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Sustainability Centre of Expertise
West Europe

Project Pandia

LCA0014

Comparative Life Cycle Assessment of LED-enabled LCD TVs over their entire life cycle, comparing the effect of the integration of cadmium based and non-cadmium based light enhancement films.
Non-confidential version, for public consultation.

Version 1

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		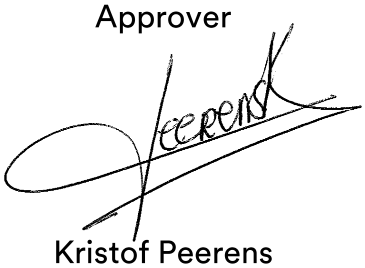
Katerina Softa 7-Dec-2015	Jonas Depelchin 9-Dec-2015	Kristof Peerens 11-Dec-2015

Revision comments

Version 1 N/A.

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Acronyms

3M	Minnesota Mining and Manufacturing
Acid	Acidification
ADPe	Abiotic Depletion Potential, elements
ADPf	Abiotic Depletion Potential, fossil
AP	Acidification Potential
APF	Advanced Polarizer Film
BEF	Brightness Enhancement Film
CC_ex	Climate Change, excluding biogenic carbon
CC_in	Climate Change, including biogenic carbon
Cd	Cadmium
cd	Candela (unit of luminous intensity)
CdSe	Cadmium Selenide
DCS	Data Collection Sheet
DMSD	Display Materials and Systems Division
DQI	Data Quality Indicator
DQR	Data Quality Rating
Ecotox	Ecotoxicity
EoL	End of Life
EoL	End of Life
EP	Eutrophication Potential
EPD	Environmental Product Declaration
EPF	Eutrophication Freshwater
EPM	Eutrophication Marine
EPT	Eutrophication Terrestrial
ESR	Enhanced Specular Reflector
ETF	Ecotoxicity Freshwater
FAETP	Freshwater Aquatic Ecotoxicity Potential
GaBi	Ganzheitliche Bilanzierung (German for holistic balancing)
GWP	Global Warming Potential
GWPex	Global Warming Potential, excluding biogenic carbon
GWPin	Global Warming Potential, including biogenic carbon
HT_c	Human Toxicity, cancer effects
HT_nc	Human Toxicity, non-cancer effects
Htox_c	Human Toxicity, cancer
Htox_nc	Human Toxicity, non-cancer
HTP	Human Toxicity Potential
IR	Ionising Radiation, human health
ISO	International Standardization Organization
LCA	Life Cycle Analysis
LCD	Liquid Crystal Display
LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Assessment
LED	Light-Emitting Diode
LGP	Light Guide Plate

MAETP	Marine Aquatic Ecotoxicity Potential
MEK	Methyl Ethyl Ketone
NTSC	National Television System Committee
OD	Ozone Depletion
ODP	Ozone Depletion Potential
PCR	Product Category Rules
PEF	Product Environmental Footprint
PM/RI	Particulate Matter/Respiratory Inorganics
POCP	Photochemical Ozone Creation Potential
POF	Photochemical Ozone Formation, human health
QD	Quantum Dot
QDEF	Quantum Dot Enhancement Film
RDMFR	Resource Depletion, Mineral, Fossil and Renewables
RDW	Resource Depletion, Water
RM	Raw Material
RMIF	Raw Material Information Form
S	Sulphur
Se	Selenium
TBEF	Thin Brightness Enhancement Film
TETP	Terrestric Ecotoxicity Potential
ZnS	Zinc Sulphide

1 Introduction to Life Cycle Assessment

Life Cycle Assessment (LCA) is a tool for analysing and assessing the environmental impacts resulting from all life cycle stages of a product system; from raw material (RM) acquisition or consumption of natural resources, all the way to end-of-life (EoL) treatment. LCA normally considers a range of different environmental impact categories and, as such, does not always produce clear-cut straightforward assertions but gives diverse and complex results illustrating the trade-offs associated with different choices.

This LCA study complies with the requirements of the ISO standards 14040 and 14044. In the first step, goal and scope of the life cycle assessment are defined. A LCA study may consider the whole life cycle of a product "from cradle to grave" or have a more limited scope e.g. to calculate the environmental impact categories for the production process of a product ("cradle to factory gate").

Depending on the system boundaries, the relevant data are collected to allow the product system to be modelled. This second stage of the LCA is called Life Cycle Inventory (LCI). Data originate either from measurements, calculated data, literature or are based on expert judgment.

From the LCI data, the third stage is the Life Cycle Impact Assessment (LCIA), in which the environmental impacts are calculated using characterisation factors for each impact category, e.g. global warming potential.

In the fourth stage the results are evaluated and interpreted depending on the objective and the goal of the study. In most cases it is possible to determine environmental hotspots in the life cycle of the product system and draw conclusions for further investigations and optimisation.

2 Goal of the study

2.1 Justification for the study

This LCA is conducted in support of 3M's Display Materials and Systems Division's (DMSD) request for exemptions to Directive 2011/65/EU on the restriction of the use of certain hazardous substances in electrical and electronic equipment, also referred to as RoHS II:

- Ex. Re. No. 2013-2 for "Cadmium in color converting II-VI LEDs (< 10µg Cd per mm² of light-emitting area) for use in solid state illumination or display systems" (Request for renewal of Exemption 39 of Annex III of Directive 2011/65/EU);
- Ex. Re. No. 2013-5 for "Cadmium in light control materials used for display devices".

The intent of the study is to compare the environmental impact of LED-enabled LCD TVs without enhancement films, with 3M Quantum Dot Enhancement Film (QDEF), or with alternative enhancement films, over the lifetime of the device. In particular, the focus is on the following topics:

- The contribution of 3M QDEF to the overall environmental impact of the TV;
- Comparison of the environmental impact of TVs with and without 3M QDEF, including production, distribution, use and end-of-life treatment;
- The effect of Cd on the overall environmental impact of TVs incorporating 3M QDEF.

The LCA practitioners for this study are Katerina Softa, LCA Engineer and Jonas Depelchin, Advanced LCA Engineer in 3M West Europe's Sustainability Centre of Expertise's LCA Department.
This is a non-confidential version of the full LCA report, from which 3M confidential information has been omitted. The full report contains a detailed description of the LCA model, and is therefore not for public consultation. For the purpose of external communication, this modified report is available, excluding and generalising all confidential and sensitive information.

2.2 Methodology

This LCA is in line with the requirements of ISO 14040:2006 [1] and ISO 14044:2006 [2] for a "cradle-to-grave" assessment. Where appropriate, the requirements and guidelines of the European Commission's Product Environmental Footprint Guidance are integrated in this LCA study [3].
All LCA calculations were completed using the GaBi™ software (version 7.0.0.19) from thinkstep AG (hereafter referred to as thinkstep). The modelling process used both primary data collected from the actual manufacturing process, and secondary data available in the GaBi databases including industry-average data, data available from literature studies and data available from published databases [4].

2.3 Disclaimer

The results presented in this report are unique to the assumptions and practices of the 3M Company. The results are not meant as a tool for comparability to other companies and/or products examined in other LCA studies. Even for similar products, differences in functional unit, boundaries, assumptions and data quality may produce results which are not appropriate for comparison. The reader is referred to the commissioner of the study for more information on this study and to the ISO 14040:2006 on 'Environmental Management – Life Cycle Assessment – Principles and Framework' for the framework of LCA and EPD and additional insight into the LCA principles.

3 Scope of the study

3.1 Product description and application

3M QDEF is a light control film used in consumer electronics applications with LED-enabled liquid crystal display (LCD) screens, such as televisions, smart phones, tablets, notebooks, monitors, refrigerators, etc. This results in an LCD make-up as displayed in Figure 1. 3M QDEF is manufactured in the United States.

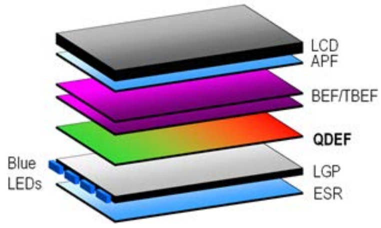

Figure 1 - LCD screen incorporating QDEF

The quantum dots (QDs) used in this film are nanocrystals (~3-7 nm in size) made of a cadmium selenide (CdSe) core in a zinc sulphide (ZnS) shell, as shown in Figure 2. The QDs used in 3M QDEF are manufactured in the United States.

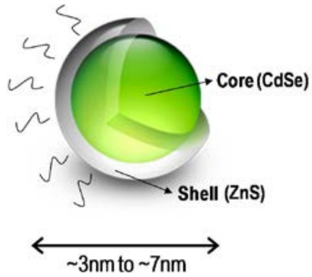

Figure 2 - Core/Shell architecture in QDs

In order to accurately assess the environmental impact of 3M QDEF, the field of application is important to be included in the life cycle. As a result, the focus of the study is not on 3M QDEF as such, but on the life cycle of a LED-enabled LCD TV.

LED-enabled LCD TVs are commonly used LCD TVs that use light-emitting diodes (LEDs) to backlight the display instead of the cold cathode fluorescent lights (CCFLs) used in standard LCD televisions. LED TVs are more formally known as LED-backlight LCD TVs. In order to be able to cover a wide spectrum of LED-enabled LCD TVs, a model was considered for a general LCD screen and additional housing, but excludes TV stands.

3.2 Functional unit

To determine the functional unit of the system under analysis, a number of references were used:

- PCR for preparing an EPD for TFT-LCD Televisions, prepared by AU Optronics Corporation, version 1.0 (valid until February, 2013) [32]
- The International LCA Journal's article on "Preliminary assessment for global warming potential of leading contributory gases from a 40 inch LCD flat screen TV" (2012)
- Availability of primary data for the foreground systems (more detailed and complete information on the production of 3M QDEF manufacturing processes)
- 3M internal test data

Based on the above information, the functional unit in this assessment is determined to be a 65" LCD TV, in operation for 5 hours per day (and on stand-by mode for 19 hours per day), 365 days per year, for a total period of 7 years. To ensure that the environmental impacts are comparable, the luminance of all TVs must be equivalent, and is set to 311 cd/m², whilst the colour gamut is 100% NTSC[1].
The geographical scope for the use phase of the study is the European Union, whilst the default end-of-life (EoL) scenario is the waste treatment process in line with European Directive 2002/96/EC on Waste of Electrical and Electronic Equipment, as amended.

