, against which energy savings scenarios can be developed. The steps followed in estimating annual sales and stock of tertiary lighting are outlined below.

The model takes as its starting point the lamp shipment estimates from the preparatory study (shown in the table below). [5]These in turn, were based on shipment data from the European Lamp Companies Federation (ELC).[6] The model then projects lamp shipments using the same categories to the year 2030.

---

[2] COMMISSION STAFF WORKING DOCUMENT Accompanying document to the Commission Regulation implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for fluorescent lamps without integrated ballast, for high intensity discharge lamps, and for ballasts and luminaires able to operate such lamps, and repealing Directive 2000/55/EC of the European Parliament and of the Council FULL IMPACT ASSESSMENT
Link: http://ec.europa.eu/governance/impact/ia_carried_out/docs/ia_2009/sec_2009_0324_en.pdf

[3] Neither the impact assessment nor the preparatory study considered LED lighting in their market forecasts, whether baseline estimates or energy savings estimates.

[4] Energy Savings Potential of Solid-State Lighting in General Illumination Applications, Prepared for: Solid-State Lighting Program; Building Technologies Program Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy; Prepared by: Navigant Consulting, Inc. January 2012

[5] Preparatory Studies for Eco-design Requirements of EuPs: Final Report Lot 8: Office lighting, P. Van Tichelen et al., Study for the European Commission DGTREN unit D3, Andras Toth; prepared by VITO, April 2007

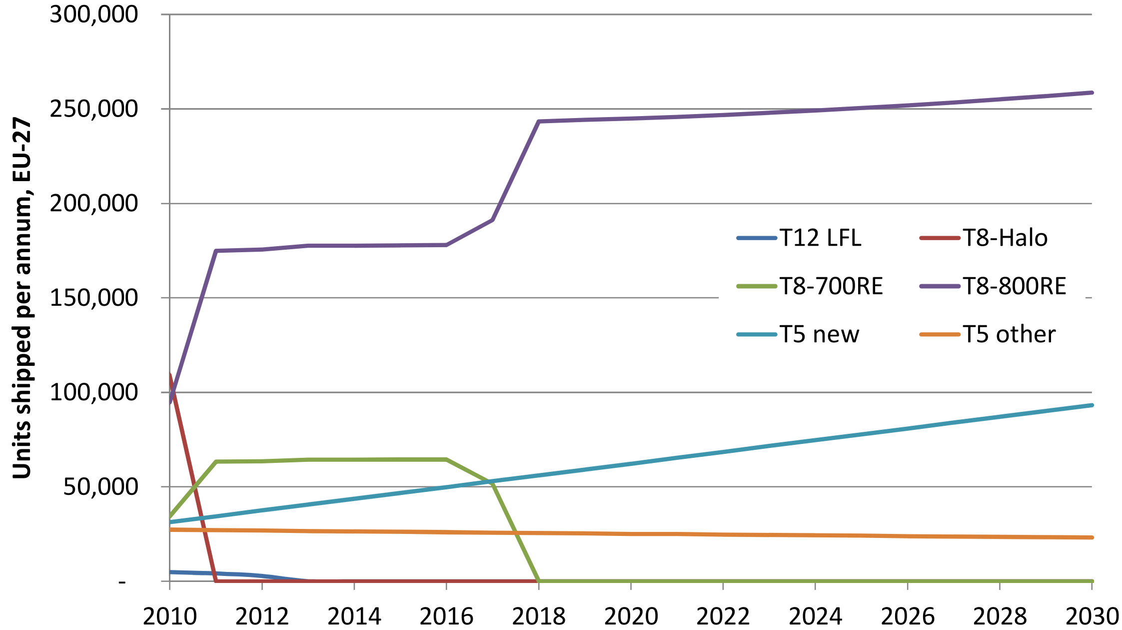
[6] Note: in December 2012, the European Lamp Companies Federation (ELC) and the Federation of National Manufacturers Associations for Luminaires and Electrotechnical Components for Luminaires in the European Union (CELMA) merged to form LightingEurope

Table 2-1. ELC Sales Data from Preparatory Study for Europe

	1999	2000	2001	2002	2003	2004
Linear Fluorescent Lamps (LFL), thousand units						
T12	24,179	25,808	19,619	17,486	15,672	14,164
T8 halo-phosphor	116,392	126,321	126,041	127,290	135,310	149,982
T8 tri-phosphor	75,146	80,660	83,050	85,038	79,499	88,312
T5 (14 -80W)	-	-	-	-	9,598	12,133
Other T5 and special	26,679	28,514	30,654	29,923	31,196	33,048
Total LFL:	242,396	261,303	259,364	259,737	271,275	297,639
Compact Fluorescent Lamps (CFL), thousand units						
Non-Retrofit	40,355	45,750	47,366	48,612	51,131	56,049
High Intensity Discharge (HID) Lamps, thousand units						
Mercury	8,711	9,333	8,501	8,542	8,151	7,938
Sodium	8,801	9,151	10,265	10,206	10,457	10,982
Metal Halide	5,649	6,935	7,531	8,011	8,958	10,714
Total HID	23,161	25,419	26,297	26,759	27,566	29,634

The model then imposes the different stages of the regulation on the shipments of those lamps that are affected by the requirements of the regulation. For example, stage 1 of the regulation established an efficacy requirement that phased-out T8 halo-phosphor starting in September 2010. The figure below illustrates the substitution effect on the shipments of fluorescent lamps to the Europe. For T8 lamps, three subcategories of products were identified – one group based on the halophosphor, one group based on the 700-series rare-earth phosphor and one group based on the 800-series rare-earth phosphor. As shown in the figure, the T8 market is pushed to the 800-series phosphor, which is more efficacious than the 700-series (and also provides better colour rendering).

Figure 2-1. Interim Step Projection of Fluorescent Lamp Shipments in Europe, BAU Scenario



Similar projections were prepared for the other products covered (including non-integrally ballasted CFLs and the three HID lamp types, high pressure mercury, high pressure sodium and metal halide). For these other lamp types, the ELC shipments database did not provide sufficient granularity of compliant versus non-compliant lamps with respect to the regulatory requirements. Therefore, the total lamp shipments by product type from the ELC shipments dataset were apportioned to compliant and non-compliant products using the same proportions as those from in the Impact Assessment.[7] The following table presents these values from the Impact Assessment, and illustrates how the ELC shipments data was divided for the purposes of calculating the energy consumption of the installed stock. The lamp wattage and annual operating hours were taken from the Impact Assessment.

[7] These proportions can be found in the Impact Assessment in Annex IV, Lamp types affected by the stages of sub-option 2 and their respective electricity consumption in 2005, on page 40 of the English version.

Table 2-2. Apportioning Lamp Shipments for Stock Energy Consumption Calculation

ELC Database Category	% in Impact Assessment	New Lamp Categories	Rated Wattage (Watts)	Annual Operating Hours
T12	100%	T12 LFL	35	3,500
T8 Halo	100%	T8-Halophosphor	32	3,500
T8 Triphosphor	27%	T8-700RE triphosphor	30	3,500
	73%	T8-800RE triphosphor	28	3,500
T5 new	100%	T5 new lamps	25	3,500
T5 other	100%	T5 and other	12	3,500
CFLni	50%	CFLni - noncompliant	11.5	3,500
	50%	CFLni – compliant	9.5	3,500
Mercury	100%	High Pressure Mercury	250	4,000
Sodium	74%	HPS - Stage 2 noncompliant	140	4,000
	2%	HPS - Stage 3 noncompliant	140	4,000
	24%	HPS – compliant	120	4,000
Metal Halide	4%	MH - Stage 2 noncompliant	225	4,000
	10%	MH - Stage 3 noncompliant	175	4,000
	86%	MH – compliant	150	4,000

By applying wattages and the percentage share of compliant and non-compliant products (see table above) to the aforementioned shipment projections, the energy savings due to shifts from non-compliant to compliant products can be estimated to ensure that the sales and stock in the CLASP market model are consistent with the previous impact assessment market model.

2.2 Projected energy consumption

The next step was to enter these shipments into an inventory stock model to calculate the energy consumption of the installed stock of compliant lamps. That estimate could then be compared to the estimated energy consumption of the tertiary lighting market in the Impact Assessment to be sure that the new stock model is calibrated correctly. The results are shown below. It should be noted that in this table LED technology has not yet been integrated into the BAU scenario.

Table 2-3. Comparison of New Stock Model vs. Impact Assessment Model

Year	New Tertiary Lighting Model (TWh/yr)	Impact Assessment Sub-Option 2 (TWh/yr)
2010	225.5	218.1
2011	226.3	218.7
2012	227.0	219.6
2013	227.1	219.6
2014	227.7	220.0
2015	228.6	220.7
2016	229.5	222.4
2017	231.1	224.4
2018	232.7	223.4
2019	234.9	222.6
2020	237.6	222.2

The new tertiary lighting model developed for this paper has approximately 3 to 7% higher electricity consumption compared to the Impact Assessment Sub-Option 2 (the representation of the regulation as it was adopted). The new market model is, therefore, deemed to be reasonably well aligned with the model used for the Preparatory Study and the Impact Assessment.

Now that an estimate of energy consumption has been prepared and validated against the impact assessment, the next step is to improve that BAU forecast by taking into account LED lamps and luminaires. LEDs are entering the tertiary lighting market today as both replacement lamps and dedicated luminaires. Since regulation EC No 245/2009 applies to both lighting equipment categories, the model should take into account the possibility of end-users choosing to install an LED lamp as well as a dedicated LED fixture.

An estimate of the penetration rate of LEDs entering the commercial and industrial lighting markets was published by the US Department of Energy for the North American market, taking into account first-cost, electricity, maintenance, and payback periods.[8] One of the interim results reported in the DOE study is an estimate of the rate of market penetration of LEDs into the Commercial and Industrial lighting markets (note: DOE defines this metric as “LED market share (% of lm-hr)”).

These percentages are then applied to the European estimates of annual lumen-hour sales for the tertiary lighting market, after converting the unit sales of fluorescent and HID lamps into lumen-hour sales per year (lm-hr/yr). The table below presents the assumed lamp characteristics used to convert the European shipments into lighting service. The lamp characteristics and operating hours were taken from the Impact Assessment.

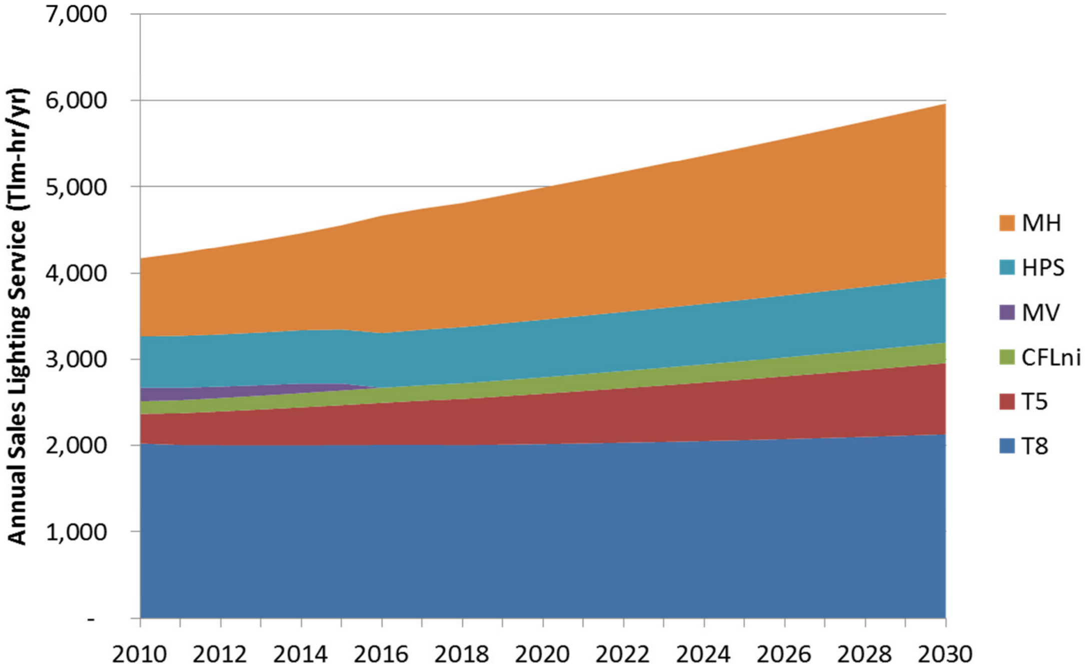
[8] Energy Savings Potential of Solid-State Lighting in General Illumination Applications, Prepared for: Solid-State Lighting Program; Building Technologies Program Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy; Prepared by: Navigant Consulting, Inc. January 2012

Table 2-4. Lamp Types and Characteristics to Determine Lighting Service (lm-hr/yr)

Lamp Type	Rated Wattage (Watts)	Efficacy (lm/W)	Light Output (lumens)	Annual Operating Hours
T12 LFL	35	70	2,450	3,500
T8-Halophosphor	32	75	2,400	3,500
T8-700RE triphosphor	30	80	2,400	3,500
T8-800RE triphosphor	28	84	2,352	3,500
T5 new lamps	25	91	2,275	3,500
T5 and other	12	86	1,032	3,500
CFLni - noncompliant	11.5	55	632	3,500
CFLni - compliant	9.5	65	617	3,500
High Pressure Mercury	250	40	10,000	4,000
HPS - Stage 2 noncompliant	140	95	13,300	4,000
HPS - Stage 3 noncompliant	140	95	13,300	4,000
HPS - compliant	120	110	13,200	4,000
MH - Stage 2 noncompliant	225	65	14,625	4,000
MH - Stage 3 noncompliant	175	82	14,350	4,000
MH - compliant	150	90	13,500	4,000

The values from the above table were then applied to the shipment forecast to calculate the lumen-hours of lighting service sold each year. The figure below presents this lighting-service shipment forecast for the conventional lamp technologies. The annual year-on-year shipments growth rate in terms of lumen-hours of lighting service delivered in Europe between 2010 and 2030 is approximately 1.8% per year.

Figure 2-2. Lighting Service Shipment Forecast, Teralumen-hours/year



The DOE study estimated the LED penetration rate as a percentage of total annual lumen-hours of lighting sales. The table below reproduces the values presented in the DOE study. For the Commercial and Industrial sectors, the relative proportion of lighting service sales was projected to increase from 0% to approximately 70% between 2010 and 2030. These same percentages were used to apportion to annual European shipments of tertiary lighting service (i.e., the teralumen-hours/year of lighting service shown in the figure above) to LED technology.

Table 2-5. US DOE Estimates of LED Market Penetration Rate (Lumen-Hour/year)

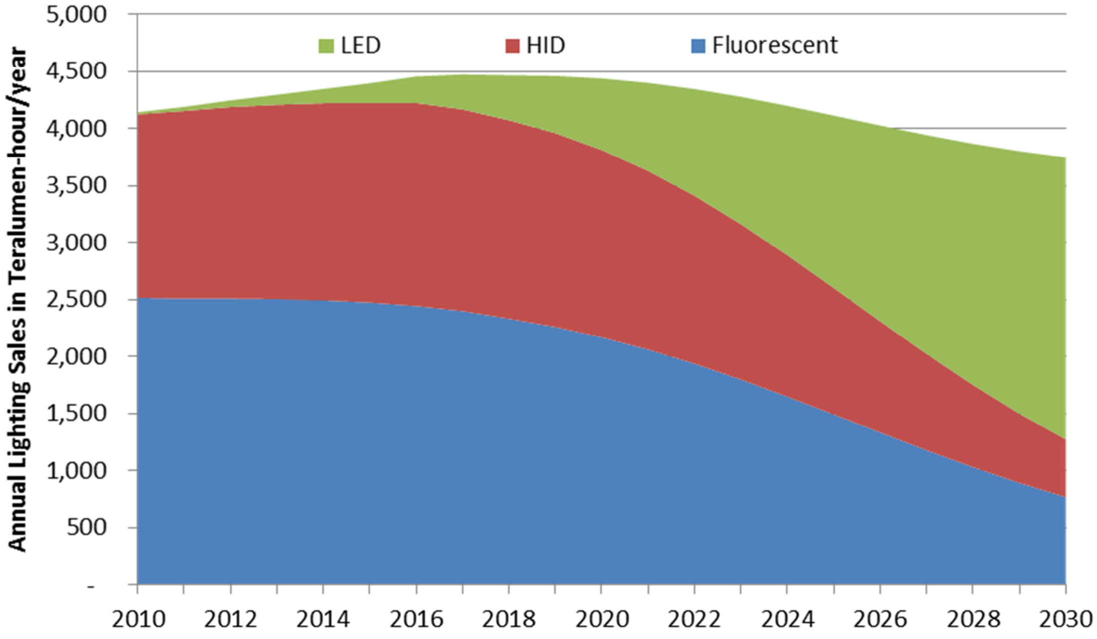
Sector	2010	2015	2020	2025	2030
Commercial	0%	5.0%	27.8%	52.2%	70.4%
Industrial	0%	8.8%	36.0%	59.2%	72.3%

Applying these estimated market penetration rates to the annual shipments of lighting service in Europe, the figure below was prepared. This figure below depicts the rate of penetration of LEDs relative to the other light sources, which are grouped into fluorescent and HID lamps. Please note that this trend does not represent stock of these lighting technologies in the tertiary sector, instead it is illustrating annual sales of lighting equipment by technology by light output (comparable to Figure 2-2).[9] Comparing the total lumen-hours of lighting service shipped each year, the annual value is declining as LED technology penetrates. The reason for this is because LED technology is assumed to have a 35,000 hour lifetime, which is approximately double that of fluorescent and HID lamps.

[9] This projection should not be confused with a revenue forecast for LED lighting versus fluorescent and HID lamps. LED lighting is today more expensive on a lumen per Euro basis than these other sources, which is part of the reason for its slow take-up in the market. However, as prices come down over time, payback periods shorten and it is expected that LED will achieve an increasingly larger market share.

Therefore, the replacement lamp business (i.e., the annual shipments of lighting service) will be lower in the future as longer life LED products enter the market.

Figure 2-3. Annual EU Tertiary Lighting Sales in Teralumen-hours/year



The final step is to calculate the energy consumption from this new BAU scenario that includes LED technology in the tertiary lighting sector. To prepare this estimate, the wattages and operating hours of the LEDs and conventional lamp technologies are applied to the installed stock of lamps. The wattages and operating hours for the conventional technologies are taken from the Impact Assessment.