The following situations are compared:

- The environmental impact of a standard LCD TV, not using enhancement films (TV1);
- The environmental impact of an LCD TV, incorporating 3M QDEF (TV2);
- The environmental impact of an LCD TV, incorporating an alternative, indium-based, non-3M light control film (TV3). Note that due to the lack of knowledge related to the alternative, technology, the environmental impact of the light control film is assumed to be negligible, which is the most conservative assumption for this situation.

3.3 Content of material and chemical substances

The below tables represent the composition of a key ingredient used in 3M QDEF, namely the QDs, as well as the composition of 3M QDEF, incorporating these QDs, and a very high level composition of the LCD TVs. Note that the focus is on the products, and that packaging materials are excluded from this overview.
With regards to the composition of the LCD TVs, these models were created by thinkstep, as described in the supporting documentation. Detailed composition information was not made available, as the TV models were made available as black box to 3M.

In making the QD's CdSe core, a Cd containing reagent and a Se containing reagent are mixed, followed by a shelling process during which sulphur (S), Cd and Zn reagents are added. The ZnS shell is a graduated layer containing CdS as well as ZnS, therefore without a discrete composition. The overall composition of QDs can vary, which is why Table 1 contains slight ranges of elements contained in the QD formulation. In fact, QDs' optical characteristics are the key properties to take into account, and those are a function of the size, rather than exact composition.

Composition	Weight %
Formulation agent	94 – 96.5
Zinc	1 – 2
Cadmium	1 – 2
Sulphur	0.9 – 1.1
Residuals	0.3 – 0.7
Selenium	0.3 – 0.4

Table 1 - Material content of QDs

Composition	Weight %
Barrier film	70
Epoxy hybrid	20
Epoxy resin	8
Quantum dots	2

Table 2 - Material content of 3M QDEF

[1] 100% of the colour spectrum defined in the National Television Standard Committee's (NTSC) standards which equates to the full range of colour that can theoretically be displayed.

Composition	Weight %
LCD module	40
Plastics (Assumed 50% ABS, 50% PC)	23
Metals (Assumed 100% steel)	37

Table 3 - Material content of parameterised LCD TV

3.4 System boundaries

The LCA follows a cradle-to-grave approach, which means that all life cycle stages are included in the study, therefore covering RM acquisition, production and packaging, distribution and use, up to and including the EoL treatment of the product. Figure 3 depicts the life cycle stages and boundaries for this study. Product storage is excluded from this assessment.

More precisely, RM acquisition includes the processing of RMs extracted from nature in order to create usable intermediates, as well as the packaging used to ship the RMs to the production site. Processes further up in the supply chain exclude transportation and packaging (e.g. packaging and transport of RMs used in the production of RMs in the foreground system).

All RMs are transported from the source to the respective production site(s). Most of the times the RMs need to be packed for transportation. Loading and unloading, as well as on-site transport of the RMs are excluded from the study. Disposal of RM packaging is included in the study.
Processing of the RMs into a usable product includes material and energy inputs. Packaging of the final product is included in the study. The energy consumed during the packaging process as well as the production of the packaging itself are also included within the boundaries of the study.

For the LCD TV, thinkstep's external sources were used to identify life cycle inventory data as is reported without significant change other than applying the same system boundaries as for the confidential industry data. For all modules in the LCD TV, the most important material production and average manufacturing processes have been considered, covering at least 95% of mass and energy of input and output flows, and 98% of their environmental relevance. Transportation of materials has been assumed to be local and have therefore been excluded from the foreground system and the manufacturing of the modules. Material manufacturing in the background system was not adapted to individual country-specific conditions but applied the closest match available in the GaBi Databases 2014 throughout the individual sub-models.

Distribution of RMs from suppliers to 3M's QD supplier's facility and 3M facilities is included in the study, as is the transport of 3M QDEF to the TV manufacturers in China, the transport of the LCD TV to users in Europe, and the transport of the LCD TV to the waste treatment facility. Storage of goods is excluded from the study.
For the use phase of the LCD TV, energy is the only input taken into consideration. Due to the low volumes, LCD TV packaging is assumed negligible.
EoL treatment of the LCD TV is included in the study, and brought in line with the requirements of the regulatory requirements as much as possible. Due to the fact that recycling technologies for electrical and electronic equipment are fairly new, assumptions were needed in this process.

For all stages of the product life cycle the environmental impact contribution related to the manufacture of capital goods and equipment was excluded from the inventory due to their minimal contribution. Emissions due to the fabrication and construction of capital equipment and land use impact were included in this inventory only when data was included in secondary data sets.

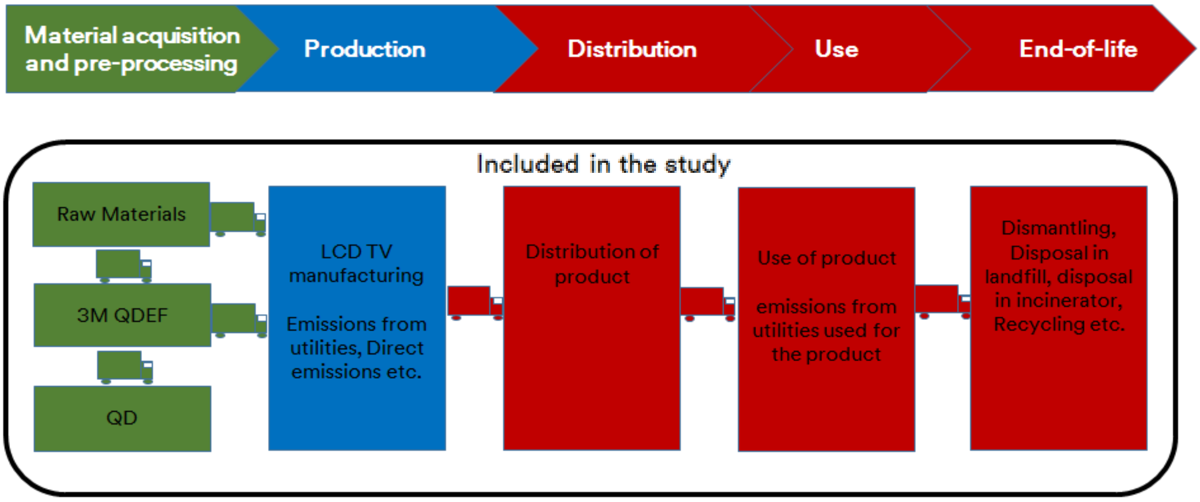

Figure 3 - Life cycle stages included in the LCA

Based on the functional unit, comparability of the systems under analysis, i.e. the LED-enabled LCD TV systems, must be guaranteed. The main differences between the three types of TVs under analysis are the following:

- Performance: The performance of the 3 TVs is calculated based on a TV efficiency model developed by 3M, and described in section 4.4. The model correlates the luminance and power consumption for a certain colour gamut and efficacy for each of the 3 TVs. The results of this analysis for a luminance of 311 cd/m² and 100% colour gamut can be deemed comparable, as they refer to the same performance, quality of image, etc.
- System boundaries: The difference in the system boundaries for the TVs is the assumption of a zero-impact for the Cd-free film in TV3, while the environmental impact of 3M QDEF is included in TV2. TV1 does not contain a specific enhancement film as such. When comparing the TVs, the impact of TV2 is therefore more conservative than TV3.
- Data quality: The data quality for the 3 TVs is not exactly the same, but following a data quality assessment, as described in section 3.10, the conclusion is that the data used in the model is sufficient to assume comparability. The results of the actual assessment can be found in section 5.3.

TECHNOLOGICAL REFERENCES

The foreground system is represented by specific data directly collected from 3M manufacturing sites, as well as 3M's supplier's QD manufacturing process. For other processes, existing data sets were used. The first data set selection criterion is based on the technology represented in the data set. If information is available regarding the method used for the production of a material, the data set most similar to the production method must be selected.

GEOGRAPHICAL BOUNDARIES

The data for the foreground system are specific, and as such representative for the actual production processes and representative for the site/region (United States for RMs, China for the TV manufacturing, and Europe for the use and EoL treatment, as appropriate for the base scenario).
For data sets, the most specific area (in order of preference: state, country, continent, global) in which the production occurs is to be selected. If no specific area exists, the next level (state to country, or country to continent, etc.) is used.
When global data are not available, data which covers the largest area (continent, country, state) is selected. In case data sets are available for multiple countries but not the country in which production occurs (for example data sets are available for Germany but production occurs in the Netherlands), the most similar data set –based on expert judgement– should be used.

TIME BOUNDARIES

The analysis is based on 2014 and/or 2015 data regarding the manufacturing and supply chain conditions. In all cases, the data are representative for the current situation, due to the fact that manufacturing processes are considered stable.
While selecting data sets, the “Reference Year” in the GaBi data set documentation tab is used to determine the temporal representativeness of the data. If there are multiple options, the most current data set is selected.

3.5 Data collection for the foreground system

A specific data collection activity for material and energy flows was set up for the foreground system, i.e. the production at six 3M manufacturing sites in the United States, involved in the manufacturing process (see Figure 6 for details on the supply chain), and 3M’s QD supplier’s manufacturing site in the United States (see Figure 5 for details). It is important to note that these processes are regarded as upstream processes, due to the fact that the LCD TV manufacturing is the core process, and the use and EoL of the TV are downstream processes.

The following data sources were consulted to collect the necessary data:

- Specific data on 3M QDEF manufacturing processes, as provided by DMSD;
- Specific data on the QD manufacturing processes, as provided by 3M’s QD supplier;
- Generic data sources as available in thinkstep’s GaBi software package;
- Parameterised LCA model for devices as specified in the functional unit above, as provided by thinkstep.

Specific data was gathered using 3M data collection sheets (DCSs):

- QDEF DCS: Information was gathered by 3M’s Film Manufacturing & Supply Chain Operations Quality Engineer (3M US), a divisional expert in QDEF manufacturing. During the LCA modelling phase, further clarification and more detailed information were requested where needed.
- QD DCS: Information was gathered by the relevant expert in QD manufacturing at 3M’s QD supplier’s facility. During the LCA modelling phase, further clarification and more detailed information were requested where needed.

3.5.1 Mass balance check

The mass balance is an indication of the consistency of a project. Process inputs and outputs are compared with each other and the relative difference between inputs and outputs is calculated. This consistency check was performed for 3M’s QD supplier’s manufacturing processes (in kg) and 3M’s QDEF manufacturing processes (in kg) respectively.
For all processes involved, an evaluation of the mass balance showed that inputs and outputs to each process did not differ more than 3%, which is deemed an acceptable deviation.

3.6 Allocation and recycling

3.6.1 Allocation of upstream data

For all refinery products, allocation by mass and net calorific value is applied. The manufacturing route of every refinery product is modelled and so the effort of the production of these products is calculated specifically. Two allocation rules are applied:

- the RM (crude oil) consumption of the respective stages, which is necessary for the production of a product or an intermediate product, is allocated by energy (mass of the product * calorific value of the product);
- the energy consumption (thermal energy, steam, electricity) of a process, e.g. atmospheric distillation, being required by a product or an intermediate product, are allocated to the product according to the share of the throughput of the stage (mass allocation).

Materials and chemicals needed during manufacturing are modelled using the allocation rule most suitable for the respective product. For further information on a specific product see http://documentation.gabi-software.com.
For the generation of LCIs for electrical and thermal energy (apart from the abovementioned allocation methods for refinery products and materials), allocations by economic value are applied, dependent on the specific technique. In case of plants for the co-generation of heat and power allocations by exergy are applied.

3.6.2 Allocation in the foreground data

One of the 3M processes, resin production, produces a co-product in addition to the resin that is produced. The co-product is a glycol by-product and is used in other process steps not included in this life cycle. The GaBi software allocates all inputs and outputs related to the production of the resin and the glycol by mass.
None of the other production processes deliver any co-products. The applied software model does not contain any allocation for those processes.

The data provided by DMSD used allocation methods, especially for energy data, determined by the availability of the requested data. This included mass allocation and/or machine runtime and performance.
For the 3M manufacturing facilities' energy, allocation was performed based on quarterly/monthly/ daily production volumes, machine run times and total site energy consumptions (as available).
The data provided by DMSD did not require further allocation. Allocation may have been used in secondary data sets as well.

3.6.3 Allocation for the LCD TV

There is no allocation considered in the TV production. In the background data, different types of allocation are used depending on the type on the materials (e.g. in the case of metals, the allocation is frequently done by price; in the case of energy, the allocation is frequently done in terms of net calorific value of the energy sources, etc...).

3.6.4 Allocation for waste materials

Production waste is either landfilled, incinerated, recycled or reused.
The cut-off approach is chosen when the data indicates that the waste is incinerated, landfilled or recycled. For waste generated during manufacturing and disposed in a landfill or incineration plant, the environmental burden of transport and the landfill and incineration are included, while the generated electricity and thermal energy is cut off. With this approach the credits generated are excluded from the system and a worst case approach is applied.
When the data indicates that the waste was incinerated with energy recuperation (waste to energy), the avoided burden approach is applied as it better represents reality. Credits are taken for the generated electricity and steam and the waste process is credited with a region specific energy source. This method is applied for incinerated waste from relevant locations.

The boundaries for waste to external recycling are set before the recycling facility gate, so transport is included, but additional treatment is excluded and cut-off is applied before the recycling facility gate.
A specific situation is the use of a cleaning chemical in one of 3M's facilities. The chemical is recovered externally, but after recovery, it is purchased from the same company and reused on-site. As no information was available on the recovery process the cut-off approach is chosen as well and virgin material is taken as an input to account for the environmental burden of the recovery process.
In case of internal waste recycling in the same process for the film production, it is decided to apply closed loop allocation. The remaining waste that is reused internally, used in other processes in the site due to quality reasons. Before this waste is reused it is re-pelletized, which is included in the model. The generated resins are credited by using the avoided burden approach as it was confirmed by the site that the re-pelletized resins are replacing the resins made in another 3M facility. Therefore these waste processes are credited at the resin's production plan.

3.7 Cut-off criteria

In the assessment, all available data from the production process are considered, i.e. all pre-products used, packaging material, utilised thermal energy, and electric power consumption using best available LCI datasets.
Transport processes for the packaging of the RMs are neglected, as well as internal transport in the manufacturing facilities. Production of machines, facilities and infrastructure required during manufacture are neglected as these impacts will be trivial compared to the process impacts.
All relevant material and energy flows (even those contributing less than 1% of mass or energy) are considered.
For the manufacturing of the LCD TVs, cut-off rules are applied for each unit process: coverage of at least 95 % of mass and energy of the input and output flows, and 98 % of their environmental relevance (according to thinkstep's expert judgement).

3.8 Assumptions

In addition to the assumptions on the system boundaries, other assumptions needed to be made during the LCA for a variety of reasons, one of which being data availability.

Key assumptions are:

- For energy and RM production, country specific data sets are used where available. In other instances, either the European average, or datasets from countries with similar energy / electricity grid mixes (in case of energy) or the most conservative dataset (in case of materials) are used;
- RM production is modelled based on composition information where no relevant dataset is available in GaBi and no other information is provided;
- Components with no corresponding data set in GaBi, such as very specific chemicals, are modelled using the closest related chemical data set or modelled based on a stoichiometric reaction to produce the chemical;
- If no distance data is mentioned for the disposal of materials, a distance of 100 miles is assumed as a reasonable distance between the manufacturing plant and a disposal site;
- The tare and net weight for many RM packaging materials is not made available and therefore requires estimation based on readily available information. Often the disposal method of the RM packaging needs to be assumed as well;
- For assumptions related to the TV manufacturing, use and end-of-life, reference is made to the documentation from thinkstep;
- When a supplier's manufacturing location is unknown, distances are assumed based on expert judgment and input from DMSD.

3.9 Software and database

The LCA model was created using the GaBi Software (version 7.0.0.19) system for life cycle engineering, developed by thinkstep. The GaBi database provides the LCI data for several of the raw and process materials obtained from the background system. Last update of the database was October 2015.
Each data set used in the model, is listed in section 4 under each GaBi plan described. The data set indicates which LCI database has been used as well as the reference year of the data set. If there is no indication of the LCA database, an ecoinvent data set is used.

3.10 Data quality

The foreground data collected by 3M are mostly based on 2014 and/or 2015 production volumes and extrapolations of measurements on specific machines and plants. Most of the necessary LCI details for the basic materials are available in the GaBi database. Data quality analysis is performed based on the EU Product Environmental Footprint (PEF) Guidance, and is described in more detail in section 9. The actual data quality assessment was conducted for the foreground processes (i.e. QDs and 3M QDEF), as well as the LCD TVs. All assessment results can be found in section 5.3.

3.10.1 Representativeness

Technological: All primary and secondary data are modelled to be specific to the technologies or technology mixes under analysis. Where technology-specific data are unavailable, proxy data are used. Technological representativeness is considered to be good.
Geographical: All primary and secondary data are collected specific to the countries / regions under analysis. Where country / region specific data are unavailable, proxy data are used (country / region specific data are displayed in the figures in section 4). Geographical representativeness is considered to be good.
Temporal: All primary data are collected for the year 2014 and/or 2015. All secondary data come from the GaBi 2015 databases and are representative of the years 2006-2015.

3.10.2 Completeness

All relevant process steps for each scenario are considered and modelled to represent each specific situation. The process chain is considered sufficiently complete with regard to the goal and scope of this study. Neglected material and energy flows are described in section 0.

3.10.3 Reliability

Primary data are collected using a specifically adapted data collection sheet. Cross-checks concerning the plausibility of mass and energy flows are carried out on the data received. Similar checks are made on the software model developed during the study.
All relevant flows were taken into account when collecting the primary data, resulting in representative data collection.

3.10.4 Consistency

To ensure consistency, all primary data are collected with the same level of detail, while all background data are sourced from the GaBi databases. Allocation and other methodological choices are made consistently throughout the model.

3.11 Critical review

During the course of the project, plausibility checks on the models related to the foreground system were performed by thinkstep, which resulted in a number of model modifications, incorporated in the LCI and LCIA.
In addition to the above, continuous peer reviews between the LCA practitioners and data gathering coordinators took place during the modelling phase.

A critical review of the LCA model, the LCA report and the LCA Summary report was performed by a panel of specialists, coordinated by SGS Italia S.p.A. The nominated members for the panel review are:

- Angelo Ferlini, Technical reviewer (SGS Italia S.p.A.)
- Ambra Morelli, EPD and Weeelabex Lead auditor, WEEE and environmental specialist (SGS Italia S.p.A.)
- Paolo Simon Ostan, LCA specialist and PCR moderator (Technical expert)
- Roberta Bertani, Professor of Chemistry for Technologies Science and Technology of Materials at the Department of Industrial engineering (University of Padova, Italy)

The finding, actions and outcome from the critical review can be found in Annex A.

4 Life cycle inventory analysis (LCI)

This section describes the GaBi model with screenshots and their respective explanations, including data choices and substantiation of assumptions made.
The documents and references that are used to model, substantiate and describe the LCI are listed in the bibliography (section 7.1). The relevant document numbers for this section are: 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 31, 33, 34, 35 and 36.

4.1 Flow diagramme

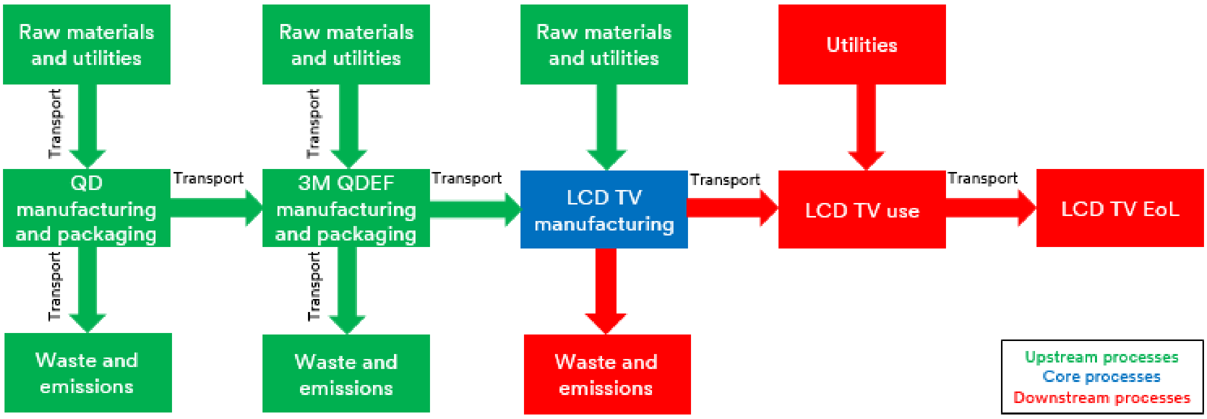

Figure 4 - High level overview of the system under analysis

4.2 Ancillaries, utilities, packaging, transport

Ancillary plans are used to model materials used by a specific manufacturing location, but not necessarily being part of the product, such as chemicals to clean mixing equipment, cooling chemicals, etc. This allows for consistent treatment of the ancillaries for each manufacturing and disposal site.
Utility plans are used to model a specific utility used by a specific manufacturing location, such as electricity, steam, natural gas, etc. This allows for consistent treatment of the utilities for each manufacturing and disposal site.
Packaging plans are used to represent a unit of packaging to ensure that all packaging materials are treated the same throughout the model. Multiple forms of packaging are used. Also, besides RM packaging, the specific packaging materials for the materials in the foreground system are discussed. Packaging is assumed to be made of virgin material and not recycled material as virgin material is the more conservative choice and also often approached by the main component of the packaging without further processing.
Transportation plans are used to consistently handle the transportation, packaging, and unpacking of raw materials, intermediates, and products within the GaBi models.