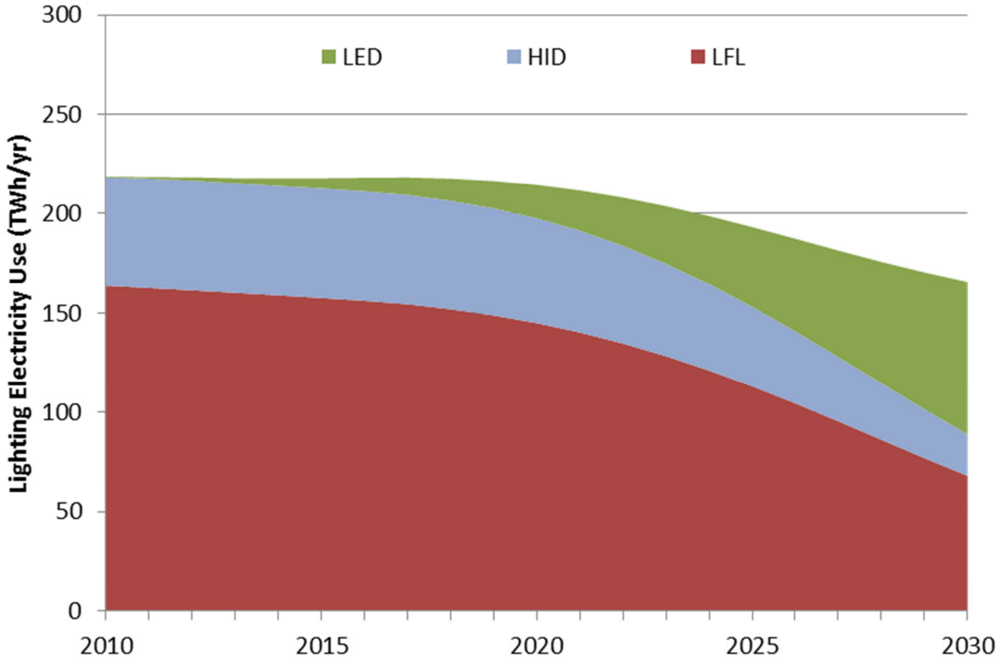
To determine the appropriate wattage of the LED systems being installed, the total lighting demand (teralumen-hours/year) is divided by the reported average efficacy of LED lamps and luminaires given in the US DOE study, resulting in terawatt-hours of electricity consumption for LED systems. The table below presents the LED efficacies used for this calculation.

Table 2-6. Average LED System Efficacy from US DOE, 2012

EU-27 projection	2010	2015	2020	2025	2030
LED System Efficacy (lm/W)	50	120	180	195	203

The following figure presents the annual electricity consumption in TWh for tertiary lighting in Europe under the BAU scenario.

Figure 2-4. Estimated EU Tertiary Lighting Electricity Use, Terawatt-hours/year



Presenting these results in a tabular form, the projected energy consumption for tertiary lighting is estimated to be approximately 218 TWh for the EU-27 in 2013. The table below presents the BAU estimated energy consumption for tertiary lighting in Europe.[10]

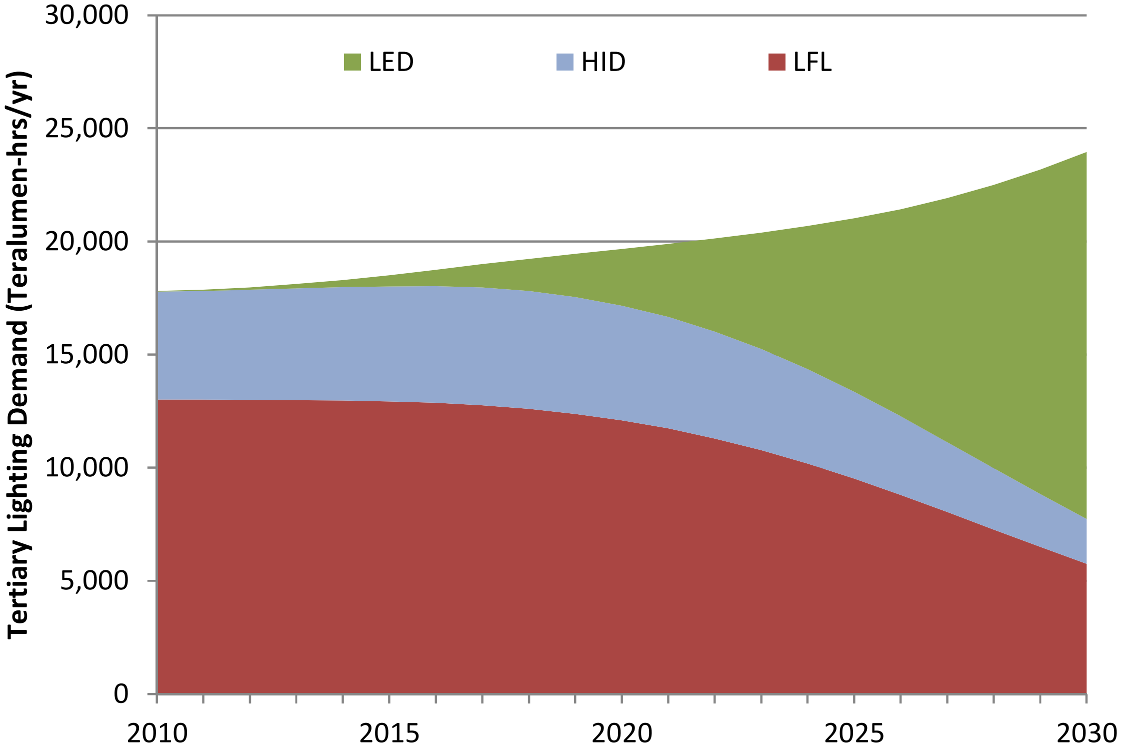
Table 2-7. BAU Electricity Consumption for Tertiary Lighting, EU-27

EU-27 projection	2010	2015	2020	2025	2030
Stock annual energy consumption (TWh), BAU	219	218	214	193	166

The BAU scenario projects a 24% reduction (53 TWh/yr) in the electricity demand for tertiary lighting over the analysis period (2010 to 2030). Over this same time period, the *quantity* of lighting service from the installed stock of tertiary lamps increases by 35% (see the figure below). This BAU scenario reflects the impact of the ecodesign regulation EC No 245/2009, the new energy labelling regulation EU No 1194/2012, and the anticipated improvements in LED-based lamps from the innovation and research efforts of lighting manufacturers.

[10] A BAU scenario was also run without LED to ascertain the anticipated impact in the market from the introduction of LED technology to tertiary lighting. The stock annual energy consumption in TWh/year were calculated as: 2010: 220 TWh; 2015: 221 TWh; 2020: 234 TWh; 2025: 252 TWh; 2030: 274 TWh.

Figure 2-5. EU Tertiary Lighting Stock Light Output, Teralumen-hours/year



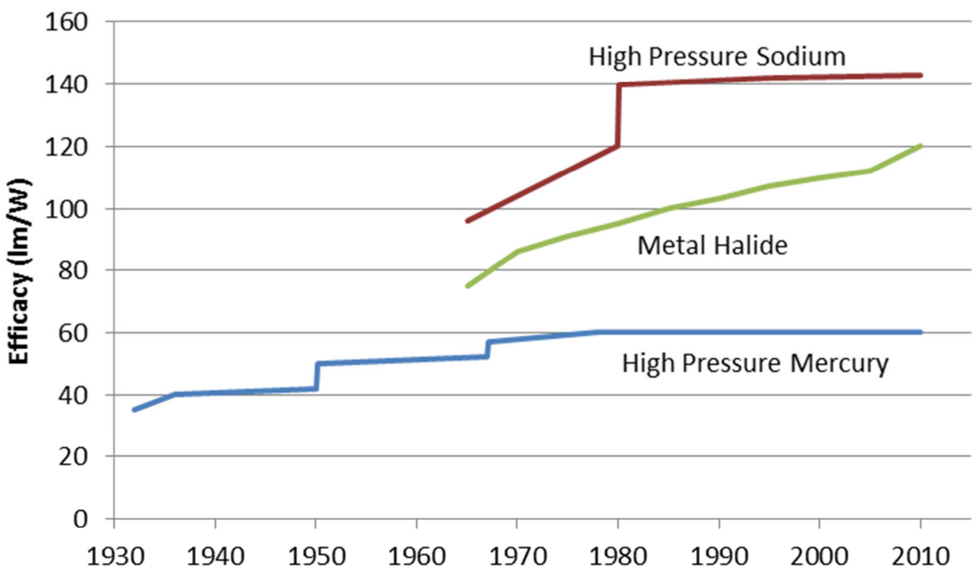
3 Technology Assessment

This section of the Annex briefly reviews HID lamps, fluorescent lamps and LEDs. Although they are not included in this paper, the other product groups falling under regulation EC No 245/2009 should still be included in the review.

3.1 High Intensity Discharge Lamps

HID lamps are often found in industrial and commercial applications, including street and area lighting and sports stadium illumination. There are three types of HID lamps – high pressure mercury (HPM), high pressure sodium (HPS) and metal halide (MH).[11] Of these, HPM and MH are considered white-light sources (although the HPM exhibits poor colour rendering) and HPS produces a yellow-orange colour light. With the notable exception of HPM which is comparatively inefficient and has declining sales in Europe; HPS and MH both have efficacies over 100 lumens per watt. The figure below presents the efficacy trends over time for commercially available HID lamps, starting with HPM in 1930s followed by the development of HPS and MH in the 1960s.[12]

Figure 3-1. Progression of Efficacy for HID Lamps, 1930-2010



Research into efficacy improvements for HID lighting technologies has generally followed market demand for these lamps. HPM is experiencing declining sales, and thus is no longer being researched to improve its performance. HPS has reached a plateau in terms of market sales, and research and development into HPS sources has essentially stopped, with any remaining effort focused on developing longer lamp lifetime and improved lumen maintenance. MH, on the other hand, is increasing in market share and is continuing to benefit from research to improve its performance. These three trends are reflected in the efficacy curves plotted in the figure above.

[11] Although low-pressure sodium lamps are not an HID lamp, they are sometimes used in similar applications such as street lighting or area lighting. Low pressure sodium lamps tend not to be used in new installations now, therefore they are not included in this discussion.

[12] Max Tech and Beyond: High-Intensity Discharge Lamps, Lawrence Berkeley National Laboratory, One Cyclotron Road, Berkeley, CA, USA; April 2012. Link: http://www.escholarship.org/uc/item/9491c4wx

In general, lighting manufacturers are moving the bulk of their research into solid-state lighting technologies, including LED. Of the HID lamp research programmes that remain, manufacturers tend to concentrate on MH technologies, with some limited amount of investment in HPS for specific niche applications (e.g., agricultural greenhouses). Thus, the efficacy values of commercially available HPM and HPS lamps are not expected to improve. MH lamps, and more specifically, ceramic MH lamps are continuing to improve in efficacy as well as light quality, manufacturability and lamp life. Within an HID lamp, the light-producing plasma must be heated to sufficiently high temperatures to achieve high efficiencies, without melting the electrodes or altering the operating conditions of the lamp. The research in ceramic MH has focused on the arc tube, the electrodes and the plasma, resulting in an innovation called the “unsaturated lamp.”[13]

The unsaturated lamp addresses a problem experienced by standard ceramic MH lamps where a pool of liquid salt develops in the arc tube while the lamp is operating. This pool of liquid salt limits the light characteristics of the lamp such as the efficacy and colour quality, and reduces the lamp lifetime. By making modifications to the arc tube, the pressure and the operating temperature, the unsaturated ceramic MH lamp resolves this issue by keeping all the halide salts in the gaseous phase, even while the lamp is dimming (down to 50%). This new arc tube also was improved with a better solution for sealing the electrodes, further improving lifetime and performance of the arc tube.

By avoiding the liquid salt issue and improving the electrode seals, this new lamp design significantly reduces the reaction and attack on the ceramic arc tube, so lamp lifetime will increase. Plus, this technology has the potential to offer high performance characteristics such as fast run-up to full brightness (<30 seconds), dimmability without colour shift, longer operating life, mercury-free lamps, hot re-strike and miniaturisation. Following on from these innovations, researchers are now focusing on optimisation and further improvement to the light quality and lamp efficacy.

Manufacturers currently offer ceramic MH lamps that can achieve over 120 lumens per watt (initial), well above the minimum rated efficacy values in Table 10 of the regulation EC No 245/2009. Even though the bulk of lighting research is into solid-state technologies, the efforts on HID are focusing on MH lamps have yielded impressive results. According to lighting industry researchers interviewed for the LBNL report, MH lamps should continue to improve their efficacy, incrementally, over the next 2 to 4 years, potentially reaching up to 150 lm/W.

3.2 Fluorescent Lamps

Fluorescent lamp technology is the most widely used artificial light source today, responsible for more than half the lumens delivered to our living spaces globally. Originally commercialised in the 1930s, manufacturers have been steadily improving the efficacy of these fluorescent lamps over the intervening years through modifications to the phosphors, cathodes, fill-gas, operating frequency, tube diameter and other design attributes.

Linear fluorescent lamps (LFLs) and compact fluorescent lamps (CFLs) are both mature technologies with known strengths and weaknesses. Even though fluorescent lamps date back over 80 years, the lighting industry has continued to invest in securing better performing lamps, in part due to the demanding consumers in the commercial and industrial markets. There has also been investment made

[13] “Unsaturated ceramic metal halide lamps – a new generation of hid lamps.” J. Hendricx, Philips Lighting, Proceedings of the 12th International Symposium on the Science and Technology of Light Sources (LS-WLED 2010), Eindhoven, pages 405-414, 2010.

to reduce the mercury content of fluorescent lamps, as legal requirements are being introduced and made more stringent.

Despite having commercialised lamps that offer more than 115 lumens per watt of energy, there are still areas where research may result in some performance improvements for fluorescent lamps, including:

- Phosphor improvements – better blends and new materials continue to be developed and patented, offering higher efficacies as well as better colour rendering and lumen maintenance over the lamp's service life;
- Enhanced fill gas – adjusting proportions of argon, krypton, neon and xenon to optimize performance, while also minimizing the mercury dose;
- Improved cathode coatings – these coatings can enhance electron emissivity and extend lamp life; and
- UV-reflective glass coatings – this thin-film coating can be deposited between the layer of phosphor and the glass tube, and would capture any UV light that inadvertently passes through the phosphor and reflect back into the phosphor layer for down-conversion.

These areas of research are consistent with those efforts taking place on linear fluorescent and compact fluorescent lamps, and the technology improvements can apply to both. It is important to note, however, that any investment in CFLs is going to be quite small given that manufacturers have really shifted their attention to LED lamps. Thus, some improvements such as better cathode coatings and UV-reflective glass coatings may not be commercialised for CFLs because it would require investment in manufacturing and increase the per-unit cost of CFLs, which are becoming a commodity product.

3.3 Light Emitting Diodes

LED technology is the focus of the majority of the research and development investment in lighting technology today. Efforts are being made to simultaneously lower manufacturing costs while improving efficacy (i.e., more light-output per watt consumed). LED technology is fulfilling its promise of offering the market the most efficient means of converting electrons into photons. In 2010, LED efficacy exceeded 200 lumens per watt in the laboratory, and leading researchers projected a future device-level efficacy of between 250 to 280 lm/W.[14] At the device-level, these prototype laboratory LEDs have more than double the efficacy of LEDs being used in lamps today.

There are many areas of research that are being investigated simultaneously which is contributing to the overall rapid improvement in efficacy and reduction in cost expected in the coming years. The following list identifies five priority areas on an efficacy and cost basis:[14]

- Efficiency droop – LED internal quantum efficiency declines (i.e., "droops") as current increases, or, in other words, LEDs tend to be most efficient when operating at low-currents. The cause of this reduction in efficiency is not yet fully understood but is believed to be caused primarily by Auger recombination and Shockley–Read–Hall or other non-radiative

[14] White Paper Summarizing Findings of a One-Day Workshop: Fast-Tracking Widespread Adoption of LED Lighting, May 2010, The Institute for Energy Efficiency, University of California Santa Barbara.

recombination and defects. Tests have shown that the efficiencies can drop from 150 lm/W to as low as 70 lm/W at higher current densities.

- Thermal droop – heat in the LED chip also causes a reduction in efficacy. When LEDs are operating in a fixture, the junction temperature can get very hot - 120°C – and the efficiency can drop by 20 or 30%. More research is needed to fully understand this phenomenon, but it is believed that part of this problem is caused by Auger recombination. Researchers have found that some of the negative impact can be mitigated through good thermal management in the chip packaging.

- Phosphor – good phosphors are critical to ensuring that consistent, quality white light is available for general illumination. The wavelengths driving these phosphors can also have an impact – shifts in the blue or UV source driving the phosphor can cause the white light to be noticeably different. Manufacturers of equipment that produce LED chips are working to improve production processes and tighten up the emission wavelengths.

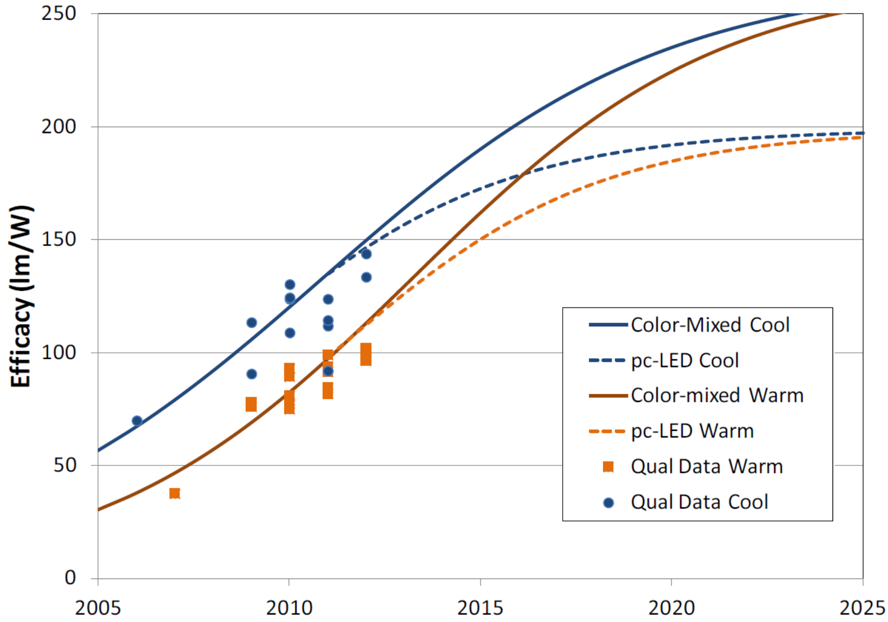
- Light extraction – packaged light extraction is currently at 80% efficiency and we believe another 15% can be achieved through roughening, high-reflectors, exotic structures and shapes, photonic crystals, and other extraction efficiency structures.

- Electrical efficiency – the best DC-drivers for LED lamps are 92 to 93% efficient. Researchers are working on a new set of drivers, and several companies are working on “driverless” lamps which are directly driven by AC. Experts estimate AC-driver efficiencies upward of 98% or higher can be achieved.

Through research on these and other aspects of LED technology, improvement is occurring at a rapid pace, as shown in the figure below. This diagram is taken from the US Department of Energy’s Multiyear Programme Plan for Solid-State Lighting, 2012.[15] The focus of DOE’s report is on LEDs for general illumination, and this diagram shows the commercially available products as well as laboratory prototypes, and the projection for energy performance improvement in the coming years.

[15] Solid-State Lighting Research and Development Multiyear Program Plan for 2012; prepared for: Lighting Research and Development, Building Technologies Program, Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy; prepared by: Bardsley Consulting, Navigant Consulting, Inc., Radcliffe Advisors, Inc., SB Consulting, and Solid State Lighting Services, Inc.; April 2012

Figure 3-2. White Light LED Package Efficacy Projections for Commercial Product



Please see Chapters 3 and 5 of the US DOE's report for detail on the research and innovation in LED technology that will drive these performance improvement curves.

Under the Digital Agenda for Europe, the European Commission issued a Green Paper entitled "Lighting the Future: Accelerating the deployment of innovative lighting technologies" which also discusses how LED technology is rapidly evolving and how Europe's markets can benefit from this technology.[16]

In addition to being highly energy-efficient, good quality LEDs offer the market long life (in excess of 50,000 hours), have no filament or glass envelope to break, offer a small form factor and are mercury-free in their construction. Good thermal management of LEDs is critical to ensure these performance attributes are met. Although white-light LED packages operating in excess of 200 lm/W are starting to become commercially available,[17] there is still considerable research and development that remains to be done on the technology and on addressing the cost of manufacturing LEDs.

[16] Green Paper: Lighting the Future, Accelerating the deployment of innovative lighting technologies. The European Commission, Brussels, 15.12.2011, COM(2011) 889 final.
Link: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0889:FIN:EN:PDF

[17] Cree Reaches LED Industry Milestone with 200 Lumen-Per-Watt LED, Cree Inc. Press Release, Durham, North Carolina, USA. December 2012, see: http://www.cree.com/news-and-events/cree-news/press-releases/2012/december/mkr-intro

4 Energy Savings Potential

The purpose of this section is to provide an estimate of the potential for additional energy savings from revised regulations in the context of different levels of ambition. After briefly setting out the requirements of existing regulations, a high, medium and low ambition illustrative policy scenario is presented based on the preceding assessment of technological development. These policy scenarios provide an indicative estimate of the energy savings potential, based on updated regulatory requirements.

4.1 Existing Regulations

4.1.1 Ecodesign

Annex III on of EC No 245/2009 sets out the stages of the regulation at some length. A summary of the regulation is provided below, copied from ELC/CELMA (2010) publication.[18]

LAMPS[19]

1. For HID lamps only the lamps, which have an E27, E40 or PGZ, are within the scope of the directive.
2. Starting at the first stage (13.04.2010), the following halophosphate fluorescent lamps are not to be put on the EU 27 market anymore: T8 linear, U shaped, T9 circular, T4 linear lamps.
3. Starting at the second stage (13.04.2012), the following lamps are not to be put on the EU 27 market anymore:
    a) Halophosphate Fluorescent Lamps: T10, T12;
    b) High Pressure Sodium – HPS / Metal Halide MH Lamps (E27/E40/PGZ12):
        - Set up established performance criteria for MH E27/E40/PGZ12 lamps;
        - Standard HPS E27/E40/PGZ12.
4. In an intermediate stage (13.04.2015) the following lamps are not to be put on the EU 27 market anymore:
    a) High pressure mercury lamps;
    b) High Pressure Sodium-Plug-in/Retrofit lamps (HPM replacement).
5. In the third stage (13.04.2017) the following lamps are not to be put on the EU 27 market anymore:
    a) Low performing MH E27/E40/PGZ12 lamps;
    b) Compact Fluorescent Lamps with 2 pin caps and integral starter switch (Reason: These lamps are phased out in stage 3 as they do not in practice operate on A2 class ballasts).

[18] Guide of the European Lighting Industry (CELMA & ELC) for the application of the Commission Regulation (EC) No. 245/2009 amended by the Regulation No. 347/2010 setting EcoDesign requirements for "Tertiary sector lighting products"; Ecodesign requirements for fluorescent and high intensity discharge lighting products, 2nd Edition, December 2010.

[19] Notes: (1) Low pressure sodium lamps and ballasts are excluded from this regulation; (2) Lamps from some manufacturers could fulfil the requirements; the CE marking is the distinguishing factor in this; (3) Further detailed information on specific lamps can be obtained at several information platforms of all different lamp manufacturers.

FLUORESCENT LAMP BALLASTS[20]

This regulation is based on ballast efficiency (i.e., lamp power divided by system power).

1. Starting at the first stage (13.04.2010), the requirements are equal to the ones from the "Ballast Directive" (2000/55/EC), only a conversion has taken place from system power to ballast efficiency. Some additional requirements are:
   a. Standby losses less or equal to 1 W per ballast;
   b. Ballasts for current lamps in the market shall fulfil at least EEI = B2 requirements;
   c. For new lamps not designed for current ballasts the efficiency requirements for ballasts are: class A3 (see Annex C.2.2, Table C.3, $\eta_{ballast} \geq 0.94*EBb_{FL}$).
2. In the second stage (13.04.2012) the requirements for standby losses are stricter – must be less than or equal to 0.5 W per ballast.
3. In the third stage (13.04.2017) the requirements are for:
   a. non dimmable ballasts: A2 or A2 BAT (Best Available Technology);
   b. dimmable ballasts: A1 BAT.

HID LAMP BALLASTS[20]

1. In the first stage (13.04.2010) no requirements are defined.
2. In the second stage (13.04.2012) introduction of minimum ballast efficiency demands and the obligation to make them available either as a mark on the ballast or in the documentation. Marking the ballasts fulfilling requirements with EEI = A3.
3. In the third stage (13.04.2017) introduction of more strict efficiency requirements for the ballasts, marking with: A2.

LUMINAIRES

1. In the first stage (13.04.2010) the standby losses of the luminaires for fluorescent lamps are equal to the sum of the number of ballasts incorporated, neglecting other components inside the luminaire which may use power. So the standby losses are less than n watt, whereby n is the number of built in ballasts.
2. Intermediate stage (from 13.10.2010 onwards). Manufacturers of luminaires for fluorescent lamps without integrated ballast with total lamp luminous flux above 2000 lumen shall provide at least the following information on free-access websites and in other forms they deem appropriate for each of their luminaire models. That information shall also be contained in the technical documentation file drawn up for the purposes of conformity assessment pursuant to Article 8 of Directive 2009/125/EC:
   a) if the luminaire is placed on the market together with the ballast, information on the efficiency of the ballast according in accordance with the ballast manufacturer's data;
   b) if the luminaire is placed on the market together with the lamp, lamp efficacy (lm/W) of the lamp, in accordance with the lamp manufacturer's data;
   c) if the ballast or the lamp are not placed on the market together with the luminaire, references used in manufacturers' catalogues must be provided on the types of lamps or ballasts compatible with the luminaire (e.g. ILCOS code for the lamps);
   d) maintenance instructions to ensure that the luminaire maintains, as far as possible, its original quality throughout its lifetime;

[20] Note: the following ballasts are excluded from the regulation: (1) Reference ballasts for the use in laboratories for lighting measurement techniques; (2) Integrated ballasts as a non replaceable part of a luminaire – in this case all the requirements shall be fulfilled from the luminaire. Integrated ballasts are not usable within a luminaire or a special enclosure; and (3) Ballasts intended for use in emergency lighting luminaires and emergency sign luminaires and designed to operate the lamps in emergency conditions.

   e) disassembly instructions.
3. In the second stage (13.04.2012) a design requirement for both fluorescent and HID lamp luminaires is introduced. The luminaire must be designed so that it is suitable for stage 3 ballasts; this is in order to have a changeover in the third stage without delay.
4. In the third stage (13.04.2017) the luminaires for fluorescent or HID lamps may only use ballasts of the third stage.

4.1.2 Energy Label

In addition to these regulatory requirements, the Commission established revised labelling requirements for all lamps that were adopted in September 2012 as part of regulation EC No 874/2012. The scope covers all of the lamps covered under the tertiary lighting regulation, EC No 245/2009.[21]

The energy labelling regulation specifies seven energy labelling classes from E (least efficient) to A++ (most efficient).

Table 4-1. Energy Classes for Lamps from Labelling Regulation 874/2012

Energy Efficiency Class	Energy Efficiency Index
A++ (most efficient)	EEI ≤ 0.11
A+	0.11 < EEI ≤ 0.17
A	0.17 < EEI ≤ 0.24
B	0.24 < EEI ≤ 0.60
C	0.60 < EEI ≤ 0.80
D	0.80 < EEI ≤ 0.95
E (least efficient)	EEI > 0.95

The Energy Efficiency Index (EEI) is calculated in accordance with Annex VII of the energy labelling regulation, and represents the ratio of power of the light source being measured relative to a reference power derived from the light output.

4.2 Illustrative Policy Scenarios

As discussed earlier, the focus of the energy savings potential in tertiary lighting is on the lamps and does not take into consideration improvement potential in ballasts or luminaires. In the regulation, the requirements in Annex III are introduced in three stages, taking into account progress that has been observed in the market for various products used in the tertiary sector. For these illustrative policy scenarios, a fixed percentage improvement in efficacy requirements for the general classes of lamps is presented.

As an example, consider the group of lamps classified under CFLni, the pin-based fluorescent lamps. To calculate energy savings, the efficacy requirement on this group would be raised by say 10% and the stock would then gradually be replaced with more efficient lamps and energy savings compared to the BAU would then be realised. In practical terms, this would mean that all the tables of efficacy

[21] It also includes lamps covered in the scope of EC No 244/2009 (see Annex F).

requirements in regulation EC No 245/2009 would have that same fixed percentage improvement in efficacy applied to the specific lamp types and wattages, using the existing requirements in the regulation as a starting point.

In preparing this model, the three principal regulated tertiary lamps that remain in the market after the final stage of the regulation in 2017 were assessed – linear fluorescent T8 and T5, and MH lamps. A cursory review of manufacturer's lamp catalogues found that the regulatory efficacy levels were well below the performance of products currently in the market. There is, therefore, the capacity to increase the requirements on the regulated products, and capture energy savings for Europe.

The following table illustrates some of the comparisons made by CLASP between the requirements in EC No 245/2009 and 2012 manufacturer catalogues. It should be noted that some of the metal halide lamps offered in the European market in 2012 exceeded the benchmark performance levels presented in Table 20 of Annex V in regulation EC No 245/2009. Fluorescent lamp benchmarks are given as the best performance levels in Annex III, Parts 1.1 and 1.2, and products available in 2012 also exceeded these benchmarks.

Table 4-2. Comparison of EC No 245/2009 MEPS Threshold to Market and Potential for Improvement

Lamp Wattage	245/2009 MEPS Requirements	Manufacturer Catalogue Best Products 2012	Improvement Over Existing MEPS
T8 Fluorescent Lamps			
18W	75 lm/W	16W @ 87.5 lm/W	17%
36W	93 lm/W	32W @ 100 lm/W 32W @ 110 lm/W*	18%
58W	90 lm/W	50W @ 104 lm/W*	15%
T5 Fluorescent Lamps[22]			
14W	86 lm/W	13W @ 91 lm/W	6%
28W	93 lm/W	25W @ 103 lm/W	11%
35W	94 lm/W	32W @ 98 lm/W	4%
Metal Halide Lamps (based on Table 10)			
20W clear	70 lm/W	110 lm/W	57%
35W clear	70 lm/W	129 lm/W	84%
50W clear	70 lm/W	104 lm/W	49%
100W clear	85 lm/W	105 lm/W	24%
150W not clear	80 lm/W	106 lm/W	33%
250W clear	85 lm/W	113 lm/W	33%

* This lamp retails in Japan.

From this table, it is clear there is technical potential to increase the requirements on both fluorescent lamps and HID lamps.

[22] The efficacy values reported for T5 lamps are at 25°C. These lamps exhibit higher efficacy when measured at 35°C.

The illustrative policy scenarios developed for this paper therefore are based on holding light output constant and improving the efficacy to reduce the wattage of the shipments of the regulated lamp types. Three scenarios were prepared, each with increasing levels of regulatory ambition and potential energy savings.

Scenario 1 considers the situation where efficacy requirements for both T8 and T5 lamps are increased by 5% at Tier 1 and by a further 5% at Tier 3. MH lamps are improved by 20% in Tier 1 and a further 10% in Tier 2 and Tier 3. HPS lamps are not subject to any new regulation, and CFLni lamps are increased by the same amount and the same Tiers as the linear fluorescent lamps. The final regulatory measure of EC No 245/2009 will take effect in 2017, however no increase in efficacy requirements for T8 and T5 lamps has occurred since 2010 and the levels of ambition for MH lamps in 2017 are far lower than many MH products in the market, therefore Tier 1 is proposed in 2018, followed by Tier 2 in 2021 and Tier 3 in 2023.

Scenario 2 considers the same levels of ambition, but the schedule is accelerated so that Tier 2 occurs in 2020 and Tier 3 in 2022.

Scenario 3 considers the same schedule as Scenario 2, however the ambition of the requirements are greater, with a further 10% at Tier 3 for the fluorescent lamps and an additional 15% at Tiers 2 and 3 for MH lamps.

The following table summarises the three policy scenarios that were created for this analysis.

Table 4-3. Table Depicting the Efficacy Improvement of the Policy Scenarios

Scenario	Tiers	Year Effective	% Increase in Efficacy Relative to EC No 245/2009	
			Fluorescent Lamps	Metal Halide Lamps
Scenario 1	Tier 1	2018	+ 5%	+ 20%
	Tier 2	2021	--	+ 10%
	Tier 3	2023	+ 5%	+ 10%
Scenario 2	Tier 1	2018	+ 10%	+ 20%
	Tier 2	2020	--	+ 10%
	Tier 3	2022	+ 5%	+ 10%
Scenario 3	Tier 1	2018	+ 10%	+ 20%
	Tier 2	2020	--	+ 15%
	Tier 3	2022	+ 10%	+ 15%

To interpret the levels of ambition being contemplated in these scenarios, consider a 50W metal halide lamp which will have a regulatory requirement of 70 lm/W in 2017 yet already has at least one commercially available lamp that is 104 lm/W. In 2018, the requirement would increase by 20%, going from 70 lm/W to 84 lm/W. In 2020, the requirement would increase by 10% to 92.4 lm/W. And finally, in 2022, the requirement would increase by a further 10% to 102 lm/W.

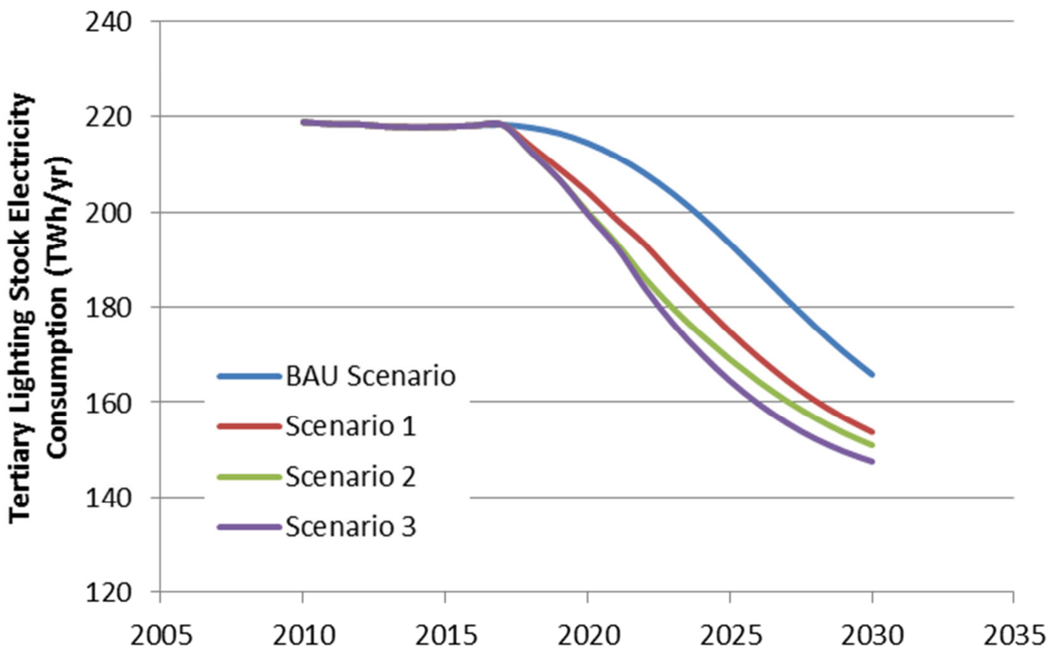
Although LED lighting systems are included in the stock model, regulations on LED lamps were not considered in any of these draft scenarios because the projected efficacy of LEDs would already exceed the levels being considered for these traditional lamp types at the time these scenarios become effective.

4.3 Energy Savings Potential

As more energy efficient tertiary lighting equipment is sold into the market each year, the average efficacy of the installed stock increases. The effect of the three illustrative policy scenarios on total energy consumption across the EU-27 relative to the BAU scenario is shown in the figure below. In each scenario, the stock model moves the shipment-weighted average efficacy of each of the major lamp types by the percentage increase over its existing mandatory efficiency requirement. Light output is the same across the four scenarios and the resultant energy savings from the efficacy improvement is calculated.

The figure below illustrates the total energy consumption of the installed stock of tertiary lamps in Europe under the BAU scenario and the three illustrative policy scenarios.

Figure 4-1. Projected Stock Energy Consumption for BAU and Scenarios



The energy savings potential of the three illustrative policy scenarios ranges from approximately 12.1 to 18.3 TWh of annual electricity saved in 2030, however the savings are larger – 18.5 to 28.8 TWh of annual electricity in 2025. The reason for the savings being greater in 2025 is due to the overall market penetration of LED relative to the conventional lighting technologies (i.e., fluorescent and HID lamps) in the market model. Thus, although the fluorescent and HID lamps in each of the three scenarios have a much higher efficacy when compared to the BAU scenario, the conventional lighting technologies are becoming an increasingly smaller and smaller share of the installed base, and thus the differential energy savings relative to the BAU scenario is reduced over time. The energy savings in annual TWh are shown in the table below.

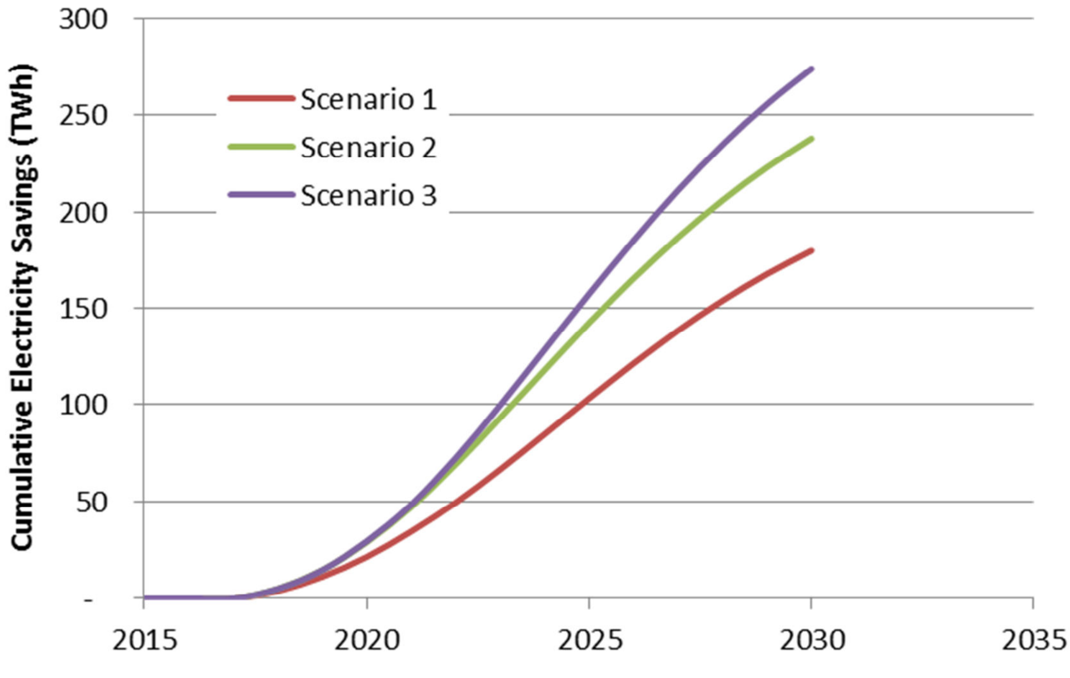
Table 4-4. Estimated Annual Energy Savings of Efficient Policy Scenarios, EU-27

EU-27 Projection	2015 (TWh/yr)	2020 (TWh/yr)	2025 (TWh/yr)	2030 (TWh/yr)
Scenario 1	-	10.3	18.5	12.1
Scenario 2	-	14.5	24.3	14.8
Scenario 3	-	14.9	28.8	18.3

Across the EU, tertiary lighting is projected to consume 214 TWh of electricity in 2020. The energy savings estimate from Scenario 2 is 14.5 TWh in that year, or approximately 6.8%. By 2030, the baseline energy consumption is 166 TWh of electricity and the energy savings estimate from Scenario 2 is 14.8 TWh, or 8.9% of the baseline.