4.3 Manufacturing

When describing manufacturing of products, there are two main elements to take into account: inputs into the manufacturing process, in the form of materials, and processes run to turn these materials in a final output. Both elements are described below, after which an overview of all manufacturing elements are described in detail.

- Materials: RM acquisition includes the processing of RMs from nature to create usable intermediates, as well as the packaging used to ship the RMs to the manufacturing site.
  RM plans include packaging materials for transportation from the manufacturer to the location of use, as well as unpacking of the RM, and disposal of any packaging material. Where available, transportation information for RMs is provided in the DCSs. Where data is not provided, assumptions are made regarding the mode of transport, transportation distances, and packaging as described below. An unpacking step (assuming no energy use) is used to differentiate transportation weight (which includes the weight of the packaging materials) from the RM weight (no packaging). The packaging material is disposed of, or assumed to be transported to a disposal or recycling site, where emissions associated with disposal are accounted for. The output of each RM plan is the RM as used in the process. Backhaul, or trucks running with no cargo, were included in the model by increasing the mileage by 25%. In the case of tanker trucks, the transportation distance is doubled regardless of distance as they generally return empty.
  The different RMs used in the system under analysis are described below. The title of each material contains the RM or reference number, trade name, supplier and manufacturing location. Following a short product and manufacturing process description, details on how the material is modelled are provided. An image of the GaBi plan is given, as well as a table with details on the RM data and modelling.
- Processing plans: Processing plans are used to model the transformation of RMs, utilities, and waste disposal into a usable product.
  For all stages of the product's life cycle, the environmental impact contribution from the production of capital goods and equipment is excluded from the inventory due to the minimal contribution to the overall environmental impact. Emissions due to the production and construction of capital equipment and land use impact are included in this inventory only when data is available in secondary data sets.

4.3.1 Quantum Dots

QDs are highly efficient, inorganic phosphor crystals grown through standard wet chemical manufacturing processes. Governed by their size, QDs have the unique capability to precisely generate a specific wavelength of light. They produce high purity colours or can be blended to a precisely defined white point.
The QDs are used in the last of 3M's film coating processes. The different process steps to produce and deliver the QDs cover the production of both the red and green QDs based on the ratio between red and green dots required for 3M QDEF.

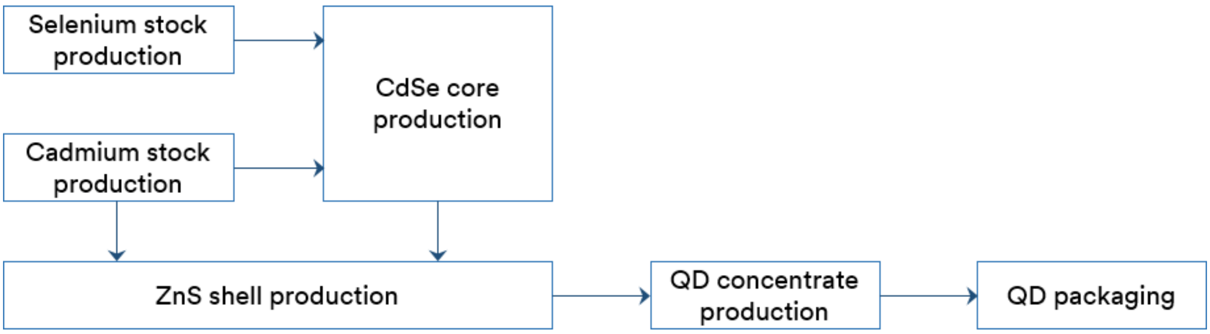

Figure 5 - QD manufacturing process

4.3.2 3M QDEF

3M QDEF is a light control film used in consumer electronics applications with liquid crystal display (LCD) screens, such as televisions, smart phones, tablets, notebooks, monitors, refrigerators, etc. in order to have a positive effect on the display's luminance.
The manufacturing process for 3M QDEF spans over a multiple 3M facilities, each of which cover specific processes in the production process.

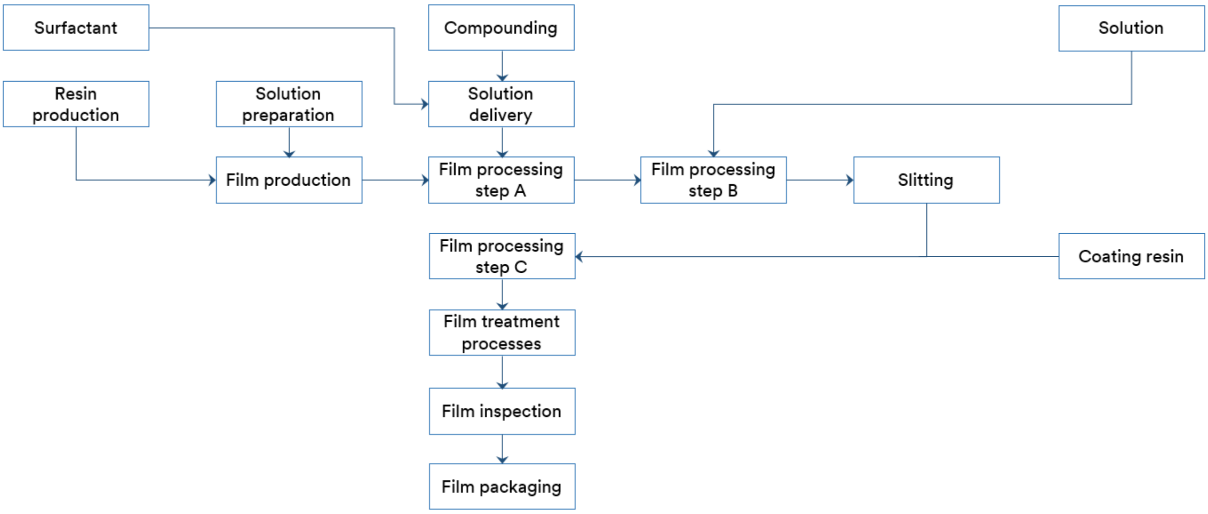

Figure 6 - 3M QDEF manufacturing process

4.3.3 LCD TV

3M QDEF can be used in the manufacturing of a number of types and models of LCD TVs, each of which can be different depending on the manufacturer, materials used, etc. For the purpose of the project, thinkstep were commissioned to create a manufacturing model of a LCD TV, incorporating a number of different parameters, allowing the assessment of different scenarios, based on information and input from DMSD. The plan for the manufacturing of the LCD TV is represented in Figure 7. Both the model and the parameters are described in the thinkstep documentation.

For the TV datasets, a global mix is considered, as the suppliers are established in different countries. Material manufacturing in the background system was not adapted to individual country-specific conditions but applied the closest match available in the GaBi Databases 2014 throughout the individual sub-models.

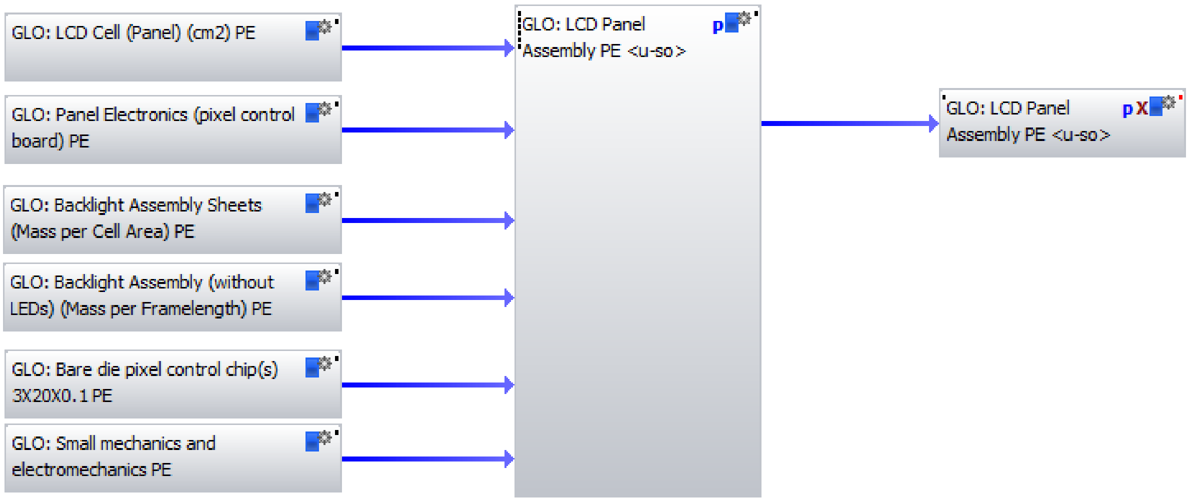

Figure 7 - GaBi plan for "LCD panel assembly"

In the production processes, the main differences between the LCD TVs are:

- The types of LEDs used in the TVs (white LEDs in TV1 vs. blue LEDs in TV2 and TV3)
- The amount of LEDs used in the TVs
- A backlight film in TV1 vs QDEF in TV2 and TV3

The LCD TV dataset contains the following modules, as shown in Figure 7:

- LCD Cell (Panel) (cm^2): this module contains the manufacturing of liquid crystal cells that make up the pixels of the panel. The dataset represents a mixture of TN and IPS technology of cell manufacture scaled to 1 cm^2 cell area. The manufacturing can be applied for diagonal panel sizes ranging from 10 to 25 inch. The cell manufacture contains the preparation of the raw materials (mother glass, liquid crystal polymer), auxiliaries (target, developer, etchant, stripper etc.) and water and energy consumed during manufacturing as well as the direct emissions from the manufacturing, notoriously sulphur hexafluoride. Energy consumption represents global manufacturing, including the Korean, Chinese and Taiwanese power grid mixes.
- Panel electronics (pixel control board): this module includes a populated printed wiring board designed to control displays between 10 and 25 inches in diameter. The board includes the making of the printed wiring board, the production of the individual components including ICs, capacitors, resistors, diodes, transistors etc. and the assembly of the populated printed wiring board. The Display Electronics dataset also includes the production of the LEDs used to light up the display although these are typically not physically attached to the same board. The reference unit of this module is 1 piece of populated printed wiring board.
- Backlight Assembly Sheets (Mass per cell area): The dataset represents a mixture of TN and IPS technology backlight sheets scaled to 1 cm^2 cell viewing area. The sheets contain polarizer, prism, diffuser and reflector sheets with scalability over the viewing area. The material of all sheets is mostly based on polyethylene terephthalate film. The reference unit is mass per cell viewing area (kg/cm”).
- Backlight Assembly (without LEDs) (Mass per frame length): The dataset represents a mixture of TN and IPS technology backlight systems scaled to 1 cm frame length. The backlight contains mechanical components such as frames, light guide panel and light bar (without LEDs). The materials used contain aluminium, steel and various plastics. The reference unit is mass per frame length (kg/cm).
- Bare die pixel control chip(s) 3X20X0.1: The bare dice applied for column control chips are sized 3 by 20 by 0.1mm, totaling a die size of 60 mm^2. The dataset includes front-end and back-end processing of the wafer, including Czochralski method of silicon growing. No housing, lead frame or bond wires are assumed necessary for these components. This dataset represents a global technology and energy mix. The wafer processing model is representative of several manufacturing platforms (defined methods of IC production) developed and/or used by leading manufacturers of logic and memory (Intel, AMD/Global Foundries, IBM, TSMC, Samsung, Micron), which compose the majority of IC production worldwide. The production location (energy, materials and fuels) represents a mix of IC producing nations weighted by installed manufacturing capacity, see also respective documentation of the module “Open IC model”. The front-end technology node applied was MPU 130nm. The reference unit of this module is 1 piece of chip with the described characteristics.
- Small mechanics and electro-mechanics: The module represents a mixture of small mechanics used as screws (steel), gaskets, fillers and tapes (PU and PET) as well as electro-mechanical components such as internal cables (copper and PVC) and connectors (with gold, brass and polyamide 6.6). The reference unit is mass.

Specific LCD TVs were used as a reference for creating the LCA model, but details on make and model must be kept confidential. The weights of the TVs are:

- TV1: 26.3 kg
- TV2: 28.0 kg
- TV3: 32.3 kg

Waste treatment is integrated throughout the whole system during modelling wherever possible and known to occur. For all known treatment pathways (e.g. for regulated waste with calorific value) the incineration and landfilling processes of the residues are integrated.
Different waste treatment options are provided in the GaBi databases (inert matter landfill, domestic waste landfill, hazardous waste landfill underground / above ground, waste incineration of domestic

waste, waste incineration of hazardous waste). The waste fractions of the processes are identified by the composition and their appropriate treatment and the respective GaBi process applied.
"Waste" going to any kind of reuse or recycling is modelled in loops or allocated/substituted, if a considerable positive market value (a product) exists.
There are many products which are legislatively considered a waste, but which must be treated as products in life cycle analysis. It should be noted that the same market value is applied at the point where the waste (or waste products) accumulates and at the point where the waste is recycled. For suitable modelling feedback from both sides (producer of waste product and user or processor of waste product) is necessary. Waste to be recycled without a market value will stay (virtually) as waste in the producer process and is documented as such.

In the case that specific information is not available for the respective situation, a standard procedure is adopted according to secondary material markets:

- Any secondary material that already has a recycling market is treated as recycled according to the market share (see examples in Table 4)
- All waste generated within the EU that has a calorific value and can be disposed with municipal solid waste (MSW), is treated in an incineration plant (see selected examples)
- If case-specific treatment is specified and known, and the waste cannot be mixed with MSW, specific treatment is modelled
- All other waste (mainly inert waste) goes to landfill

Material/Waste	Treatment process
Mixture of plastics	Incineration, waste to energy
Polyolefin and PVC	Incineration, waste to energy
Wood	Incineration, waste to energy
Aluminium, non-ferrous metals	Recycling
Steel	Recycling
Coating and sealing	Incineration, waste to energy
Glass, concrete, stones	Inert landfill

Table 4 - General EoL treatment procedure for common wastes

Hazardous waste streams are often hard to define as default in a background database, because, depending on various options to mix different waste streams, several disposal options exist. Hazardous waste streams in the upstream chains are modelled according to their specific fate, if it is known (e.g. in tailing ponds). Hazardous slags/sludges are treated via vitrification, encapsulation and landfill. If unspecific hazardous waste streams appear, a worst case scenario (precaution principle rule) is used. The worst case scenario models incineration, vitrification, macro-encapsulation and the inert landfill of the remains. Carbon-rich and carbon-free hazardous waste is differentiated, as are other emissions which occur in incineration.

4.4 Use

Given that displays are energy using products, not only is it expected that the use phase of the device is likely to have the most significant impact on the overall environmental impact of the device, but also that the source of this impact is the energy, more specifically the electricity, used when the device is in operation.

Internal test results for TV1, TV2 and TV3 were generated by DMSD, aiming to get an understanding of the energy use of the device at a certain luminance, and measured luminance at a certain energy use. These test results were incorporated in the life cycle models of the three LCD TVs.

A stream model was generated to be able to evaluate the colour gamut coverage and efficiency of a display given the following inputs:

- LED spectrum and efficiency
- Backlight film stack hemispherical reflectivity and transmission
- Backlight backplane reflectivity
- LCD panel transmission spectrum
- QD efficiency, absorption spectrum, and excitation spectrum (for QD systems only)

To achieve different levels of color gamut coverage, numerous commercially available LCDs were measured (to determine the LCD panel transmission spectrum). For each technology, the model was run for each of the LCDs. The model provided color gamut and efficiency for each LCD by the different technologies. These data were then fit with a regression line that shows, by technology, what the efficiency will be for a given color gamut. These regression lines allow a comparison of the efficiencies of different technologies at equivalent colour gamuts [36].

Calculation Results				
System	Modelled efficacy	Luminance gain of TV2	Power (W) 48" TV	Power (W) 65" TV
TV1	0.99	2.28	238	386
TV2	2.25	1	140	213,4
TV3	1.44	1.56	183	290
Modelled power savings of TV2 over TV3			24%	26%
Modelled Power savings of TV2 over TV1			41%	45%

Table 5 - LCD TV energy consumption modelling

The geographical coverage of the study is the European Union. As a result, the electricity grid mix selected for the electricity required in the LCD TV's use phase is the European average. The figures below provide an overview of how the different countries in the EU-27 contribute to the European average grid mix, and also what the sources of electricity are when approaching it from a European level.

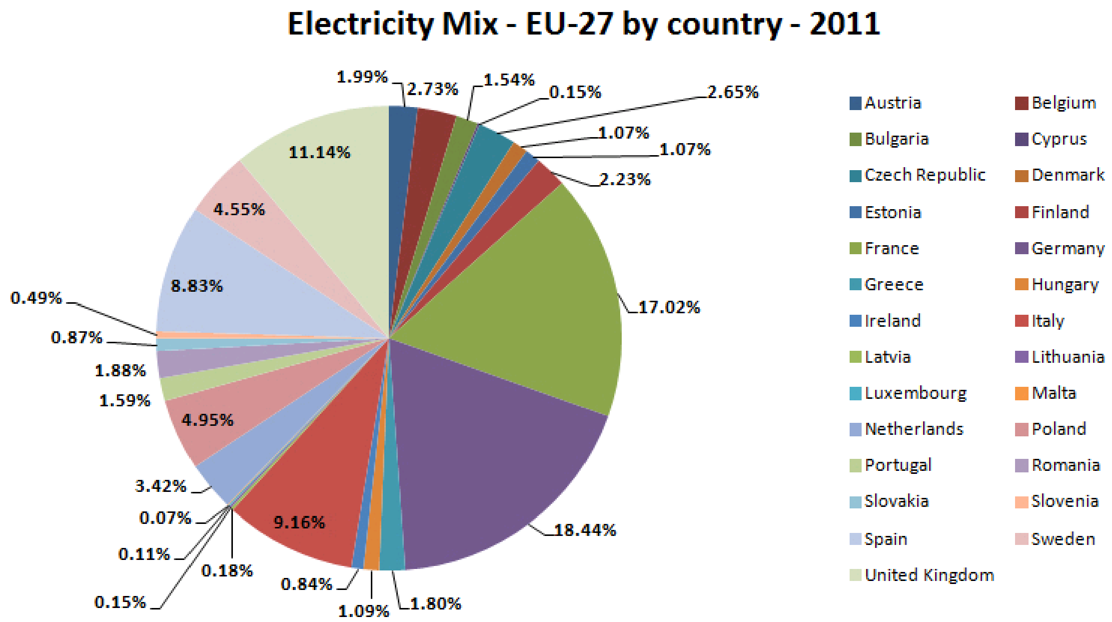

Figure 8 - EU-27 electricity grid mix, by country

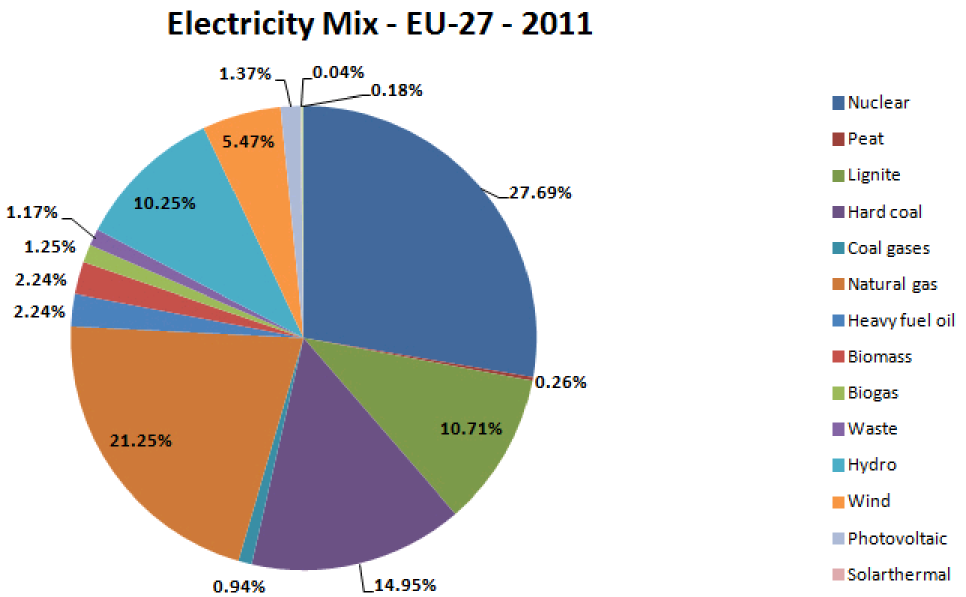

Figure 9 - EU-27 electricity grid mix, by electricity source

4.5 EoL treatment

When an electrical device comes to the end of its life, the EU WEEE directive describes the requirements for treatment of the waste. For the purpose of the project, thinkstep AG were commissioned to create an EoL model for a LCD TV, incorporating a number of different parameters, allowing the assessment of different waste treatment scenarios, based on commonly used waste treatment practices. The plan for the EoL treatment of the LCD TV is represented in Figure 10, and the weights for EoL treatment are available in Table 6. Both the model and the parameters are described in the thinkstep documentation.