The figure below plots these energy savings on a cumulative basis, so the total energy savings at the end of the time period can be visualised. The scenarios considered for tertiary lighting have the potential to save Europe between 180 and 274 TWh of electricity over the next fifteen years, worth tens of billions of Euro in avoided electricity bills over that time period.

Figure 4-2. Projected Stock Cumulative Energy Savings for 3 Policy Scenarios, EU-27



5 Additional Issues

In line with the framework directive on ecodesign, reviews must assess potential future minimum performance requirements in light of technological progress. Above we have provided three illustrative policy scenarios in support of this. Further, implementing measures often require additional issues to be assessed in connection with the review. It may be that some issues are not anticipated in implementing measures, but could be relevant to include in a review. Below we consider both types of additional issues.

5.1 Additional Issues Required to be Assessed by the Implementing Measure

The ecodesign implementing measure on tertiary lighting does not point to any additional issues that should be included as part of a review.

5.2 Additional Issues Not Anticipated in the Implementing Measure

5.2.1 Level of Ambition of Existing Tier 3 for MH Lamps

The final stage of regulation EC No 245/2009 takes effect in 2017, and will adopt more ambitious efficacy requirements for all metal halide (MH) lamps. The table of requirements (Table 10 from Annex III of the regulation) is reproduced below.

Table 5-1. Rated minimum efficacy values for metal halide lamps (third stage)

Nominal Lamp wattage (W)	*Rated Lamp Efficacy (lm/W) — Clear lamps*	*Rated Lamp Efficacy (lm/W) — Not clear lamps*
W ≤ 55	*≥ 70*	*≥ 65*
55 < W ≤ 75	*≥ 80*	*≥ 75*
75 < W ≤ 105	*≥ 85*	*≥ 80*
105 < W ≤ 155	*≥ 85*	*≥ 80*
155 < W ≤ 255	*≥ 85*	*≥ 80*
255 < W ≤ 405	*≥ 90*	*≥ 85*

Lamps equipped with Tc ≥ 5 000 K or with a second lamp envelope shall fulfil at least 90 % of the applicable lamp efficacy requirements.

A review of the European market of MH lamps was conducted with respect to these requirements. It was found that there is a wide range of performance values for metal halide lamps. There are some products with performance levels that are at or near to the levels in Table 10, but then there are other products that have higher efficacy values. In general, the efficacy requirements that will take effect in 2017 were found to be lower than many products that are already commercially available in 2012.

The table below offers some examples of commercially available, high-efficacy MH lamps taken from a European manufacturer's catalogue. For the wattages shown, the table presents the requirement from Table 10 for that lamp (clear and not-clear), the reported efficacy in the catalogue and the percentage difference between the two values. It should be noted that some of the lamps offered in the European market in 2012 already exceed the benchmark performance levels presented in Table 20 of Annex V in regulation EC No 245/2009.

Table 5-2. Metal Halide Requirements in EC No 245/2009 for 2017 and Potential for Improvement

MH Lamp Wattage	245/2009 2017 Requirements	Manufacturer Catalogue Best Products 2012	Improvement Over 2017 Requirements
20W clear	70 lm/W	110 lm/W	57%
35W clear	70 lm/W	129 lm/W	84%
50W clear	70 lm/W	104 lm/W	49%
100W clear	85 lm/W	105 lm/W	24%
150W not clear	80 lm/W	106 lm/W	33%
250W clear	85 lm/W	113 lm/W	33%

From this table, it appears that MH technology has evolved faster than was anticipated when EU No 245/2009 was adopted.

5.2.2 Scope of Coverage: Certain HID Lamp Base Types; Certain Halogen Lamps; LED

The scope of coverage of the ecodesign implementing measure EC No 245/2009 seems adequate from the point of view of fluorescent and HID lamps and ballasts and luminaires that operate such lamps. However, it does not include all HID lamp base types, certain halogen lamps or LED technology[23]. It would therefore be appropriate to review the scope of coverage associated with this regulation, taking into consideration products that are covered under the recent labelling regulation for lighting products, Regulation EU No 1194/2012.[24]

The regulation will require a careful review to ensure compatibility with this expansion of scope including, for example, revising the definition for the term 'luminaire'[25]. This definition states that a luminaire shall not contain the light source, however for some LED luminaires, the LED light source is permanently embedded in the luminaire.

5.2.3 Verification Tolerances and Correction Factors

As for most other product groups considered in this paper, the magnitude of the measurement verification tolerance could be reviewed as smaller tolerance may now suffice. A similar point can be made in relation to assessing the possibility for removing or reducing existing correction factors.

[23] The HID lamp base types and halogen lamps that are not included in the scope of the present implementing measure are low volume products and are expected to remain so. This is not the case for LEDs.
[24] Commission Regulation (EU) No 1194/2012 of 12 December 2012 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for directional lamps, light emitting diode lamps and related equipment; link: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:342:0001:0022:EN:PDF
[25] A 'luminaire' is an apparatus which distributes, filters or transforms the light transmitted from one or more light sources and which includes all the parts necessary for supporting, fixing and protecting the light sources and, where necessary, circuit auxiliaries together with the means for connecting them to the supply, but not the light sources themselves;

5.2.4 Potential Additional Savings from Electronic Ballasts and Tertiary Luminaires

We have not included electronic ballasts and tertiary luminaires in our estimate of the potential savings from a revision to the existing implementing measure. However these technologies appear to also offer additional savings, and should be assessed in the context of a review.

5.2.5 Minamata Convention on Mercury

The Minamata Convention on Mercury adopted in early 2013[26] includes certain types of CFLs and fluorescent lamps and is thus of relevance to the review of EC No. 245/2009.

[26] Minamata Convention Agreed by Nations: Global Mercury Agreement to Lift Health Threats from Lives of Millions World-Wide, United Nations Environment Programme (UNEP), Geneva, Switzerland, 19 January 2013. See link: http://www.unep.org/newscentre/Default.aspx?DocumentID=2702&ArticleID=9373&l=en

Annex F. Non-Directional Household Lamps

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1 Introduction and Context

In common with the other six annexes, this annex starts by setting out the timetable and scope of the upcoming reviews. It then sets out the scope of the existing implementing measures. Having provided this context, a BAU energy consumption scenario is developed. Next an assessment of technology developments is made and this is used to develop a set of illustrative policy scenarios on the basis of which a range of energy savings potentials are defined. Finally, a set of issues of relevance in the context of upcoming reviews is outlined.

1.1 Timetable and Scope of the Upcoming Review

Commission Regulation EC No 244/2009 on the ecodesign requirements for non-directional household lamps[1] states in Article 7 that it shall be reviewed no later than five years after its entry into force i.e. by 13 April 2014 and the results of that review shall be presented to the Ecodesign Consultation Forum. Article 7 does not mention any special requirements for the review, other than, in line with the framework directive, it should be conducted "in light of technological progress." However the recitals of the implementing measure does provide some supplementary information. Thus recital 20 explains that a review should:

- Verify that special purpose lamps are not used for general lighting purposes;
- Take note of the development of new technologies such as LED;
- Assess the feasibility of establishing energy efficiency requirements at the 'A' class level as defined in Directive 98/11/EC.

1.2 Scope of Coverage of the Implementing Measure

Article 1 of the ecodesign regulation[2] states which lamps are included in the regulation:

> *"This Regulation establishes ecodesign requirements for the placing on the market of non-directional household lamps, including when they are marketed for non-household use or when they are integrated into other products. It also establishes product information requirements for special purpose lamps. The requirements set out in this Regulation shall not apply to the following household and special purpose lamps:*
>
> *(a) lamps having the following chromaticity coordinates x and y:*
> - $x < 0{,}200$ *or* $x > 0{,}600$
> - $y < -2{,}3172\,x^2 + 2{,}3653\,x - 0{,}2800$ *or* $y > -2{,}3172\,x^2 + 2{,}3653\,x - 0{,}1000$;
>
> *(b) directional lamps;*
> *(c) lamps having a luminous flux below 60 lumens or above 12 000 lumens;*
> *(d) lamps having:*
> - *6 % or more of total radiation of the range 250-780nm in the range of 250-400nm,*

[1] The term 'non-directional household lamp' is used in the Ecodesign implementing measure to refer to lamps that are not directional in their light emission pattern. From a technical point of view, they are defined as a light source having less than 80% light output in a solid angle of π sr (corresponding with a cone with angle of 120°). Examples of non-directional household lamps include general service incandescent lamps and compact fluorescent lamps (CFL) that do not incorporate a directional reflector. All 'reflector lamps' that emit light in a certain direction are considered directional lamps.

[2] Commission Regulation (EC) No 244/2009 of 18 March 2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for non-directional household lamps, in the Official Journal of the European Union, 24 March 2009

- *the peak of the radiation between 315-400 nm (UVA) or 280-315 nm (UVB);*

(e) fluorescent lamps without integrated ballast;

(f) high-intensity discharge lamps;

(g) incandescent lamps with E14/E27/B22/B15 caps, with a voltage equal to or below 60 volts and without integrated transformer in Stages 1-5 according to Article 3."

The scope of coverage for non-directional household lamps includes incandescent, halogen, compact fluorescent lamp (CFL) and LED lamps – in other words, all light source technologies are included. The exemptions identified in Article 1 of the ecodesign regulation still appear to be appropriate, particularly as many of these lamps such as fluorescent lamps and high-intensity discharge lamps are covered under other regulatory measures.

2 Market Projection

2.1 Non-directional Household Lighting Stock and Sales Project

In this section, we explain how the projection for annual sales and stock was developed. The methodology followed is important to understand because public-domain data on the non-directional lamp market in Europe is scarce.

The market projection takes into account the fact that regulation EC No 244/2009 split the general illumination market (i.e., non-directional lamps) into clear and non-clear general service lamps. The non-clear or frosted lamps were required to reach energy label class A while the clear lamps were required to reach energy label class C, and are slated to reach energy label class B from September 2016. Having the lower requirement for clear lamps means that if an end-user is willing to switch from a frosted lamp to a clear one, they would be able to purchase energy label class C lamps (i.e., a normal halogen lamp) instead of benefitting from the larger energy savings associated with energy label class A (i.e., CFL or LED lamps). The market projection considers this point, estimating an increase in both CFL and halogen sales in response to the various stages of regulation EC No 244/2009, but with slightly more consumers moving to halogen lamps as the incandescent lamps are removed from the market.

For example in 2012, it is estimated that approximately 60% of the incandescent market will shift to halogen and 40% will use CFL, with just 2% switching to LED. Thus, in general, the model assumes that halogen lamps tend to be the first choice of consumers in response to the regulation, followed by CFL and LED. However, this is assumed in the model to change over time as LED technology evolves and prices are reduced. Sales of LED retrofit lamps are expected to surpass CFLs in 2016, driven in part by their superior performance (i.e., energy label class A+ and eventually A++), and because LEDs are more environmentally sound.[3]

Although they offer longer service life, CFLs contain mercury, take time to achieve full brightness and often cannot be used on dimmer circuits. LED lamps, on the other hand, can offer even longer service life, contain no mercury and attain near-instant full brightness. Thus LED lamps offer consumers a better product; however in 2012, good quality LED lamps had a high upfront cost which is preventing widespread market adoption. Halogen lamps therefore represent the lowest first-cost replacement for an incandescent lamp, making it an attractive option for this market segment. However, in the long run, LED prices are projected to decline significantly, and the market will eventually shift to LED replacement lamps.

Incandescent lamps generally have a short life-time, usually between 1,000 and 2,000 hours of service life, however they are being replaced with halogen, compact fluorescent and LED lamps, all of which have longer operating lives. This means that once the incandescent lamp has been replaced with an energy-efficient lamp, the new lamp will operate in that socket for a longer period of time, reducing the annual sales volume. Thus the sales volumes of non-directional lamps will decrease over time even as the lighting service and the number of new sockets in the stock model increase. The market projection reflects this fact, by incorporating longer lifetimes of the individual lamps sold into the stock model, and in that way, gradually reducing the number of units sold each year as the lamps installed in the stock turn-over with less frequency.

[3] Life Cycle Assessment studies have compared LED replacement lamps with CFLs and incandescent lamps and found LEDs to be the least environmentally harmful. For more information, see the OSRAM study from 2009 and the US DOE study from 2012. Citations appear in the references section of this chapter.

The market forecast for lamp sales is based on projecting forward the same lamp classes from the Preparatory Study[4], and draws upon the most recent Europroms[5] data as well as a 2012 report by McKinsey and Company[6]. The methodology followed with the Europroms data is consistent with the approach followed in the Preparatory Study, namely that apparent EU-27 consumption = Production + Imports – Exports. These data are now available through the end of 2011, and are presented in the table below with the codes (NACE[7] version 1.1) and descriptions. The volumes associated with these product descriptions are higher than those directly associated with non-directional household lamps because the eight-digit codes include products that are not part of this regulation.

Table 2-1. Prodcom Codes and Descriptions of Relevant Lighting Products

Prodcom Code	Description
3150 1293	Halogen lamps, including mains-voltage halogen non-direction (HL-MV) and directional lamps (HL-R-MV)
3150 1295	Halogen lamps, including low-voltage halogen non-directional (HL-LV) and directional lamps (HL-R-LV)
3150 1300	Incandescent lamps, including frosted non-directional, clear non-directional and directional incandescent lamps.
3150 1530	Compact fluorescent lamps, including integrally ballasted non-directional (CFLi) and directional (CFL-R-i) and compact fluorescent lamps that are not integrally ballasted (and tend not to be used in household applications) - CFLni and CFL-R-ni.

The following table presents the Europroms data, which takes the European production, adds imports and deducts exports. These values are representative of the net shipments to the EU-27 during the time period shown. Note, for example, the significant decline in incandescent lamps over the time period shown, depicted in the column second from the right with code 3150 1300. The unit shipments decrease by more than 50% between 2007 and 2011.

[4] Preparatory Studies for Eco-design Requirements of EuPs, Final report, Lot 19: Domestic lighting. Study for European Commission, by Paul van Tichelen VITO http://www.eup4light.net/default.asp?WebpageId=33
[5] Where Prodcom only provides production data, Europroms provides production as well as export and import data. All the data are displayed by Prodcom heading, and for EU totals, trade partners are aggregated.
[6] McKinsey & Co. "Lighting the way: Perspectives on the global lighting market", Second Edition, 2012.
[7] NACE is the "Nomenclature statistique des Activités économiques dans la Communauté Européenne"

Table 2-2. Europroms Data of Lamp Shipments to EU-27 Market

	Tungsten halogen filament lamps, for a voltage > 100 V (excluding ultraviolet and infra-red lamps, for motorcycles and motor vehicles)	Tungsten halogen filament lamps for a voltage <= 100 V (excluding ultraviolet and infrared lamps, for motorcycles and motor vehicles)	Filament lamps of a power =< 200W and for a voltage > 100V including reflector lamps excluding ultraviolet and infrared lamps, tungsten halogen filament lamps - sealed beam lamp units	Fluorescent hot cathode discharge lamps (excluding ultraviolet lamps, with double ended cap)
Code:	*3150 1293*	*3150 1295*	*3150 1300*	*3150 1530*
2007	316,962,882	336,267,402	1,249,624,271	626,794,478
2008	305,165,578	283,925,388	1,002,973,419	687,213,940
2009	253,324,976	278,684,530	946,708,491	694,851,823
2010	373,093,981	437,569,916	839,454,245	548,527,265
2011	455,305,429	397,355,253	524,834,077	456,632,274

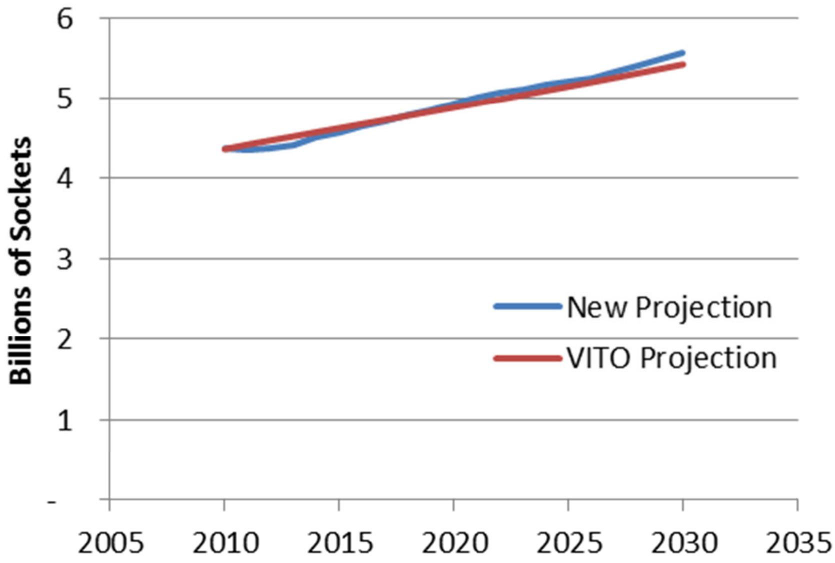
Taking these various inputs into consideration, a series of shipment projections for each of the lamp types servicing the general illumination, non-directional lamp applications across Europe were developed. The shipment projections were then compiled into an inventory stock model with assumptions consistent with those used in the Preparatory Study, such as expected service life of the lamp types and operating hours. The table below presents the input assumptions from the Preparatory Study that were used as inputs to the stock model.

Table 2-3. Lamp Lifetime and Operating Hours Assumed for Stock Model

Type of Lamp	Lamp Lifetime (hours)	Operating Hours (hours/year)	Operating Hours (hours/day)
Incandescent	1,000	600	1.64
HL-MV-LW	2,000	600	1.64
HL-MV-HW	2,000	600	1.64
HL-LV	3,000	600	1.64
CFLi	6,000	1,000	2.74
LED	20,000	1,000	2.74

The lamps that remain in service from the year they were installed are summed across the time period of interest to arrive at an estimate of total number non-directional lamp sockets. This summation was compared to the projected growth rate derived from the Preparatory Study business as usual scenario. Using an exponential function to forecast growth of lamp shipments to 2030 based on the Preparatory Study, the total number of non-directional lamp sockets was found to increase by approximately 1.1% to 1.4% per year. The figure below illustrates the aggregate number of sockets from the Preparatory Study projection (red line, labelled the “VITO Projection”) and the aggregate sockets from the stock model prepared for this review (blue line, labelled the “New Projection”).