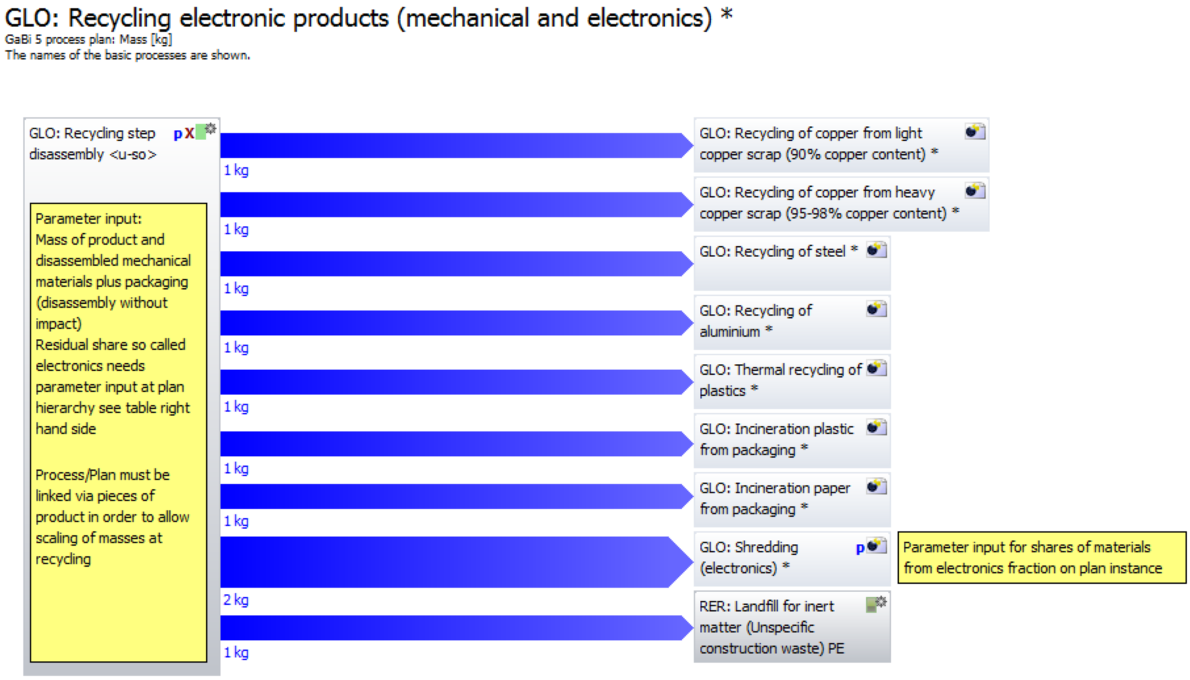

Figure 10 - GaBi plan for "LCD TV EoL"

EoL Scenario values (kg)	TV1	TV2	TV3
LCD Module (recovered metals)			
Copper	3.18E+00	3.20E+00	3.24E+00
Gold	3.50E-04	3.50E-04	3.50E-04
Palladium	1.22E-04	1.22E-04	1.22E-04
Platinum	3.73E-06	3.73E-06	3.73E-06
Silver	6.53E-03	6.53E-03	6.53E-03
Housing (plastics and metals)			
Plastics	7.11E+00	7.49E+00	7.30E+00
Metals	1.46E+01	1.54E+01	1.90E+01

Table 6 - EoL values for LCD TVs

5 Life cycle impact assessment (LCIA)

5.1 Introduction to the impact assessment

The software model described above enables the calculation of various environmental impact categories. The impact categories describe potential effects of the production process on the environment. As different resources and emissions are summed up per impact category the impacts are normalised to a specific emission and reported in “equivalents”, e.g. Greenhouse gas emissions are reported in kg CO_2 equivalents.
Environmental impact categories are calculated from “elementary” material and energy flows. Elementary flows describe the origin of resources from the environment as basis for the manufacturing of the pre-products and generating energy, as well as emissions into the environment, which are caused by a product system. LCIA results are relative expressions and do not predict impacts on category endpoints, the exceeding of thresholds, safety margins or risks.

For the purpose of the study, the following methodologies and impact categories were selected for inclusion in the LCIA:

- CML 2001 method (April 2013 characterisation factors): this commonly used and widely accepted impact assessment method, developed by the Institute of Environmental Sciences, Leiden University (Netherlands), restricts quantitative modelling to early stages in the cause-effect chain in order to limit uncertainties. Results of the assessment are grouped in midpoint categories, all of which are included in the report:
    - Abiotic depletion potential, elements (ADPe)
    - Abiotic depletion potential, fossil (ADPf)
    - Acidification potential (AP)
    - Eutrophication potential (EP)
    - Freshwater aquatic ecotoxicity potential (FAETP)
    - Global warming potential (GWPin)
    - Global warming potential, excluding biogenic carbon (GWPex)
    - Human toxicity potential (HTP)
    - Marine aquatic ecotoxicity potential (MAETP)
    - Ozone layer depletion potential (ODP)
    - Photochemical ozone creation potential (POCP)
    - Terrestric ecotoxicity potential (TETP)
- Product Environmental Footprint (PEF) method: As part of the European Commission’s initiative around “building the single market for green products”, an EU-wide methodology was developed in order to streamline environmental communication across the European Member States. This methodology combines a number of midpoints from different methodologies, all of which are included in the report:
    - Acidification (Acid)
    - Climate change, excluding biogenic carbon (CC_ex)
    - Climate change, including biogenic carbon (CC_in)
    - Ecotoxicity freshwater (ETF)
    - Eutrophication freshwater (EPF)
    - Eutrophication marine (EPM)
    - Eutrophication terrestrial (EPT)
    - Human toxicity, cancer effects (HT_c)
    - Human toxicity, non-cancer effects (HT_nc)
    - Ionising radation, human health (IR)
    - Ozone depletion (OD)
    - Particulate matter/Respiratory inorganics (PM/RI)
    - Photochemical ozone formation, human heath (POF)
    - Resource depletion, water (RDW)
    - Resource depletion, mineral, fossils and renewables (RDMFR)

Even though LCIA methodologies are developed based on principles and practices of the organisation responsible for them, a number of impact categories end up having the same or a similar effect on the environment, even if the actual LCIA results may be completely different. Especially when normalising results, which is a process to be able to compare the relative impact of midpoints to each other, this overlap may be of interest. Table 7 contains an overview of midpoints that have the same or a very similar environmental effect, regardless of the methodology they are used in.

Indicator	CML2001 indicator	PEF indicator
Abiotic depletion	ADPe and ADPf	RDMFR
Acidification	AP	Acid
Eutrophication	EP	EPF and EPM
Freshwater ecotoxity	FAETP	ETF
Global warming	GWPin	CC_in
Human toxicity	HTP	HT_c and HT_nc
Ozone depletion	ODP	OD
Photochemical ozone creation	POCP	POF

Table 7 - Corresponding midpoints across LCIA methodologies

5.2 <u>Detailed impact assessment results</u>

This section contains the results for the calculations of the environmental impact categories described in the different methodologies above (CML, PEF, USEtox). To be able to draw conclusions in line with the goal and scope of the study, results were generated on different levels:

- Environmental impacts of the LCD TVs under analysis, including impacts per life cycle stage
- Environmental impacts of 3M QDEF, as a key input into TV2
- Environmental impacts of QDs, as a key input into 3M QDEF

5.2.1 Total environmental impact of LCD TVs

The tables below represent the environmental impact of the different LCD TVs under analysis, for each of the methodologies described above. Further to the absolute results of the calculations, a comparison is made between each of the TVs. Where the percentage is positive, the environmental impact of the TV is higher than the reference TV for that midpoint, and vice versa.