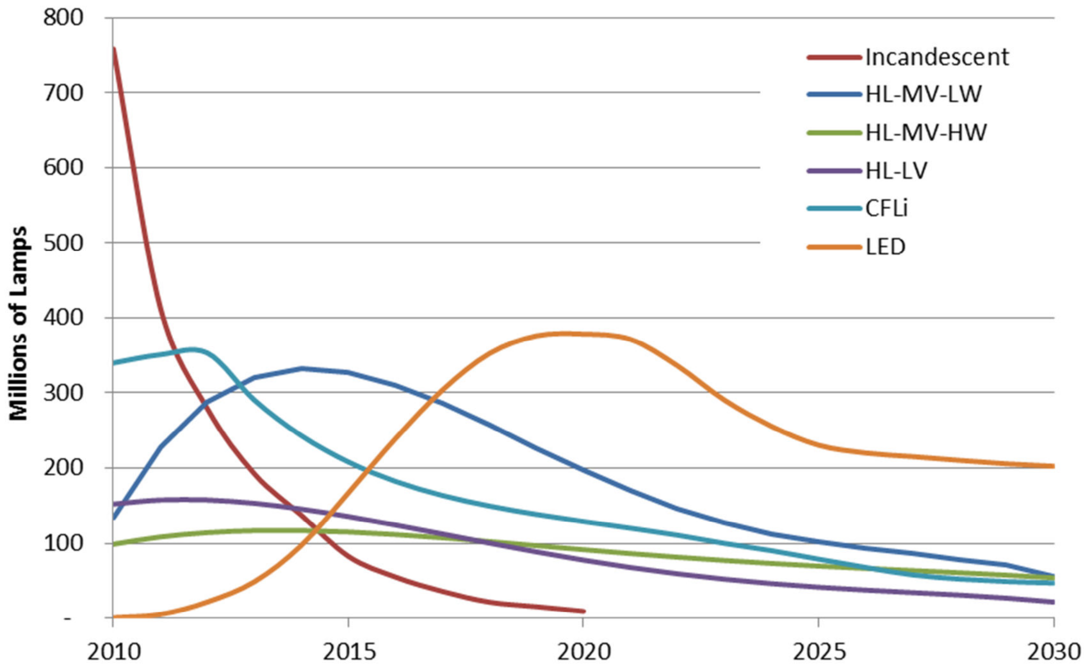
Figure 2-1. Projection of Non-Directional Lamp Sockets in EU-27, 2010-2030



The market forecast developed for the business as usual (BAU) scenario takes into account the existing ecodesign regulation and the two new labelling categories that were adopted in December 2012, but it does not consider any new regulatory measures. The trends project a rapid decline in incandescent lamps to zero shipments in 2021. Halogen is the more popular replacement for incandescent, however it starts to decline around 2015 and trends downward in response to Stage 6 in September 2016 which requires halogen lamps to achieve energy label B rating. CFLs peak in 2012 and then decline as the most suitable sockets for CFLs will then have long-life CFLs installed and consumers are expected not to fully embrace the technology due to warm-up time, mercury content and other issues. LEDs start to gain market-share, surpassing CFLs on a unit basis in 2015 and halogens in 2017. However, LEDs are very long life, thus once installed the socket is not available for replacement in the household setting for approximately 20 years – leading to peak in LED replacement lamp sales around 2020 and a gradual decline and levelling off by 2030 at around 200 million LED lamp sales per annum.

The following figure provides a graphical illustration of the projection of non-directional lamp sales for the BAU scenario, as described above.

Figure 2-2. Projected Non-Directional Lamp Sales in EU-27 Countries, BAU



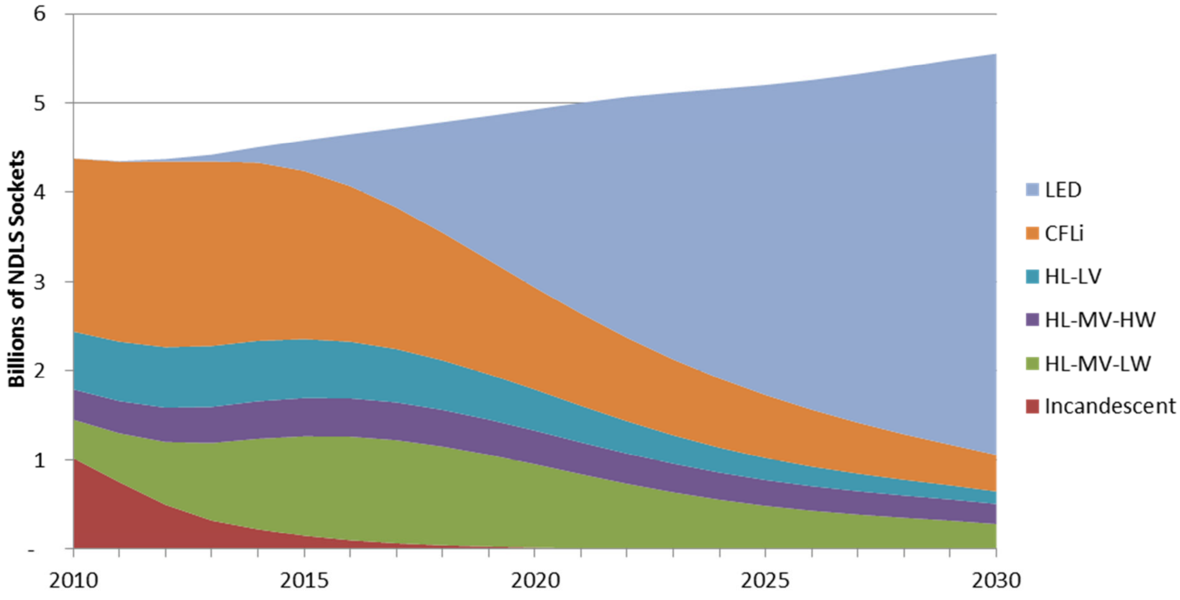
The numerical values of the shipments of lamps for this BAU scenario are provided in the table below in millions of units shipped. As plotted in the figure above, the annual shipments of incandescent lamps are shown to drop from 759 million in 2010 to 9 million in 2020. The decrease in the total volume of lamps is also observed over time, due to the longer lifetime of the new lamps being installed.

Table 2-4. Projected Non-Directional lamp Sales in EU-27 Countries, BAU (millions)

Year	2010	2015	2020	2025	2030
Incandescent	759	82	9	0	0
HL-MV-LW	134	327	197	102	55
HL-MV-HW	99	115	91	70	54
HL-LV	152	136	78	41	22
CFLi	340	208	129	79	47
LED	0.6	167	378	231	203
Total:	1,485	1,037	883	522	381

The following diagram presents the results of the stock model for the BAU scenario, illustrating the lighting technologies that are servicing the billions of non-directional lamp sockets across the EU-27. It is clear that although the volume in shipments of incandescent lamps is high in 2010, the relative proportion of stock is actually quite low because of the short service life of an incandescent lamp. Lamps that have a longer service life such as CFLi and LED lamps occupy the sockets in the stock model for longer periods of time.

Figure 2-3. Projected Non-Directional Lamp Stock in EU-27 Countries, BAU



The numerical values of the stock model of non-directional lamps for this BAU scenario presented in the figure above are provided in the table below in millions of units of the installed stock. CFLs have the largest share (44%) of the sockets in 2010, closely followed by halogen lamps. By 2020, LEDs dominate the installed stock and constitute 80% of the sockets by 2030.

Table 2-5. Projected Non-Directional Lamp Stock in EU-27 Countries, BAU (millions)

Year	2010	2015	2020	2025	2030
Incandescent	1,017	148	16	0.0	0.0
HL-MV-LW	435	1118	935	484	282
HL-MV-HW	338	427	378	288	224
HL-LV	650	663	459	248	139
CFLi	1,937	1,883	1,149	707	412
LED	0.7	341	1,991	3,475	4,500
Total	4,377	4,580	4,928	5,202	5,556

2.2 Projected Energy Consumption

The business as usual (BAU) scenario was prepared with inputs from the Preparatory Study, which constitute the basis for the energy consumption and energy savings estimates associated with the EC No 244/2009 regulation. The table below presents the wattages and the average annual operating hours associated with the various technologies that constitute the BAU scenario. The energy consumption estimate is calculated by multiplying the average wattages and operating hours by the installed stock of lamps for the EU-27. It should be noted that the wattages presented in this table represent the weighted average of the installed stock of each lamp type. For the incandescent, halogen and CFLi technologies, this wattage is held constant over the analysis period, signifying that there is no expected improvement in efficacy. For the LED lamp, it is assumed to be approximately 14W in 2010 for an equivalent light output to a 60W incandescent lamp, and later reducing to 11W in 2030 for 890 lumens of light. These assumptions constitute the BAU scenario.

Table 2-6. Stock Average Wattage and Operating Hours Assumed for Stock Model

Type of Lamp	Average Wattage*	Operating Hours (hours/year)	Operating Hours (hours/day)
Incandescent	60W	600	1.64
HL-MV-LW	52W	600	1.64
HL-MV-HW	100W	600	1.64
HL-LV	35W	600	1.64
CFLi	13W	1,000	2.74
LED	14W to 11W	1,000	2.74

* The average wattages are meant to represent the weighted average of the installed stock of each lamp type. These numbers are held constant over the analysis period, except for LEDs which are projected to drop from 14W in 2010 to 11W in 2030. This represents the average wattage of the installed LED lamp to migrate from an A to an A+ under the new labelling scheme.

Using these inputs, the resulting energy consumption for non-directional lighting is calculated to be 111.9 TWh for the EU-27. This number aligns well with the estimate in the Preparatory Study, which calculated that for the energy consumption of non-directional lamps used in all sectors (i.e., not only the household sector) was approximately 112.5 TWh in 2007. At that time, 112.5 TWh represented approximately 4 % of EU-27 total electricity consumption. The table below presents the estimated energy consumption for non-directional lighting sources in Europe.

Table 2-7. BAU Energy Consumption for Non-Directional Lamp Stock, EU-27

EU-27 projection	2010 (TWh/yr)	2015 (TWh/yr)	2020 (TWh/yr)	2025 (TWh/yr)	2030 (TWh/yr)
Stock annual energy consumption, BAU	111.9	106.8	89.1	81.5	79.6

Thus the BAU scenario projects a 34% reduction in the electricity use for non-directional lamps over the analysis period (2010 to 2030) despite the fact that there is a 23% increase in the number of sockets and there is a slight increase in operating hours of more efficient lamps (see Table 2-3). This increase in operating hours of the more efficient lamps is meant to reflect the attitude that consumers will use the more efficient lamps for approximately one more hour per day due to the fact that they are perceived as more efficient (i.e., the 'take back effect'). The BAU scenario reflects the impact of the ecodesign regulation EC No 244/2009, the new energy labelling regulation EU No 1194/2012, and the anticipated improvements in LED-based lamps from the innovation and research efforts of lighting manufacturers.

3 Technology Assessment

Non-directional lighting technologies covered by the ecodesign regulation include incandescent, halogen, CFLi and LED. Of these, incandescent technology is being phased out and thus will not be discussed in this review. Halogen technology has some room for improvement through the use of infrared reflective coatings, low voltages and improvements to halogen capsules. CFLs are only expected to experience minor improvements in performance, as they are already a mature technology and are not the focus of any significant research and development investment. LED technology, on the other hand, is the subject of large research investments, on every aspect of an LED lamp, from chip and package-level improvements through to the LED driver and optical performance. This section of the chapter discusses the opportunities for further improvements to halogen, CFL and LED light sources.

3.1 Halogen Lamps

Halogen lamps operate on the same principle as an incandescent lamp in that they heat a tungsten filament so hot that it emits light. However, a halogen lamp is different in that its filament operates in a small capsule that contains halogenated gases which 'recycle' evaporated tungsten by depositing it back onto the filament. The re-deposited tungsten is not always put back in the same location on the filament where it evaporated from, thus the filament does eventually break – however the halogen-cycle enables the lamp to operate at a higher temperature and achieve better efficacy than a standard incandescent lamp.

Halogen lamps can generally attain an energy label class of "C", which is approximately 15-25% more efficient than a standard incandescent lamp. Halogen lamps also tend to be designed to have twice the operating life of an incandescent lamp. While both of these are significant improvements, even better performance of halogen lamps is possible, attaining energy label class of "B" through a combination of measures that are discussed in detail in an eceee study.[8] The critical difference between a C-class and a B-class halogen is the use of an effective infrared reflective coating (IRC). IRC technology is based on a series of selective reflectors that allow visible light to pass through but reflect back various infrared wavelengths. If those reflected infrared wavelengths are re-adsorbed by the tungsten filament, they will generate heat and thereby reduce the number of watts of power needed to maintain the filament's operating temperature. This reduction in power, while maintaining operating temperature, results in energy savings.

Obtaining the best performance from IRC involves (1) maximising the filament's ability to absorb the reflected infrared light and (2) having a good quality coating. In order to maximise infrared light adsorption, one approach involves reducing line voltage from 230V to 12V through the use of an electronic transformer. The filament thickness and length changes with voltage, and a 12V filament is much shorter and thicker than a 230V filament, making it an easier optical target for reflected infrared light. In addition, the location of the filament must be carefully controlled to ensure it is at the optical centre of the halogen capsule.

There are two important points to take into consideration concerning this design approach to producing a B-class halogen lamp. First, the integrated transformer used in the retrofit mains voltage lamps can be problematic in this a small package, particularly in situations where the lamp is operated

[8] "B Class Halogens and Beyond, Design Approaches to Complying with Proposed EU Eco-design Domestic Lighting Requirements: A Technological and Economic Analysis" commissioned and published by The European Council for an Energy Efficient Economy (eceee) with financial support from the European Climate Foundation and Defra's Market Transformation Programme (UK); prepared by Ecos Consulting in the United States, December 2008. http://www.eceee.org/press/B_Class_lamps/index/BClassHalogens_and_beyond-eceeeReportDecember12.pdf

upside down (e.g., hanging from a socket suspended from the ceiling). In these installations, much of the heat from the lamps operation will rise up into the housing of the lamp that contains the transformer / electronics, and this may affect the reliability of the circuit.

Secondly, there is also the issue of the quality of the IRC coating itself, which is built-up by applying a series of coatings to the surface of the halogen capsule. IRC are thin-film coatings that generally consist of two alternating materials, one with a high refractive index and one with low refractive index. By adjusting the number of layers and the thickness of each layer, a manufacturer can adapt the IRC to reflect infrared light and transmit visible light. Depositing multiple layers on a capsule takes time and requires investment in equipment to meet required production capacity. Furthermore, in the Impact Assessment conducted for the directional lamps regulatory measure (EU No 1194/2012) which also considered IRC coatings for directional lamps.[9] On this topic, the Impact Assessment concluded the following: "In summary, due to intellectual property rights, direct or indirect barriers may exist to the manufacturers intending to product IRC lamps. It was therefore not considered appropriate to raise the level of requirement on halogen lamps to a level that can only be achieved by IRC halogens."

Thus, the typical performance improvement from an IRC coating would enable a low-voltage halogen lamp to attain the B-class, however the technology for a mains-voltage retrofit lamp that incorporates this technology has yet to be commercialised successfully.

3.2 Compact Fluorescent Lamps

Fluorescent lamp technology is the most widely used artificial light source today, responsible for more than half the lumens delivered to our living spaces globally. Originally commercialised in the 1930s, manufacturers have been steadily improving the efficacy of these fluorescent lamps over the years through modifications to the phosphors, cathodes, fill-gas, operating frequency, tube diameter and other design attributes.

CFLs are simply miniaturised versions of the larger, linear fluorescent lamp systems. CFLs were first commercialised in 1980s as a technological response to the oil price shocks of the 1970s. They are, after 40 years of development, a mature technology with known strengths and weaknesses, and experience with consumers world-wide.

There are some areas where research may result in some performance improvements for CFLs, including:

- Phosphor improvements – better blends and new materials continue to be developed and patented, offering higher efficacies as well as better colour rendering and lumen maintenance over the lamp's service life;

- Enhanced fill gas – adjusting proportions of argon, krypton, neon and xenon to optimize performance, while also minimizing the mercury dose;

[9] For more information on this topic, see section 5.2.13 of the directional lamps impact assessment available at: http://ec.europa.eu/governance/impact/ia_carried_out/docs/ia_2012/swd_2012_0419_en.pdf

- Improved cathode coatings – these coatings can enhance electron emissivity and extend lamp life; and

- UV-reflective glass coatings – this thin-film coating can be deposited between the layer of phosphor and the glass tube, and would capture any UV light that inadvertently passes through the phosphor and reflect back into the phosphor layer for down-conversion.

These areas of research are consistent with those efforts taking place on linear fluorescent lamps, and the technology improvements can apply to both. It is important to note, however, that any investment in CFLs is going to be quite small given that manufacturers have really shifted their attention to LED lamps. Thus, some improvements such as better cathode coatings and UV-reflective glass coatings may not be commercialised for CFLs because it would require investment in manufacturing and increase the per-unit cost of CFLs, which are becoming a commodity product. At the same time that investment in CFLs is in decline, industry is researching techniques for reducing the mercury content of CFLs to comply with increasing regulatory stringency and other market forces.

3.3 Light Emitting Diode Lamps

LED technology is the focus of the majority of the research and development investment in lighting technology today. Efforts are being made to simultaneously lower manufacturing costs while improving efficacy (i.e., more light-output per watt consumed). LED technology is fulfilling its promise of offering the market the most efficient means of converting electrons into photons. In 2010, LED efficacy exceeded 200 lumens per watt in the laboratory, and leading researchers are projecting device-level efficacy potential of 250 to 280 lm/W (UCSB, 2010). At the device-level, these prototype laboratory LEDs have more than double the efficacy of LEDs being used in lamps today.

There are many areas of research that are being investigated simultaneously which is contributing to the overall rapid improvement in efficacy and reduction in cost expected in the coming years. The following list identifies five priority areas for research on an efficacy and cost basis[10]:

- Efficiency droop – LED internal quantum efficiency declines (i.e., “droops”) as current increases, or, in other words, LEDs tend to be most efficient when operating at low-currents. The cause of this reduction in efficiency is not yet fully understood but is believed to be caused primarily by Auger recombination and Shockley–Read–Hall or other non-radiative recombination and defects. Tests have shown that the efficiencies can drop from 150lm/W to as low as 70 lm/W at higher current densities.

- Thermal droop – heat in the LED chip also causes a reduction in efficacy. When LEDs are operating in a fixture, the junction temperature can get very hot - 120°C – and the efficiency can drop by 20 or 30%. More research is needed to fully understand this phenomenon, but it is believed that part of this problem is caused by Auger recombination. Researchers have found that some of the negative impact can be mitigated through good thermal management in the chip packaging.

- Phosphor – good phosphors are critical to ensuring that consistent, quality white light is available for general illumination. The wavelengths driving these phosphors can also have an impact – shifts in the blue or UV source driving the phosphor can cause the white light to be

[10] White Paper Summarizing Findings of a One-Day Workshop: Fast-Tracking Widespread Adoption of LED Lighting, May 2010, The Institute for Energy Efficiency, University of California Santa Barbara.