CML2001 indicator	Life cycle TV1	Life cycle TV2	Life cycle TV3	% Diff. TV2 vs TV1	% Diff. TV3 vs TV1	% Diff. TV2 vs TV3
ADPe [kg Sb-eq.]	1,67E-02	1,73E-02	2,04E-02	3%	22%	-15%
ADPf [MJ]	3,50E+04	2,39E+04	2,93E+04	-32%	-16%	-18%
AP [kg SO2-eq.]	1,65E+01	1,15E+01	1,39E+01	-31%	-15%	-17%
EP [kg Phosphate-eq.]	1,15E+00	2,26E+00	1,02E+00	96%	-12%	122%
FAETP [kg DCB-eq.]	1,28E+01	1,06E+01	1,24E+01	-17%	-3%	-15%
GWPin [CO2-eq.]	3,29E+03	2,29E+03	2,77E+03	-30%	-16%	-17%
GWPex [CO2-eq.]	3,27E+03	2,26E+03	2,75E+03	-31%	-16%	-18%
HTP [kg DCB-eq.]	4,44E+02	3,94E+02	4,59E+02	-11%	3%	-14%
MAETP [kg DCB-eq.]	5,32E+05	4,17E+05	4,89E+05	-22%	-8%	-15%
ODP [kg R11-eq.]	1,94E-06	1,20E-06	1,52E-06	-38%	-22%	-21%
POCP [kg Ethene-eq.]	1,13E+00	8,38E-01	9,80E-01	-26%	-13%	-14%
TETP [kg DCB-eq.]	7,83E+00	6,60E+00	7,62E+00	-16%	-3%	-13%

Table 8 - CML indicators for LCD TVs

PEF indicator	Life cycle TV1	Life cycle TV2	Life cycle TV3	% Diff. TV2 vs TV1	% Diff. TV3 vs TV1	% Diff. TV2 vs TV3
AC [Mole of H+ eq.]	1,90E+01	1,33E+01	1,61E+01	-30%	-15%	-17%
CC_ex [CO2-eq.]	3,27E+03	2,27E+03	2,75E+03	-31%	-16%	-17%
CC_in [CO2-eq.]	3,29E+03	2,29E+03	2,77E+03	-30%	-16%	-17%
ETF [CTUe]	3,13E+02	3,03E+02	3,13E+02	-3%	0%	-3%
EPF [kg P-eq.]	1,28E-02	1,19E-02	1,21E-02	-7%	-5%	-2%
EPM [kg N-eq.]	1,80E-01	1,43E-01	1,60E-01	-20%	-11%	-11%
EPT [Mole of N-eq.]	3,10E+01	2,37E+01	2,74E+01	-23%	-11%	-14%
HT_c [CTUh]	7,21E-06	8,37E-06	7,52E-06	16%	4%	11%
HT_nc [CTUh]	1,23E-04	1,01E-04	1,15E-04	-18%	-6%	-12%
IR [kBq U235-eq.]	5,34E+02	3,20E+02	4,16E+02	-40%	-22%	-23%
OD [kg R11-eq.]	1,95E-06	1,21E-06	1,54E-06	-38%	-21%	-21%
PM/RI [kg PM2,5-Eq.]	1,44E+00	1,09E+00	1,28E+00	-24%	-11%	-15%
POF [kg NMVOC]	8,61E+00	6,53E+00	7,59E+00	-24%	-12%	-14%
RDW [m³ eq.]	3,23E+01	2,15E+01	2,61E+01	-33%	-19%	-18%
RDMFR [kg Sb-eq.]	7,57E-02	7,48E-02	8,31E-02	-1%	10%	-10%

Table 9 - PEF indicators for LCD TVs

5.2.2 Normalised environmental impact of LCD TVs

Due to the use of different units, it is impossible to compare impact categories, and to make statements about which midpoint is more impactful than the others. In order to get an idea of which midpoints are more relevant than others for the purpose of the study, normalisation can be used, which is an optional step of LCIA which allows the practitioner to express results after the characterisation step using a common reference impact. This supports the comparison between alternatives using reference numerical scores. The normalisation factors express the total impact occurring in a reference region for a certain impact category (e.g. climate change, eutrophication, etc.) within a reference year. The tables below represent the normalised environmental impact of the different LCD TVs under analysis, for each of the methodologies.

CML2001 indicator	Life cycle TV1	Life cycle TV2	Life cycle TV3
ADPe	1,03E-10	1,07E-10	1,26E-10
ADPf	9,96E-10	6,82E-10	8,34E-10
AP	9,80E-10	6,81E-10	8,28E-10
EP	6,22E-11	1,22E-10	5,50E-11
FAETP	6,14E-11	5,08E-11	5,95E-11
GWPin	6,31E-10	4,39E-10	5,32E-10
GWPex	Excluded from normalisation		
HTP	8,87E-10	7,88E-10	9,17E-10
MAETP	1,20E-08	9,37E-09	1,10E-08
ODP	1,91E-13	1,17E-13	1,49E-13
POCP	6,52E-10	4,85E-10	5,66E-10
TETP	6,75E-11	5,69E-11	6,57E-11

Table 10 - Normalised CML indicators for LCD TVs

PEF indicator	Life cycle TV1	Life cycle TV2	Life cycle TV3
Acid	4,02E-01	2,81E-01	3,41E-01
CC_ex	0,00E+00	0,00E+00	0,00E+00
CC_in	3,56E-01	2,48E-01	3,01E-01
ETF	3,58E-02	3,47E-02	3,59E-02
EPF	8,63E-03	8,03E-03	8,19E-03
EPM	1,06E-02	8,48E-03	9,47E-03
EPT	1,76E-01	1,35E-01	1,56E-01
HT_c	1,95E-01	2,27E-01	2,04E-01
HT_nc	2,30E-01	1,89E-01	2,17E-01
IR	4,73E-01	2,83E-01	3,69E-01
OD	9,05E-05	5,59E-05	7,12E-05
PM/RI	3,78E-01	2,87E-01	3,36E-01
POF	2,72E-01	2,06E-01	2,39E-01
RDW	3,96E-01	2,64E-01	3,21E-01
RDMFR	7,49E-01	7,40E-01	8,23E-01

Table 11 - Normalised PEF indicators for LCD TVs

5.2.3 Environmental impact of LCD TVs by life cycle stage

In order to fully understand the environmental impact of LCD TVs, it is important to know which life cycle stages contribute most to the overall environmental impact. The sections and tables below describe the environmental impact of the different LCD TVs, for each of the methodologies, by life cycle stage. In addition, each of the life cycle stages is expressed as a percentage of its gross environmental impact (i.e. sum of the absolute of each life cycle impacts). Where the environmental impact of a life cycle stage is negative, it is presented in brackets.

5.2.3.1 TV1

CML2001 indicator	Total TV1	Manufacturing	Distribution	Use	EoL
ADPe [kg Sb-eq.]	1,67E-02	4,49E-02	2,11E-07	4,30E-04	-2,86E-02
ADPf [MJ]	3,50E+04	8,35E+03	7,22E+01	2,73E+04	-7,61E+02
AP [kg SO2-eq.]	1,65E+01	4,72E+00	6,96E-02	1,23E+01	-6,28E-01
EP [kg Phosphate-eq.]	1,15E+00	5,01E-01	9,33E-03	6,70E-01	-2,99E-02
FAETP [kg DCB-eq.]	1,28E+01	7,47E+00	4,58E-02	5,96E+00	-6,44E-01
GWPin [CO2-eq.]	3,29E+03	8,86E+02	5,34E+00	2,45E+03	-5,44E+01
GWPex [CO2-eq.]	3,27E+03	8,60E+02	5,30E+00	2,46E+03	-5,44E+01
HTP [kg DCB-eq.]	4,44E+02	3,55E+02	2,64E-01	1,51E+02	-6,23E+01
MAETP [kg DCB-eq.]	5,32E+05	2,76E+05	1,01E+02	2,81E+05	-2,57E+04
ODP [kg R11-eq.]	1,94E-06	1,21E-07	1,48E-11	1,82E-06	-1,04E-09
POCP [kg Ethene-eq.]	1,13E+00	4,52E-01	-2,66E-03	7,19E-01	-3,97E-02
TETP [kg DCB-eq.]	7,83E+00	4,96E+00	1,67E-02	3,25E+00	-3,85E-01

Table 12 - CML indicators by life cycle stage, TV1

CML2001 indicator	Manufacturing	Distribution	Use	EoL
ADPe	61%	0%	1%	(39%)
ADPf	23%	0%	75%	(2%)
AP	27%	0%	69%	(4%)
EP	41%	1%	55%	(2%)
FAETP	53%	0%	42%	(5%)
GWPin	26%	0%	72%	(2%)
GWPex	25%	0%	73%	(2%)
HTP	62%	0%	27%	(11%)
MAETP	47%	0%	48%	(4%)
ODP	6%	0%	94%	(0%)
POCP	37%	(0%)	59%	(3%)
TETP	58%	0%	38%	(4%)

Table 13 - Relative impact CML indicators by life cycle stage, TV1

PEF indicator	Total TV1	Manufacturing	Distribution	Use	EoL
AC [Mole of H+ eq.]	1,90E+01	5,72E+00	8,97E-02	1,39E+01	-7,25E-01
CC_ex [CO2-eq.]	3,27E+03	8,60E+02	5,31E+00	2,46E+03	-5,44E+01
CC_in [CO2-eq.]	3,29E+03	8,86E+02	5,36E+00	2,45E+03	-5,45E+01
ETF [CTUe]	3,13E+02	2,58E+02	1,41E+00	8,72E+01	-3,36E+01
EPF [kg P-eq.]	1,28E-02	9,74E-03	1,48E-05	3,08E-03	-6,49E-05
EPM [kg N-eq.]	1,80E-01	6,36E-02	1,02E-02	1,08E-01	-1,82E-03
EPT [Mole of N-eq.]	3,10E+01	1,37E+01	2,97E-01	1,79E+01	-8,99E-01
HT_c [CTUh]	7,21E-06	5,44E-06	6,04E-08	2,11E-06	-4,05E-07
HT_nc [CTUh]	1,23E-04	7,62E-05	3,63E-07	5,95E-05	-1,33E-05
IR [kBq U235-eq.]	5,34E+02	2,73E+01	5,34E-03	5,08E+02	-8,09E-01
OD [kg R11-eq.]	1,95E-06	1,32E-07	1,48E-11	1,82E-06	-1,04E-09
PM/RI [kg PM2,5-Eq.]	1,44E+00	6,50E-01	3,38E-03	8,39E-01	-5,64E-02
POF [kg NMVOC]	8,61E+00	3,72E+00	5,04E-02	5,10E+00	-2,68E-01
RDW [m³ eq.]	3,23E+01	4,96E+00	1,43E-03	2,75E+01	-2,24E-01
RDMFR [kg Sb-eq.]	7,57E-02	1,05E-01	1,31E-06	7,37E-03	-3,64E-02

Table 14 - PEF indicators by life cycle stage, TV1

PEF indicator	Manufacturing	Distribution	Use	EoL
Acid	28%	0%	68%	(4%)
CC_ex	25%	0%	73%	(2%)
CC_in	26%	0%	72%	(2%)
ETF	68%	0%	23%	(9%)
EPF	76%	0%	24%	(1%)
EPM	35%	6%	59%	(1%)
EPT	42%	1%	55%	(3%)
HT_c	68%	1%	26%	(5%)
HT_nc	51%	0%	40%	(9%)
IR	5%	0%	95%	(0%)
OD	7%	0%	93%	(0%)
PM/RI	42%	0%	54%	(4%)
POF	41%	1%	56%	(3%)
RDW	15%	0%	84%	(1%)
RDMFR	71%	0%	5%	(25%)