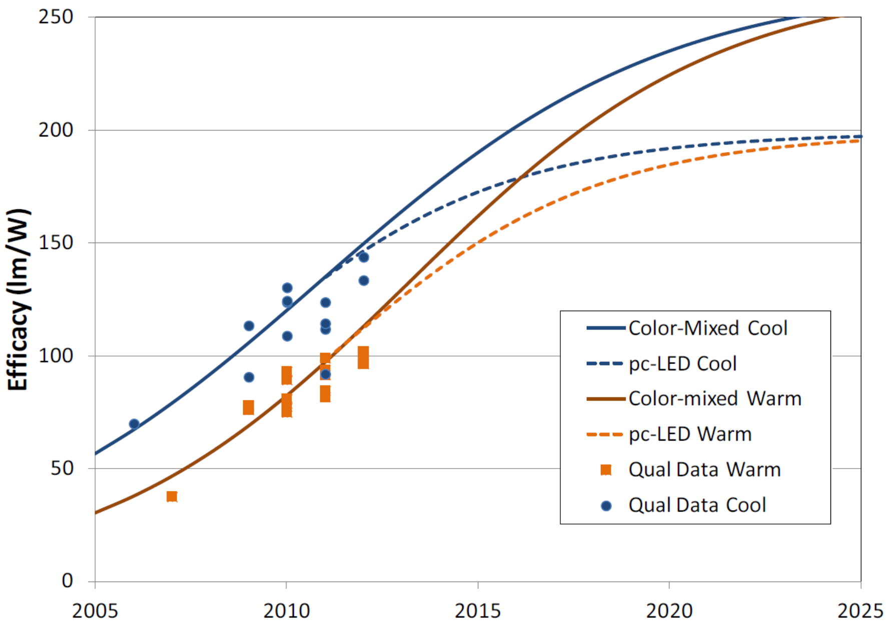
noticeably different. Manufacturers of equipment that produce LED chips are working to improve production processes and tighten up the emission wavelengths.

- Light extraction – packaged light extraction is currently at 80% efficiency and we believe another 15% can be achieved through roughening, high-reflectors, exotic structures and shapes, photonic crystals, and other extraction efficiency structures.

- Electrical efficiency – the best DC-drivers for LED lamps are 92 to 93% efficient. Researchers are working on a new set of drivers, and several companies are working on "driverless" lamps which are directly driven by AC. Experts estimate AC-driver efficiencies upward of 98% or higher can be achieved.

Through research on these and other aspects of LED technology, improvement is occurring at a rapid pace, as shown in the figure below. This diagram is taken from the US Department of Energy's Multiyear Programme Plan for Solid-State Lighting, 2012.[11] The focus of DOE's report is on LEDs for general illumination, and this diagram shows the commercially available products as well as laboratory prototypes, and the projection for energy performance improvement in the coming years.[12]

Figure 3-1. White Light LED Package Efficacy Projections for Commercial Product



Please see Chapters 3 and 5 of the US DOE's report for detail on the research and innovation in LED technology that will drive these performance improvement curves.

[11] Solid-State Lighting Research and Development Multiyear Program Plan for 2012; prepared for: Lighting Research and Development, Building Technologies Program, Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy; prepared by: Bardsley Consulting, Navigant Consulting, Inc., Radcliffe Advisors, Inc., SB Consulting, and Solid State Lighting Services, Inc.; April 2012

[12] Please see Chapters 3 and 5 of the US DOE's report for detail on the research and innovation in LED technology that will drive these performance improvement curves.

Under the Digital Agenda for Europe, the European Commission issued a Green Paper entitled "Lighting the Future: Accelerating the deployment of innovative lighting technologies" which also discusses how LED technology is rapidly evolving and how Europe's markets can benefit from this technology.[13]

In addition to being highly energy-efficient, good quality LEDs offer the market long life (in excess of 50,000 hours), have no filament or glass envelope to break, offer a small form factor and are mercury-free in their construction. Good thermal management of LEDs is critical to ensure these performance attributes are met. Although white-light LED packages operating in excess of 200 lm/W are starting to become commercially available,[14] there is still considerable research and development that remains to be done on the technology and on addressing the cost of manufacturing LEDs.

[13] Green Paper: Lighting the Future, Accelerating the deployment of innovative lighting technologies. The European Commission, Brussels, 15.12.2011, COM(2011) 889 final.
Link: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0889:FIN:EN:PDF
[14] Cree Reaches LED Industry Milestone with 200 Lumen-Per-Watt LED, Cree Inc. Press Release, Durham, North Carolina, USA. December 2012, see: http://www.cree.com/news-and-events/cree-news/press-releases/2012/december/mkr-intro

4 Energy Savings Potential

The purpose of this section is to provide an estimate of the potential for additional energy savings from revised regulations in the context of different levels of ambition. After briefly setting out the requirements of existing regulations, a high, medium and low ambition illustrative policy scenario is presented based on the preceding assessment of technological development. These policy scenarios provide an indicative estimate of the energy savings potential, based on updated regulatory requirements.

4.1 Existing Regulations

4.1.1 Ecodesign

Annex III of ecodesign regulation EC No 244/2009 sets out several stages of the regulation. A summary of these stages was prepared by OSRAM, which clearly conveys the impact of each of the six stages of the regulation. The table is adapted from the OSRAM website.[15]

Table 4-1. OSRAM Table Summarising Regulation 244/2009 on Household Lamps

1 Sep. 2009	Clear lamps: Minimum requirement is energy class C for lamps ≥ 950 lm Relevance: Incandescent lamps > 100 W are phased out as well as inefficient halogen lamps.
	Non-clear lamps: Minimum requirement is energy class A (or very efficient class B) for all lamps. Relevance: All non-clear incandescent and halogen lamps are phased out.
	Minimum performance requirements apply for lamps covered by the regulation (except for LED lamps).
	Lamps with S14, S15 and S19 bases are exempted from the efficacy requirements until 1st Sep. 2013.
1 Sep. 2010	Clear lamps: Minimum requirement is energy class C for lamps ≥ 725 lm Relevance: Incandescent lamps ≥ 75 W are phased out.
	Requirements for new product information on the packaging
1 Sep. 2011	Clear lamps: Minimum requirement is energy class C for lamps ≥ 450 lm Relevance: Incandescent lamps ≥ 60 W are phased out.
1 Sep. 2012	Clear lamps: Minimum requirement is energy class C for lamps ≥ 60 lm Relevance: Incandescent lamps ≥ 7 W are phased out.
1 Sep. 2013	Increased performance requirements for all lamps covered by the regulation (except for LED lamps)
	Lamps with S14, S15 or S19 bases are not exempted anymore and thus have to fulfil the efficacy requirements.
2014	Review of the regulation by the EU Commission
1 Sep. 2016	Clear lamps: Minimum efficacy requirement increased from energy class C to B. The increased requirements are not valid for lamps with G9 or R7s bases.

[15] Link to OSRAM website table: http://www.osram.com/osram_com/sustainability/sustainable-products/phasing-out-inefficient-lighting/eu,-europe,-middle-east-and-africa/non-directional-household-lamps/index.jsp

In addition to these regulatory requirements, the Commission established revised labelling requirements for non-directional lamps which were adopted in September 2012 as part of regulation 874/2012. These are provided here for information only, as they are not part of this review.

The regulation also provides a series of correction factors in Annex II, Table 3 which account for the losses associated with external power supplies, special caps, high colour rendering indices and a second envelope.

4.1.2 Energy label

The Commission has recently revised existing energy labelling requirements for non-directional lamps (EU No 874/2012).

The energy labelling regulation specifies seven energy labelling classes from E (least efficient) to A++ (most efficient). CFLs and LEDs are comfortably able to meet the A-class, with an EEI of 0.24, they represent approximately a 75% improvement over the performance of an incandescent lamp.

Table 4-2. Energy Classes for Lamps from Regulation 874/2012

Energy Efficiency Class	Energy Efficiency Index
A++ (most efficient)	EEI ≤ 0.11
A+	0.11 < EEI ≤ 0.17
A	0.17 < EEI ≤ 0.24
B	0.24 < EEI ≤ 0.60
C	0.60 < EEI ≤ 0.80
D	0.80 < EEI ≤ 0.95
E (least efficient)	EEI > 0.95

The Energy Efficiency Index (EEI) is calculated in accordance with Annex VII of the energy labelling regulation, and represents the ratio of power of the light source being measured relative to a reference power derived from the light output. This reference power approximates an incandescent lamp, thus a C-class lamp is approximately 20% more efficient than an incandescent lamp, and when these are manufactured, an A++ will be approximately 90% more efficient.

4.2 Illustrative Policy Scenarios

The energy savings scenarios developed for non-directional household lamps all assume that new ecodesign regulations come into effect in two steps – a Tier 1 requirement with an EEI of 0.24 (energy label class A) and a Tier 2 requirement with an EEI of 0.17 (energy label class A+). The difference between the scenarios is essentially the timing of when the Regulation becomes effective. These scenarios are based on the assumption that LED technology will be diverse, compatible and offer performance equivalent to products servicing these lighting applications today. As noted before, the analysis underlying this paper did not extend to an economic assessment of technological options, and so scenarios would have to be assessed with respect to whether they offer the least life-cycle cost.

Table 4-3: Three Illustrative Policy Scenarios for Non-Directional Lamps

Scenario	Ecodesign
1	Tier 1 at EEI ≤ 0.24 from 2019 Tier 2 at EEI ≤ 0.17 from 2022
2	Tier 1 at EEI ≤ 0.24 from 2018 Tier 2 at EEI ≤ 0.17 from 2021
3	Tier 1 at EEI ≤ 0.24 from 2017 Tier 2 at EEI ≤ 0.17 from 2020

Scenario 1 includes the adoption a Tier 1 requirement with an EEI of 0.24 (energy label class A) from 2019 and a Tier 2 requirement with an EEI of 0.17 (energy label class A+) from 2022. Thus, Tier 1 is introduced three years after the final Stage 6 of Regulation 244/2009, when LED lamps are projected to be much less expensive and cost-effective replacement clear (and non-clear) lamps will be widely available. Scenario 2 assumes the same new ecodesign requirement of 0.24 at Tier 1 and 0.17 at Tier 2, however the schedule is accelerated by one year – so that Tier 1 becomes effective in 2018 and Tier 2 becomes effective in 2021. Scenario 3 mimics the other two in terms of EEI levels; however it introduces the measures one year sooner than the second scenario – in other words, 2017 and 2020.

In all cases, it is assumed that the scheduling of the requirements is consistent with that for regulation EC No 244/2009, namely being introduced on September 1 of each of the years shown. Although there are no A++ products on the market in 2012, there is clear technical potential to achieve that level through LED products. And LED lamps are projected to become more affordable, as experts project an 80% reduction in the manufacturing cost of an LED lamp by 2020.[16]

In each of the three scenarios, it is assumed that LED products will achieve higher levels of performance, driven by the new energy label as well as by the market focus on energy-efficiency measures. In other words, the efficiency of LED products is assumed to improve as the regulatory interventions of ecodesign are applied earlier, encouraging earlier innovation in LED technology.

The table below presents the embedded assumptions for the weighted average wattage of an LED lamp sold in the years shown for each of the scenarios considered. The assumption starts from an LED lamp that is approximately 57 lm/W in 2010 and finishes at between 72 and 84 lm/W in 2030. Given that there are already lamps sold in the European market that are 64 lm/W in 2012[17], these efficacy assumptions are a conservative performance projection for the average products sold over the next 20 years.

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[16] The US DOE published a report in August 2012 which focuses on the manufacturing of LED and related products. In figure 1-1, the report shows a rapid decrease in cost that reflects the significant price reduction projection for integrated lamps in DOE's 2012 MYPP, with a reduction in cost of 66% by 2015 and 80% by 2020. Solid-State Lighting Research and Development: Manufacturing Roadmap, August 2012. US DOE
See: http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/ssl_manuf-roadmap_august2012.pdf

[17] For an example of a product with this efficacy in 2012, please see the following link:
http://download.p4c.philips.com/l4b/9/929000188502_eu/929000188502_eu_pss_aen.pdf

Table 4-4. Average Wattage for 800 Lumen LED Products Sold in Year, EU-27

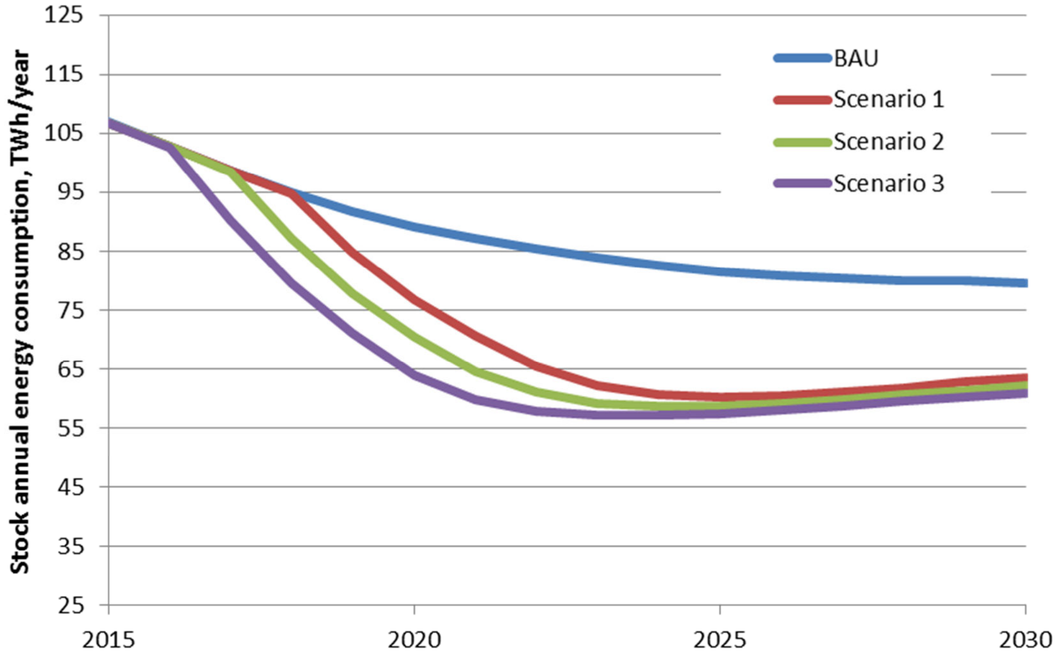
	2010	**2015**	**2020**	**2025**	**2030**
BAU	14.0 W	13.3 W	12.5 W	11.8 W	11.0 W
Scenario 1	14.0 W	13.1 W	12.3 W	11.3 W	10.5 W
Scenario 2	14.0 W	13.0 W	12.0 W	10.8 W	10.0 W
Scenario 3	14.0 W	12.9 W	11.4 W	10.5 W	9.5 W

4.3 Energy Savings Potential

As more energy efficient non-directional lamps are sold into the market each year, the average efficiency improves. The effect of the three illustrative policy scenarios on total energy consumption of across the EU-27 relative to the BAU scenario[18] is shown in the figure below. In each scenario, it is assumed that any shipments in a given year that are below the minimum requirements in the BAU scenario are then set to be minimally complaint with the regulation that year. These more efficient models are then introduced to the stock model, which tracks all the lamp lifetimes and wattages introduced to the market. The figure below illustrates the total stock energy consumption for the EU-27 for non-directional lamps under the BAU scenario and the three illustrative scenarios. The energy consumption starts to rise after 2022 - 2023 for the three scenarios as the deployment of efficient LED lighting gradually slows and the effect of increasing households and sockets as well as the embedded assumption of longer operating hours for more efficient sources (i.e., take-back effect) impacts the consumption estimate.

[18] Note that a table presenting the BAU energy consumption is provided in Table 2-7, BAU Energy Consumption for Non-Directional Lamp Stock, EU-27

Figure 4-1. Projected Stock Energy Consumption for BAU and Scenarios, EU-27



The energy savings potential of the three illustrative policy scenarios ranges from approximately 16 to 18.6 terawatt-hours of annual electricity saved in 2030. The reason the savings are greater in 2025 compared to 2030 is due to the expected natural efficacy improvement in the BAU scenario, where LED lamps continue to penetrate the market and reduce the electricity consumption. The energy savings in annual TWh are shown in the table below. The energy savings in the final few years start to decline slightly as the deployment of efficient LED lighting in the BAU scenario catches up with the accelerated energy-efficient market created in the scenarios.

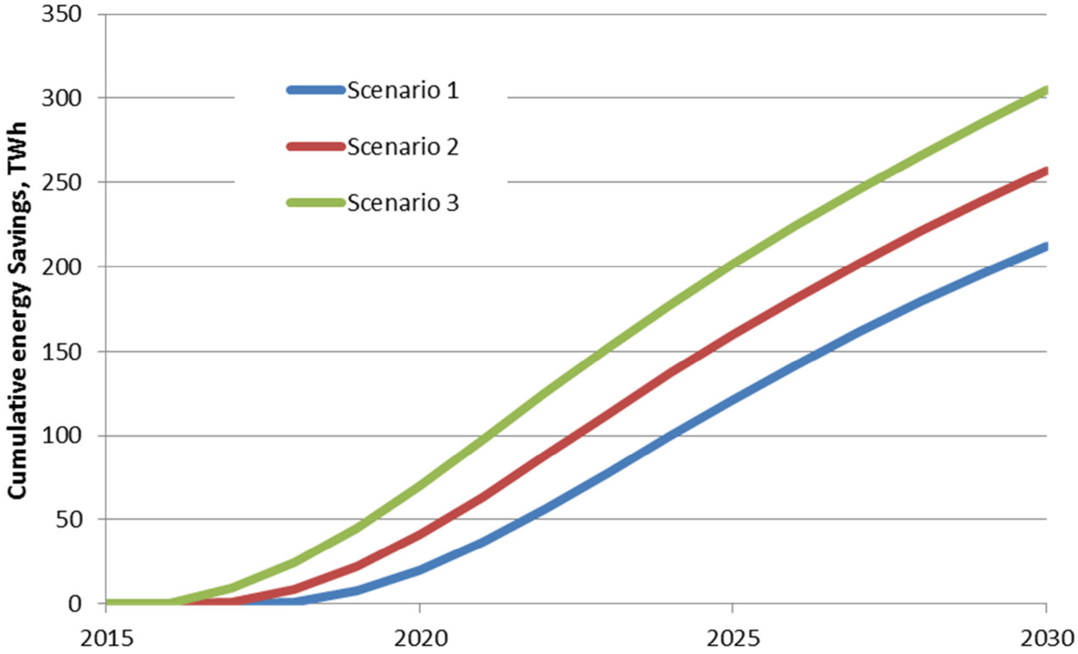
Table 4-5. Estimated Annual Energy Savings of Efficient Policy Scenarios, EU-27

EU-27 Projection	2015 (TWh/yr)	2020 (TWh/yr)	2025 (TWh/yr)	2030 (TWh/yr)
Projected Annual Energy Savings, Scenario 1	0.0	12.4	21.3	16.0
Projected Annual Energy Savings, Scenario 2	0.1	18.6	22.9	17.4
Projected Annual Energy Savings, Scenario 3	0.1	25.2	24.1	18.6

Across the EU, non-directional household lamps are projected to consume 89.1 TWh of electricity in 2020. The energy savings estimate from Scenario 2 is 18.6 TWh in that year, or approximately 21%. By 2030, the baseline energy consumption is 79.6 TWh of electricity and the energy savings estimate from Scenario 2 is 17.4 TWh, or 22%.

The figure below plots these energy savings on a cumulative basis, so the total energy savings at the end of the time period can be visualised. The scenarios considered for non-directional lighting have the potential to save Europe between 212 and 305 TWh of electricity over the next two decades.

Figure 4-2. Projected Cumulative Energy Savings for 3 Policy Scenarios, EU-27



5 Additional Issues

In line with the framework directive on ecodesign, reviews must assess potential future minimum performance requirements in light of technological progress. Above we have provided three illustrative policy scenarios in support of this. Further, implementing measures often require additional issues to be assessed in connection with the review. It may be that some issues are not anticipated in implementing measures, but could be relevant to include in a review. Below we consider both types of additional issues.

5.1 Additional Issues Required to be Assessed by the Implementing Measures

No specific additional requirements are specified in the “revision” article, Article 7. However the recitals did point to the need to verify that special purpose lamps are not used for general lighting purposes; taking note of the development of new technologies such as LED; and an assessment the feasibility of establishing energy efficiency requirements at the ‘A’ class level as defined in Directive 98/11/EC. As discussed in section 4, the energy savings scenarios are based on a Tier 1 requirement with an EEI of 0.24 (energy label class A) and a Tier 2 requirement with an EEI of 0.17 (energy label class A+), therefore the scenarios developed for this product group are consistent with these review requirements in the regulation. We have already considered the development of LED technologies at some length above. Below we briefly discuss special purpose lamps.

5.1.1 Verifying Special Purpose Lamps are Not Used for General Lighting Purposes

In 2012, several companies across Europe have started looking for ways to undermine regulation EC No 244/2009 by capitalising on the fact that the regulation has excluded ‘rough service’ incandescent lamps from the regulatory requirements.[19] Rough service lamps have a reinforced filament (extra lead supports) and tougher glass in order to enable them to operate in specialist applications where they are exposed to vibration and other harsh conditions. The extra reinforcing of the filament and robust construction causes these lamps to have a lower efficacy than the standard incandescent lamp covered by the regulation – the light output is approximately 30% lower for the same power consumption.[20]

Because rough-service incandescent lamps and are cheaper to manufacture than energy-efficient lamps that comply with regulation EC No 244/2009, they have experienced a surge in sales. According to Lux Magazine, on-line retailers have started offering these lamps which are marketed as rough service lamps for industrial applications, followed by text saying ‘commonly used domestically around the home as general lighting.’ In the UK, the National Measurement Office is investigating this issue and has already warned consumers that using these lamps in their homes may invalidate home insurance policies as these lamps are not intended for domestic use.

Promoting incandescent lamps for non-household applications to the residential market, may be mainly a matter of enforcement at the member state level, but may also raise issues of scope and definitions in the implementing measure. The topic should be included as part of the review.

In the United States, the phase-out of inefficient lighting was accompanied with a series of measures to try and ensure that the objective of the regulation was not undermined. The legislation required the US Department of Energy to prepare a shipment forecast of five exempted lamp types[21] based on historic

[19] “Beyond the ban” by Pennie Varvarides, Lux Magazine, p.72, October 2012.
[20] Comparison between a 100W incandescent lamp at 1550 lumens with a rough-service incandescent lamp at 1100 lumens
[21] The five exempted lamp types from the US regulation are: rough service lamps, vibration service lamps, 3-way incandescent lamps, 2601–3300 lumen general service incandescent lamps, and shatter-resistant lamps.

shipment data for those lamps. Starting in 2012, DOE obtains actual shipment data from the manufacturers association (NEMA) and compares the actual shipments of these lamp types to the projected shipments. If the actual shipments exceed the projected by 100%, then that lamp type loses its regulatory exemption and requirements are established for that lamp type within one year.[22]

5.2 Additional Issues Not Anticipated in the Implementing Measures

5.2.1 Level of Ambition of Existing Tier 6 for Halogen Lamps

Regulation EC No 244/2009 contains a regulatory requirement that increases the efficacy requirement on clear non-directional lamps in September 2016. Table 1 below is copied from Annex II of the regulation, which establishes the maximum rated power (P_{max}) for a given rated luminous flux (Φ). The requirement for Stage 6 of clear lamps is equivalent to an energy label class B halogen lamp (see section 4.1 of this Annex for information on B-class halogen lamps and a reference to a study on this product).

Table 5-1. Maximum Rated Power (P_{max}) for a Given Rated Luminous Flux

Application date	*Maximum rated power (P_{max}) for a given rated luminous flux (Φ) (W)*	
	Clear lamps	*Non-clear lamps*
Stages 1 to 5	*0,8 * (0,88√Φ+0,049Φ)*	*0,24√Φ+0,0103Φ*
Stage 6	*0,6 * (0,88√Φ+0,049Φ)*	*0,24√Φ+0,0103Φ*

When adopting this requirement in 2009, there were some energy label class B halogen lamps available for sale in the market. However a preliminary assessment of the market for the purposes of this paper, suggests that this is no longer the case. There was a product on the market from a European manufacturer several years ago, however it has been withdrawn from the market and we understand may have had some technical issues with the voltage converter that adjusted 230V mains voltage to 12V for operating an infrared reflective coated halogen capsule.

5.2.2 Promotion of Incandescent Lamps as Space Heating

Attempts have been made to undermine regulation EC No 244/2009 through the introduction of incandescent lamps marketed as space heating products (e.g., “Heatball”) or lamps that are not intended for “household” use (i.e., industrial lamps like rough-service incandescent lamps). In 2010, two German brothers started a company selling incandescent lamps under the brand name “Heatballs”.[23] The company claimed that these lamps were not for lighting, but were small space heaters that happened to fit into standard light bulb sockets. The German market monitoring and enforcement agency stopped the importation of these incandescent lamps and they were stopped from trading.

Attempts to promote incandescent lamps as space heating, may be mainly a matter of enforcement at the member state level, or may raise issues of scope and definitions in the implementing measure. The topic should be included as part of the review. Again it may be that the US-style supporting measures referred to above would be of value to consider.

[22] See DOE website: http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/63
[23] Heatballs website: http://www.heatball.de/en/

5.2.3 Correction Factors

There are several correction factors included in regulation EC No 244/2009 which adjust the maximum rated power for various types of lamps, most often increasing the maximum power (P_{max}) allowed under the regulation if the lamp has a high colour rendering or unusual cap. It would be desirable to assess whether these correction factors are still justified.

Table 5-2. Correction Factors from EC No 244/2009 for Special Configurations of Lamps

Scope of the correction	Maximum rated power (W)
filament lamp requiring external power supply	P_{max} / 1,06
discharge lamp with cap GX53	P_{max} / 0,75
non-clear lamp with colour rendering index ≥ 90 and P ≤ 0,5 * (0,88√Φ+0,049Φ)	P_{max} / 0,85
discharge lamp with colour rendering index ≥ 90 and Tc ≥ 5 000 K	P_{max} / 0,76
non-clear lamp with second envelope and P ≤ 0,5 * (0,88√Φ+0,049Φ)	P_{max} / 0,95
LED lamp requiring external power supply	P_{max} / 1,1

Source: Extract from EC No 244/2009

5.2.4 Measurement Tolerances

As for most other product groups considered in this paper, the magnitude of the verification tolerance could be reviewed as a smaller tolerance may now suffice.

Annex G. Simple Set Top Boxes

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1 Introduction and Context

In common with the other six annexes, this annex starts by setting out the timetable and scope of the upcoming reviews. It then sets out the scope of the existing implementing measures. Having provided this context, a BAU energy consumption scenario is developed. Next an assessment of technology developments is made and this is used to develop a set of illustrative policy scenarios on the basis of which a range of energy savings potentials are defined. Finally, a set of issues of relevance in the context of upcoming reviews is outlined.

1.1 Timetable and Scope of the Upcoming Review

Commission Regulation EC No 107/2009[1] on the ecodesign requirements for simple set-top boxes (SSTB) entered into force on 25 February 2009. The implementing measure states that it shall be reviewed no later than five years after its entry into force (i.e. by 25 February 2014) and the results of that review shall be presented to the ecodesign Consultation Forum.

There is no energy labelling regulation for SSTB.

In line with the ecodesign framework directive, the review of the implementing measure must assess potential future minimum performance requirements in light of technological progress. No additional issues to be integrated into the review were specified in Article 7.

1.2 Scope of Coverage of the Implementing Measure

A set top box is a device that connects a television to some external signal, and which turns that signal into content that is displayed on the screen. The signal source might be a satellite dish antenna, a coaxial cable (cable television), a telephone line (including DSL connections), broadband over power line, an Ethernet or optical fibre optic cable, or a VHF or UHF antenna. The content could mean video, audio, internet web pages, interactive games and others. Set top boxes exist in various forms, however they share a common set of characteristics: (1) they are connected to a television set or electronic display; (2) they are connected to a transmission medium (e.g., satellite dish, coaxial cable, antenna, internet) from which they receive content; and (3) they are usually part of media content service (and are often provided by the service operator).

Set top boxes are a group of consumer electronics products that provide similar services and which are generally grouped into two classes of product – simple set top boxes (SSTBs) and complex set top boxes (CSTBs). The table below provides a general overview of how they are categorised and differentiated along these two lines.

[1] Commission Regulation (EC) No. 107/2009 of 4 February 2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for simple set-top boxes; Official Journal of the European Union, 5 February 2009, L 36/8. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:036:0008:0014:EN:PDF

Table 1-1. Differentiating Between Simple and Complex Set Top Boxes

Product Category	Description
Simple set top box	Access to free to air broadcast programmes (same free programme for all users)
Complex set top box	Access to pay TV broadcast programmes
Complex set top box	Access to full video on demand programmes with several levels of interactivity relating to this service
Complex set top box	Access to other conditional services such as voice (telephone) and data

SSTB have been subject to an ecodesign regulatory requirement (Regulation 107/2009) that established two different levels of performance requirements (see section 4.1). CSTB are covered by a voluntary agreement (VA)[2] concluded by industry in the framework of the Ecodesign Directive (2009/125/EC) and recognised by the Commission as a valid alternative to an implementing mandatory measure[3] and a code of conduct (CoC)[4] of the Commission's Joint Research Centre (JRC). While the VA aims at laying down efficiency requirements for CSTBs, the CoC aims at laying down aspirational efficiency requirements for CSTBs. The CoC seeks to encompass all new models of CSTBs marketed in the EU for the first time by those companies wishing to achieve greater efficiencies than then those already realised under the VA.

Thus, CSTB products are part of a larger consumer electronics product group of set top boxes that offer potentially identical functions, but which are not covered by the SSTB Regulation because they incorporate other features. Generally, those products which are not SSTB are considered CSTB, and are therefore covered by the aforementioned VA and the CoC. However, there are new products emerging onto the market which do not appear to fall into either the SSTB or CSTB definitions, and thus which are not clearly covered under either the regulatory or voluntary schemes in place.

SSTB are defined in Regulation 107/2009 in Article 2, Definitions as follows:

> *"1. 'Simple set-top box' (SSTB) means a stand-alone device which, irrespectively of the interfaces used,*
>
> *(a) has the primary function of converting standard-definition (SD) or high-definition (HD), free-to-air digital broadcast signals to analogue broadcast signals suitable for analogue television or radio;*
> *(b) has no 'conditional access' (CA) function;*
> *(c) offers no recording function based on removable media in a standard library format.*

---

[2] Voluntary Industry Agreement to improve the energy consumption of Complex Set Top Boxes within the EU; Proposal from the industry group, Version 3.0, 2nd September 2011 http://ec.europa.eu/energy/efficiency/ecodesign/doc/20121217_voluntary_industry_agreement_cstb.pdf
[3] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=SWD:2012:0392:FIN:EN:PDF
[4] For more information on the European Commission's work developing the CoC for CSTB, visit the JRC's website: http://iet.jrc.ec.europa.eu/energyefficiency/ict-codes-conduct/code-conduct-digital-tv-services

A SSTB can be equipped with the following additional functions and/or components which do not constitute a minimum specification of an SSTB:

(a) time-shift and recording functions using an integrated hard disk;
(b) conversion of HD broadcast signal reception to HD or SD video output;
(c) second tuner."

Thus, a SSTB is a standalone device which has the primary function of converting SD or HD free-to-air digital broadcast signals to analogue broadcast signals suitable for analogue television or radio, and has no 'conditional access' function. For example, a set top box that has an unpopulated common interface socket (i.e. no requirement for a service provider viewing card slot) is a SSTB. A set top box that has a common interface socket which is populated with an active common interface module would be considered a CSTB.

A CSTB is defined in Annex B of the VA as follows:

"A CSTB is a device equipped to allow conditional access by descrambling using dynamically allocated keys, where the primary function of the device is the reception, descrambling and processing of data from digital broadcasting streams and related services. It may also have audio and video decoding and output capability and/or the ability to provide content to one or more dedicated Thin-Client/Remote CSTBs via a home network.

For the purposes of the Voluntary Agreement a device shall not be considered to be a CSTB unless it can fulfil the functions of a CSTB when activated by the operator of the network."

Thus, the principal product differentiator in both the VA and the CoC is the fact that CSTBs have a conditional access (CA) function. In this context an important qualification of what constitutes a CA function is given in the VA. CA means:

"the encryption, decryption and authorization techniques employed to make access to content conditional upon authorization using a key that is dynamically allocated using a Conditional Access (CA) OR Digital Rights Management (DRM) system."

The ability of an STB to decode parts of the broadcast data stream scrambled to a fixed key or Huffman code does not constitute a conditional access function.[5]

All the other qualifications that are used to determine that a CSTB product shall not be covered by either the VA or the CoC and which are not specifically excluded from the SSTB Regulation have the potential to introduce uncertainty around coverage. For example, in the y VA and the CoC, a CSTB excludes:

- Digital TVs with integrated receiver decoder;
- Digital receivers with recording function based on removable media in a standard library format (e.g., VHS tape, DVD, Blu-ray disc and similar);

[5] Fixed key scrambling or Huffman Coding is often used to encrypt programme guide data in digital TV transmissions to meet regional copyright requirements.

- Devices whose primary function is something else than the reception of digital TV signals such as computers fitted with digital TV tuners or TV add-in cards, games consoles with digital TV tuners, external plug in (e.g., USB) digital receivers for computers;

- Products handling Gateway services to multi-subscriber scenarios.

In the context of signal interfaces the VA also states that the use of an HDMI digital signal interface for the connection between the STB and the TV or display does not make the STB a CSTB.

All other CSTB functions and features other than the provision of a CA function could exist in a SSTB and not be excluded or specifically qualified by the current Regulation. This applies in particular to additional features, developed since the drafting of the Regulation which enhances the recording and viewing of TV broadcasts and which require consideration in the energy allowance budget for SSTBs.

In conclusion, the definition of SSTB in Regulation 107/2009 served its purpose but seems now outdated and may need revision. CSTB voluntary initiatives have been developed, but these exclude certain products that are otherwise also excluded from the SSTB Regulation. This new group of products are therefore not subject to either SSTB Regulation 107/2009 or the two voluntary initiatives. One of the critical aspects of the revision of Regulation 107/2009 will be to carefully establish definitions and requirements that will ensure coverage of these products that are currently omitted from SSTB and CSTB scopes of coverage.[6]

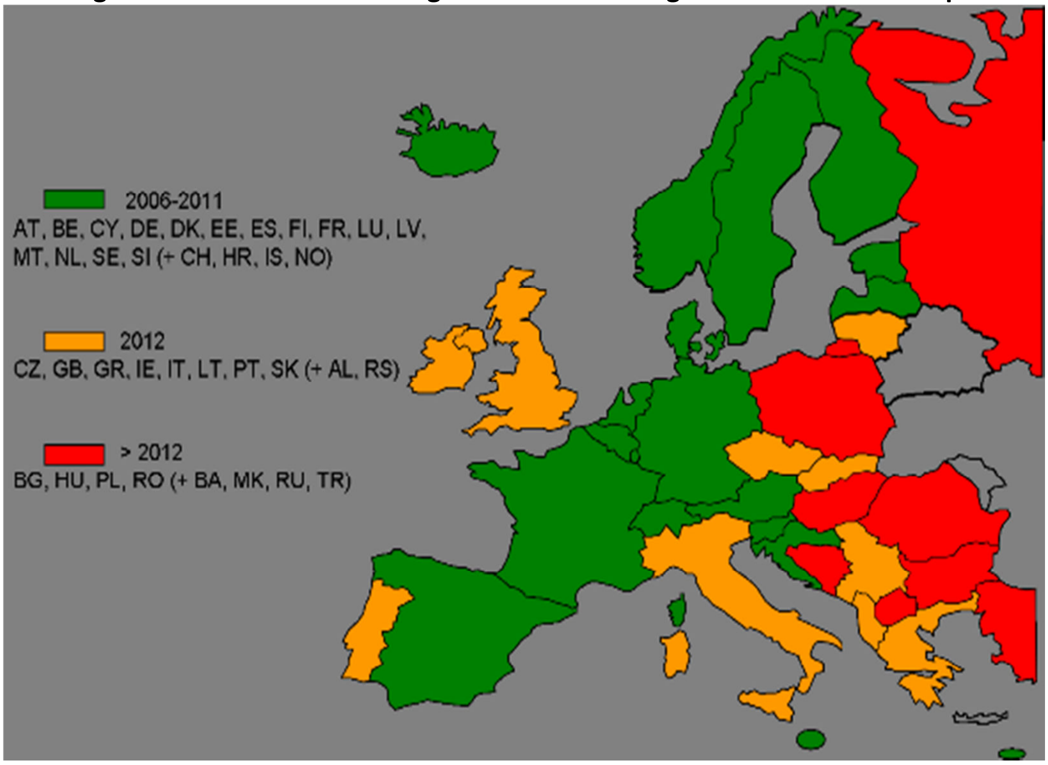
[6] Although not considered in this paper, it should be noted that all types of set top boxes (including simple and complex) are covered under Commission Regulation (EC) No 1275/2008 of 17 December 2008, implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for standby and off mode electric power consumption of electrical and electronic household and office equipment. Therefore, all set top boxes not regulated elsewhere are subject to the requirements of this regulation. See link to 1275/2008: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:339:0045:0052:en:PDF.

2 Market Projection

2.1 Installed Stock and Annual Sales

The shipments of SSTB in Europe and the magnitude of the installed stock are principally linked to the rate of the transition to digital terrestrial television (DTT) broadcasting in Europe. In most countries, a phased shutting down of analogue TV signal transmissions has overlapped with the introduction of DTT broadcasting. This transition acted as a further impetus to households who owned analogue televisions to purchase digital SSTBs or subscribe to a service provider CSTB for cable, satellite or DTT services.
As shown in the figure below, by December 2012 countries comprising the majority of European households had implemented the transition to DTT broadcast, although some delays are expected in Bulgaria, Poland, Romania and possibly Hungary. DTT roll out is currently scheduled to be completed in all EU-27 countries by 2015, which will render analogue televisions unusable unless they are used with analogue cable networks or digital SSTB and CSTB for terrestrial, satellite, cable and internet protocol television broadcast services. The map of Europe below shows the schedule for the analogue switch-off across Europe.[7]

Figure 2-1. Schedule of Analogue TV Broadcast Signal Switch-Off in Europe



An estimate has been prepared of the stock of SSTB in European households based on analysis of the "Special Eurobarometer 381" survey report.[8] The estimated sales and stock of SSTB in EU-27 households for Satellite and DTT free-to-view broadcast services are based on the annual surveys from 2007 to 2011, as shown in Table 2-1. All other TV broadcasting services (cable and ADSL-telephone line)

[7] MAVISE Database of TV companies and TV channels in the European Union and candidate countries, European Audiovisual Observatory, DG Communication of the European Commission. http://mavise.obs.coe.int/

[8] Special Eurobarometer 381, E-Communications Household Survey Report, Survey requested by the European Commission, DG for Information Society and Media and co-ordinated by DG for Communication.
Link to 2011 report: http://ec.europa.eu/public_opinion/archives/ebs/ebs_381_en.pdf

are assumed to use a CSTB only. The stock estimate also draws upon the MAVISE / European Audiovisual Observatory data to qualify the Eurobarometer data. In the market model developed from these data, free-to-view satellite service SSTBs are estimated to be 17% of the total satellite set top box annual survey shipment estimate[9] and free-to-view DTT service SSTBs are estimated to be 32.3% of the total DTT STB annual survey shipment estimate.

Table 2-1. Sales and Installed Stock of SSTB in the EU-27 Member States

EU-27 data	2007	2008	2009	2010	2011
Sales (million units)	20.0	24.5	37.2	26.5	12.3
Stock (million units)	48.8	73.3	110.5	137.0	149.3

GfK data on the 2010/2011 sales of SSTB in the EU-27 indicate that approximately 40% of SSTB sales were multi-tuner hard disc drive types (i.e., personal video recorders or PVRs) allowing simultaneous recording and viewing of separate programme services. Indeed, the vast majority of the satellite SSTBs were PVR types.

2.2 SSTB Stock and Sales Projection

In response to the analogue switch-off, TV manufacturers started to ship a large proportion of their TVs with integrated digital TV tuners (IDTVs) in 2006. According to experts at DigitalEurope, by December 2012 approximately 250 million IDTVs had been shipped to the EU-27. Many of these TVs would have replaced analogue cathode ray tube (CRT) TVs and basic SSTBs providing no hard disc drive (HDD) recording functions. In Table 2-1, the 2010 and 2011 SSTB sales figures start to decline, reflecting the impact of these IDTV shipments. The gradual reduction in cost of large screen digital TVs that have internet protocol (IPTV) capability will further reduce market demand for SSTBs. A small market for SSTB may continue to enable access to HD television services for older HD ready IDTVs with SD tuners but this niche market is not likely to continue for more than three years.

The DisplaySearch Global TV Replacement Study of May 2012 shows that in mature TV markets, 31% of households generally plan to replace an existing TV each year. DigitalEurope sources estimate that the existing EU-27 stock of approximately 600 million TVs will be rationalised to provide full digital broadcast coverage for European households through replacement and the trend toward multi screen broadcasting platforms for secondary TV viewing (e.g. internet connected tablets).

It is expected that SSTB sales will be dominated by high feature Personal Video Recorders (PVRs) supporting multi-screen local area network (LAN) programme distribution and home gateway interface functions for those households who do not wish to use subscription services. Leading European STB manufacturers predict that the basic SSTB and simple PVR SSTB will virtually disappear as a product within seven years leaving a relatively low volume of high feature SSTB products. The table below shows the projected levels of sales and stock of SSTB and a BAU projection of energy consumption to 2030.

[9] Relevant in measurable survey terms from main roll-out of “freesat” broadcast platform 2009 onwards.

Table 2-2. Projected SSTB Sales and Stock in EU-27 Member States

EU-27 projection	2010	2015	2020	2025	2030
Population (million)[10]	501.5	508.2	514.4	519.1	522.3
Sales of all SSTB (million units)	26.5	12.3	10.0	-- *	--*
Stock of basic SSTB (million units)	79.6	50.0	26.1	-*	--*
Stock of PVR SSTB (million units)	53.1	57.4	48.4	37.3	4.7

* Sales estimates are projected to drop to zero for all SSTB units by 2025, and the basic SSTB will no longer be in use in the market by 2025.

2.3 Projected Energy Consumption

The base case energy consumption projection prepared for this study reflects the on-going influence of the current ecodesign measure. This projection is referred to as the 'Business as Usual' (BAU) scenario. The SSTB can feature a large range of additional functions. These additional functions will be restricted to the existing requirement of decoding HD TV signals and the basic requirement of a second tuner for the PVR SSTB. For the purposes of the energy consumption projection, the current 2nd (final) criteria tier of the SSTB Regulation (section 4.1.1) will be used to calculate the total energy consumption (TEC) per annum using the following metrics which mirror those in the VA and CoC for CSTB but use the current SSTB Regulation criterion of 3 hours for the auto power down period:

$$= 0.365 \times (P_{on} \times 4.5hr + P_{standby} \times 16.5hr + P_{auto\ power\ down} \times 3hr)$$

Where:

P_{on} is the measured power in watts of the active mode
$P_{standby}$ is the measured power in watts of standby mode
$P_{auto\ power\ down}$ is the measured power in watts of the SSTB when it has entered into auto power down mode.

Applying this equation to the basic SSTB for HD TV, an annual average energy consumption of nearly 17 kWh is calculated:

$$0.365 \times (6 \times 4.5 + 1 \times 16.5 + 1 \times 3) = 16.97 \text{ kWh}$$

Applying this equation to the two tuner PVR SSTB for HD TV, an annual average energy consumption of nearly 29 kWh is calculated:

$$0.365 \times (13 \text{ x } 4.5 + 1 \times 16.5 + 1 \times 3) = 28.47 \text{ kWh}$$

[10] The European population projection is available from Eurostat at the following link: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=proj_10c2150p&lang=en

The active duration of 4.5 hours is that used for the CoC and VA and the auto power down duration is that specified in the SSTB Regulation.

The table below provides an estimate of the energy consumption for the BAU scenario.

Table 2-3. EU-27 Stock SSTB Energy Consumption BAU Scenario

EU-27 projection	2010 (TWh/yr)	2015 (TWh/yr)	2020 (TWh/yr)	2025 (TWh/yr)	2030 (TWh/yr)
Stock annual energy consumption, BAU	2.86	2.48	1.82	1.06	0.13

3 Technology Assessment

There are many technology measures that are adapted for use with SSTBs that improve their efficiency. The main opportunities for improvement in energy-efficiency include higher integration of chips; more energy efficient software development; higher power supply efficiency; and auto switch-off to standby-mode and low power standby.

3.1 Power Management

When the set top box is not required for decoding, the user is encouraged to put it into "standby mode" to save energy. There are three potential operational standby modes to consider which will save power.

(1) Standby-passive - with very low standby levels (<1W) most circuit blocks, the processor and the software may be inactive, signal feed through (Baseband and RF) may be disabled. All that is needed is the ability to receive and recognise an IR user command to switch the STB into the active state. This is usually achieved, with a low power MCU (Micro Control Unit) integrating a small amount of ROM a microprocessor and IR detection as well as a power supply. These devices are becoming more competitively priced and are incorporated in new low cost STB designs.

(2) Low processor speed - use the main processor of the STB running at a very low clock rate and some of the main memory. The STB is not receiving any signal but some software is running and timed or triggered wake-up is possible as well as rapid response to a user command. The set top box may periodically wake-up to check the data stream for anything addressed to it and update the EPG (Electronic Programme Guide).

(3) Software suspend mode – another approach is the use of a software suspend mode where all processing (except possibly a timer) is halted but memory self-refresh is used to enable rapid wake-up.

3.2 Hard Disk Drive

The majority of simple STBs with a programme storage capability currently use a hard disc drive (HDD) to store the MPEG data stream for later viewing or time delayed viewing (live pause) The HDD may consume 6 watts of DC power when active. Careful management of the HDD can allow it to go into a sleep mode when not required. Smaller, lower power hard discs developed for the portable computer market are now being considered to reduce energy and cost of the HDD component. Another option would be the use of medium capacity HD cards for the live pause /instant record short duration buffer. This could be backed up by the HDD for longer term recording.

3.3 Design Approaches for Maximum Energy Efficiency in an STB

Ideally adequate power management of each circuit block should be achieved by software control of the silicon. Switching of power rails may be needed but prompts careful scenario analysis of the user experience.

The designer must consider power consumption and in-built power management features when choosing silicon for the main processor and RF front-end. The software designers must be involved from the outset so that energy efficient software architecture and power management are fundamentals of the early design concepts. Third-party (licensed) software, which may be used for the operating system (or conditional access), must support power management. The designer should ensure that power to peripheral ports and devices can be turned off when not required ideally as an automatic action transparent to the user.

At the point in transition where STBs are being used solely for Digital TV reception remote control solutions must be considered allowing the user to put the STB and TV into standby simultaneously. HDMI digital signal interconnection between the TV and STB with consumer electronic control (CEC) is an obvious solution. The introduction of new silicon functional blocks is the key tool for achieving STB efficiency. Power management units come into this category.

3.4 Power Management Units

A Power Management Unit (PMU) is an up-integration into a single piece of silicon of the peripheral functions outside of the Main Processor & Power Blocks to allow the Main Processor to access a range of peripheral functions using only one control line. This means that the peripheral functions share a common interface with the Main Processor. So, Main Processor power management control can be implemented cost effectively.

Common benefits of PMUs within both major blocks are:

- The direct interconnection of blocks to the Main Processor allowing the Main Processor to readily put those blocks to “sleep” as and when needed.
- Serial addressing of the Main Processor and function blocks leads to simplification in layout, cost, and placement.
- Implementation of functions in software reduces hardware cost and power consumption.

Two physical locations in a STB can be defined as being suitable for a PMU implementation. These are the Front-Panel and the Main-Board.

3.5 Miniaturization and System Integration (one chip solution)

The increasing pressure to reduce manufacturing cost of SSTBs leads to higher system integration and miniaturization of these devices. The single-chip implementation of the complete RF satellite front-end consists of tuner, demodulator, LNB signalling controller and LNB supply regulator. The single-chip RF front-ends can simplify RF and power design for STBs. A single chip front-end dependent on the targeted medium (cable, terrestrial, satellite) then provides the Transport Stream input to the host. The target to reduce manufacturing costs using higher integrated silicon has the added benefits of a reduction in additional discrete components and the physical size of the tuner block. In this context the television industry have radically redesigned digital tuners to meet the restrictions on circuit board depth dictated by ultra-slim TV form factors. One significant benefit of these redesigns is the encapsulation of multi-tuners in one physical package with the power requirement benefits of system integration. Current tuners for digital broadcast streams require less than 0.5W to produce a fully demodulated and error corrected data stream.

3.6 Software Design

Energy demand is determined not only by hardware selection but by intelligent software design as well. Using intelligent software design opens low power demand options even for very cheap SSTBs using mass market “from the shelf” hardware components. Implementing a good software design provides a significant reduction of power demand in on-mode. Using properly designed software can detect and select the essential parts from the mpeg stream. This pre-selection reduces the working load of the processors which results in a lower power demand from these components. A good software design provides not only low power use of the hardware resources in on-mode, it offers additional features such as low power standby-mode due to software triggered switch-off of components not used during the standby operation of the STB.

3.7 Power Supply Efficiency

The power supply represents another opportunity to reduce energy waste, whether the supply is located internally or externally to the device, there are several solutions available to the market to provide an energy efficient power supply for SSTB. For details concerning improvement potential of power supplies, please refer to the Annex for external power supplies, as many of these same principles will be applicable to the power supplies for SSTB.

3.8 Other Technology Trends

The dramatic escalation in the use of internal and external solid state memory (SSM) for personal multimedia products now makes possible the use of relatively large memory storage in relatively low cost products. Apart from the potential to reduce power by replacing or buffering the HDD in a PVR STB, low cost SSM can be used to improve the boot up time of the STB allowing very low power standby levels and acceptable user experience at start up from standby.

4 Energy Savings Potential

The purpose of this section is to provide an estimate of the potential for additional energy savings from revised regulations in the context of different levels of ambition. After briefly setting out the requirements of existing regulations, two illustrative policy scenarios are presented based on the preceding assessment of technological development. These policy scenarios provide an indicative estimate of the energy savings potential, based on updated regulatory requirements.

4.1 Existing Regulations

There are three measures that warrant discussion in this section even though only one of them applies to SSTB. The other two apply to CSTB, which are related products and thus the voluntary agreements adopted for CSTB are important to discuss.

The ecodesign Regulation 107/2009 established minimum energy performance requirements for SSTB at the following levels:

From 25 February 2010, Tier 1:

SSTB placed on the market shall not exceed the following power consumption limits; SSTBs with an integrated hard disk and/or second tuner are exempt from that requirement:

Table 4-1. Ecodesign Regulation 107/2009 Requirements for Tier 1, February 2010

	Standby mode	***Active mode***
Simple STB	*1,00 W*	*5,00 W*
Allowance for display function in standby	*+ 1,00 W*	*--*
Allowance for decoding HD signals	*--*	*+ 3,00 W*

From 25 February 2012, Tier 2:

SSTBs placed on the market shall not exceed the following power consumption limits:

Table 4-2. Ecodesign Regulation 107/2009 requirements for Tier 2, February 2012

	Standby mode	***Active mode***
Simple STB	*0,50 W*	*5,00 W*
Allowance for display function in standby	*+ 0,50 W*	*--*
Allowance for hard disk	*--*	*+ 6,00 W*
Allowance for second tuner	*--*	*+ 1,00 W*
Allowance for decoding HD signals	*--*	*+ 1,00 W*

In addition to these requirements, the Regulation also requires that by 25 February 2010, SSTBs must provide a standby mode and SSTBs must be equipped with an ‘automatic power-down’ or similar function enabled as default in which the SSTB will automatically switch from active mode into standby mode after less than three hours in active mode following the last user interaction and/or a channel change with an alert message two minutes before going into standby mode.

4.2 Voluntary Agreement for Complex Set Top Boxes

The VA became effective on July 1, 2010. It has two tiers that give maximum energy consumption levels. The first (Tier 1) is effective until June 30, 2013. After that, Tier 2 energy consumption targets will become effective starting July 1, 2013.

Table 4-3. Base Functionality Annual Energy Allowance

Base	Tier1 Annual Energy Allowance (kWh/year)	Tier2 Annual Energy Allowance (kWh/year)
Cable	45	40
Satellite	45	40
IP	40	35
Terrestrial	40	35
Thin-Client/Remote	40	35

The VA makes allowances in the maximum annual power consumption for specific additional functionalities, as shown in the following table:

Table 4-4. Annual Energy Allowances for Additional Functionalities

Additional Functionalities	Tier 1 Allowance (kWh/year)	Tier 2 Allowance (kWh/year)
Advanced Video Processing	20	0
High Definition	20	0
Access to additional RF Channels [A]	20	15
DVR	20	20
Return Path Functionality	60	25
Return Path Technical Interfaces: ASDL or DOCSIS 2.0 VDSL or DOCSIS 3.0 [B]	 0 70	 30 50
Multi-decode and Multi-display	38	25 (multi-decode) 6 (multi-display)
High Efficiency Video Processing	n/a	20
Full High Definition	n/a	20
Ultra High Definition	n/a	30
3DTV	n/a	20
Advanced Graphics Processing	n/a	5
In-home Network [C]	n/a	12

[A] Allowance per RF channel
[B] Allowance per 4 bonded RF channels
[C] Allowance per network interface type implemented for Home Networks

4.3 Code of Conduct (draft v.9) for Complex Set Top Boxes

The JRC is developing a Code of Conduct. The current draft maximum energy consumption levels from the September 2012 draft version 9 are reproduced in the tables below, but these are subject to change as the work on a new version is on-going.

Table 4-5. Base Functionality Annual Energy Allowance

Base	Tier 1 Annual Energy Allowance (kWh/year)	Tier 2 Annual Energy Allowance (kWh/year)
Cable	37	32
Satellite	44	36
IP	26	25
Terrestrial	37	32
Thin-Client/Remote	26	25

Similar to the VA, the CoC makes allowances in the maximum annual power consumption for specific additional functionalities, as shown in the following table:

Table 4-6. Annual Energy Allowances for Additional Functionalities

Additional Functionalities	Tier 1 Allowance (kWh/year)	Tier 2 Allowance (kWh/year)
Additional RF channels	8	3
Advanced Video Processing #	0	0
High Efficiency Video Processing #	20	13
Full High Definition *	0	0
Ultra High Definition *	20	13
3DTV	20	13
Advanced Graphic Processing	5	0
Multi-encoding	15	10
Multi-display	5	5
In-Home Networking interface technology	18	14
In-Home Networking network port	12	5
In-Home Networking Access Point Router	53	37
Return Path technical interface ADSL/DOCSIS 2.0	30	22
Return Path technical interface VDSL/DOCSIS 3.0	45	25
DVR	15	10
VOIP	12	7

4.4 Illustrative Policy Scenarios

The most significant environmental aspect of the SSTBs is energy consumption. As the features and functions of this group of products increases in complexity[11], smart power management becomes an essential requirement. In addition, the migration to STBs from personal multi-media products to "smart phone"-type system-on-chip (SoC) designs, there may be an escalation in wasted energy through the unnecessary powering of unused functions. The development of product specific SoC and enabled power management protocols requires a minimum manufacturing volume, and for this to be viable, the SSTB is likely to be provided as a variant of CSTB designs without conditional access.

To determine the energy savings potential for SSTBs, two illustrative policy scenarios were developed that update the ecodesign regulations. Only two scenarios were developed for this product group. These were designed around the CTSB code of conduct (version 9.0) that is being developed by the

[11] Additional complexity includes, for example, providing home gateway and LAN multi-screen and multi-room thin-client STB support features.

European Commission's Joint Research Centre and experts from industry and government. For Scenario 1, it is assumed that the Tier 1 criteria of the draft CSTB CoC version 9.0 are adopted in 2016. For Scenario 2, it assumes the same efficiency requirements; however the Regulation accelerates the schedule so that it takes effect in 2014 instead of 2016. In both instances, it is assumed that the energy savings estimate associated with the draft CSTB CoC version 9.0 is approximately 15% of the BAU Scenario.

4.5 Energy Savings Potential

Based on the two scenarios discussed above, the table and figure below present the BAU energy consumption for SSTBs under the BAU case and the two scenarios.

Table 4-7. Estimated Energy Consumption for Simple Set Top Boxes, EU-27

EU-27 projection	2010 (TWh/yr)	2015 (TWh/yr)	2020 (TWh/yr)	2025 (TWh/yr)	2030 (TWh/yr)
Business as Usual	2.86	2.48	1.82	1.06	0.13
Scenario 1	2.86	2.48	1.55	0.90	0.11
Scenario 2	2.86	2.30	1.55	0.90	0.11

Note that the stock mix of basic HD TV SSTB and 2 tuner PVR HDTV SSTB in the two energy saving scenarios is the same as in the BAU scenario. Also, to be compatible with the CoC and VA an automatic power down (APD) criteria of 4.5 hours is used in the metrics instead of the 3 hours in the current SSTB Regulation.

By 2030, the energy savings potential of the two illustrative policy scenarios would range between 0.0 and 0.3 TWh per annum. On a cumulative basis, the energy savings would be between 2.4 and 3.1 TWh by 2030. The table below presents these savings estimates.

Table 4-8. Estimated Energy Savings and Cumulative Energy Savings (TWh) for SSTB, EU-27

EU-27 projection	2015 (TWh/yr)	2020 (TWh/yr)	2025 (TWh/yr)	2030 (TWh/yr)
Scenario 1, Annual Savings	--	0.27	0.16	0.02
Scenario 2, Annual Savings	0.19	0.27	0.16	0.02
Scenario 1, Cumulative Savings	--	0.99	2.09	2.41
Scenario 2, Cumulative Savings	0.29	1.68	2.77	3.09

Across the EU, SSTB are projected to consume 1.82 TWh of electricity in 2020 and the energy savings estimate from Scenario 2 is 0.27 TWh.

5 Additional Issues

The regulation does not identify any additional issues to be integrated into the review and we did not identify any.