Table 15 - Relative impact PEF indicators by life cycle stage, TV1

5.2.3.2 TV2

CML2001 indicator	Total TV2	Manufacturing	Distribution	Use	EoL
ADPe [kg Sb-eq.]	1,73E-02	4,52E-02	2,25E-07	2,46E-04	-2,81E-02
ADPf [MJ]	2,39E+04	8,97E+03	7,49E+01	1,57E+04	-7,53E+02
AP [kg SO2-eq.]	1,15E+01	4,90E+00	7,40E-02	7,07E+00	-5,87E-01
EP [kg Phosphate-eq.]	2,26E+00	1,90E+00	9,97E-03	3,84E-01	-2,98E-02
FAETP [kg DCB-eq.]	1,06E+01	7,78E+00	4,56E-02	3,42E+00	-6,29E-01
GWPin [CO2-eq.]	2,29E+03	9,30E+02	6,09E+00	1,40E+03	-5,35E+01
GWPex [CO2-eq.]	2,26E+03	9,05E+02	5,38E+00	1,41E+03	-5,35E+01
HTP [kg DCB-eq.]	3,94E+02	3,65E+02	1,13E-01	8,65E+01	-5,77E+01
MAETP [kg DCB-eq.]	4,17E+05	2,81E+05	1,86E+01	1,61E+05	-2,56E+04
ODP [kg R11-eq.]	1,20E-06	1,52E-07	7,77E-10	1,05E-06	-1,07E-09
POCP [kg Ethene-eq.]	8,38E-01	4,68E-01	-2,99E-03	4,12E-01	-3,84E-02
TETP [kg DCB-eq.]	6,60E+00	5,09E+00	1,36E-02	1,86E+00	-3,58E-01

Table 16 - CML indicators by life cycle stage, TV2

CML2001 indicator	Manufacturing	Distribution	Use	EoL
ADPe	61%	0%	0%	(38%)
ADPf	35%	0%	62%	(3%)
AP	39%	1%	56%	(5%)
EP	82%	0%	17%	(1%)
FAETP	66%	0%	29%	(5%)
GWPin	39%	0%	59%	(2%)
GWPex	38%	0%	59%	(2%)
HTP	72%	0%	17%	(11%)
MAETP	60%	0%	34%	(5%)
ODP	13%	0%	87%	(0%)
POCP	51%	(0%)	45%	(4%)
TETP	70%	0%	25%	(5%)

Table 17 - Relative impact CML indicators by life cycle stage, TV2

PEF indicator	Total TV2	Manufacturing	Distribution	Use	EoL
AC [Mole of H+ eq.]	1,33E+01	5,90E+00	9,55E-02	7,98E+00	-6,81E-01
CC_ex [CO2-eq.]	2,27E+03	9,05E+02	5,39E+00	1,41E+03	-5,36E+01
CC_in [CO2-eq.]	2,29E+03	9,30E+02	6,10E+00	1,40E+03	-5,36E+01
ETF [CTUe]	3,03E+02	2,84E+02	1,42E+00	5,00E+01	-3,23E+01
EPF [kg P-eq.]	1,19E-02	1,02E-02	1,62E-05	1,77E-03	-5,98E-05
EPM [kg N-eq.]	1,43E-01	7,23E-02	1,10E-02	6,18E-02	-1,75E-03
EPT [Mole of N-eq.]	2,37E+01	1,40E+01	3,17E-01	1,03E+01	-8,99E-01
HT_c [CTUh]	8,37E-06	7,49E-06	6,46E-08	1,21E-06	-3,89E-07
HT_nc [CTUh]	1,01E-04	7,91E-05	3,64E-07	3,41E-05	-1,28E-05
IR [kBq U235-eq.]	3,20E+02	2,96E+01	5,19E-03	2,91E+02	-8,02E-01
OD [kg R11-eq.]	1,21E-06	1,63E-07	7,77E-10	1,05E-06	-1,07E-09
PM/RI [kg PM2,5-Eq.]	1,09E+00	6,63E-01	3,05E-03	4,81E-01	-5,50E-02
POF [kg NMVOC]	6,53E+00	3,82E+00	5,36E-02	2,93E+00	-2,66E-01
RDW [m³ eq.]	2,15E+01	5,93E+00	8,07E-04	1,58E+01	-2,06E-01
RDMFR [kg Sb-eq.]	7,48E-02	1,06E-01	1,37E-06	4,22E-03	-3,51E-02

Table 18 - PEF indicators by life cycle stage, TV2

PEF indicator	Manufacturing	Distribution	Use	EoL
Acid	40%	1%	54%	(5%)
CC_ex	38%	0%	59%	(2%)
CC_in	39%	0%	59%	(2%)
ETF	77%	0%	14%	(9%)
EPF	85%	0%	15%	(0%)
EPM	49%	8%	42%	(1%)
EPT	55%	1%	40%	(4%)
HT_c	82%	1%	13%	(4%)
HT_nc	63%	0%	27%	(10%)
IR	9%	0%	91%	(0%)
OD	13%	0%	86%	(0%)
PM/RI	55%	0%	40%	(5%)
POF	54%	1%	41%	(4%)
RDW	27%	0%	72%	(1%)
RDMFR	73%	0%	3%	(24%)

Table 19 - Relative impact PEF indicators by life cycle stage, TV2

5.2.3.3 TV3

CML2001 indicator	Total TV1	Manufacturing	Distribution	Use	EoL
ADPe [kg Sb-eq.]	2,04E-02	4,90E-02	2,59E-07	3,27E-04	-2,89E-02
ADPf [MJ]	2,93E+04	9,23E+03	8,87E+01	2,08E+04	-8,50E+02
AP [kg SO2-eq.]	1,39E+01	5,12E+00	8,55E-02	9,40E+00	-6,62E-01
EP [kg Phosphate-eq.]	1,02E+00	5,28E-01	1,15E-02	5,11E-01	-3,24E-02
FAETP [kg DCB-eq.]	1,24E+01	8,50E+00	5,62E-02	4,54E+00	-6,66E-01
GWPin [CO2-eq.]	2,77E+03	9,57E+02	6,56E+00	1,87E+03	-5,97E+01
GWPex [CO2-eq.]	2,75E+03	9,31E+02	6,51E+00	1,87E+03	-5,96E+01
HTP [kg DCB-eq.]	4,59E+02	4,07E+02	3,24E-01	1,15E+02	-6,35E+01
MAETP [kg DCB-eq.]	4,89E+05	3,01E+05	1,24E+02	2,14E+05	-2,64E+04
ODP [kg R11-eq.]	1,52E-06	1,35E-07	1,81E-11	1,39E-06	-1,62E-09
POCP [kg Ethene-eq.]	9,80E-01	4,80E-01	-3,27E-03	5,48E-01	-4,41E-02
TETP [kg DCB-eq.]	7,62E+00	5,56E+00	2,05E-02	2,47E+00	-4,34E-01

Table 20 - CML indicators by life cycle stage, TV3

CML2001 indicator	Manufacturing	Distribution	Use	EoL
ADPe	63%	0%	0%	(37%)
ADPf	30%	0%	67%	(3%)
AP	34%	1%	62%	(4%)
EP	49%	1%	47%	(3%)
FAETP	62%	0%	33%	(5%)
GWPin	33%	0%	65%	(2%)
GWPex	32%	0%	65%	(2%)
HTP	69%	0%	20%	(11%)
MAETP	56%	0%	40%	(5%)
ODP	9%	0%	91%	(0%)
POCP	45%	(0%)	51%	(4%)
TETP	66%	0%	29%	(5%)

Table 21 - Relative impact CML indicators by life cycle stage, TV3

PEF indicator	Total TV3	Manufacturing	Distribution	Use	EoL
AC [Mole of H+ eq.]	1,61E+01	6,18E+00	1,10E-01	1,06E+01	-7,66E-01
CC_ex [CO2-eq.]	2,75E+03	9,31E+02	6,52E+00	1,87E+03	-5,97E+01
CC_in [CO2-eq.]	2,77E+03	9,58E+02	6,58E+00	1,87E+03	-5,97E+01
ETF [CTUe]	3,13E+02	2,80E+02	1,73E+00	6,65E+01	-3,44E+01
EPF [kg P-eq.]	1,21E-02	9,83E-03	1,81E-05	2,35E-03	-7,59E-05
EPM [kg N-eq.]	1,60E-01	6,75E-02	1,25E-02	8,21E-02	-2,06E-03
EPT [Mole of N-eq.]	2,74E+01	1,44E+01	3,64E-01	1,36E+01	-9,75E-01
HT_c [CTUh]	7,52E-06	6,29E-06	7,41E-08	1,61E-06	-4,55E-07
HT_nc [CTUh]	1,15E-04	8,52E-05	4,46E-07	4,53E-05	-1,55E-05
IR [kBq U235-eq.]	4,16E+02	3,04E+01	6,56E-03	3,87E+02	-8,76E-01
OD [kg R11-eq.]	1,54E-06	1,50E-07	1,81E-11	1,39E-06	-1,62E-09
PM/RI [kg PM2,5-Eq.]	1,28E+00	6,95E-01	4,15E-03	6,40E-01	-6,26E-02
POF [kg NMVOC]	7,59E+00	3,93E+00	6,18E-02	3,89E+00	-2,92E-01
RDW [m³ eq.]	2,61E+01	5,35E+00	1,76E-03	2,10E+01	-2,26E-01
RDMFR [kg Sb-eq.]	8,31E-02	1,14E-01	1,61E-06	5,61E-03	-3,69E-02

Table 22 - PEF indicators by life cycle stage, TV3

PEF indicator	Manufacturing	Distribution	Use	EoL
Acid	35%	1%	60%	(4%)
CC_ex	32%	0%	65%	(2%)
CC_in	33%	0%	65%	(2%)
ETF	73%	0%	17%	(9%)
EPF	80%	0%	19%	(1%)
EPM	41%	8%	50%	(1%)
EPT	49%	1%	46%	(3%)
HT_c	75%	1%	19%	(5%)
HT_nc	58%	0%	31%	(11%)
IR	7%	0%	93%	(0%)
OD	10%	0%	90%	(0%)
PM/RI	50%	0%	46%	(4%)
POF	48%	1%	48%	(4%)
RDW	20%	0%	79%	(1%)
RDMFR	73%	0%	4%	(24%)

Table 23 - Relative impact PEF indicators by life cycle stage, TV3

5.2.4 Total environmental impact of 3M QDEF

As QDEF is a key component used in TV2, it is important to understand its environmental impact, as well as how it relates to the overall environmental impact of TV2. The tables below represent the overall environmental impact of TV2, followed by the total impact of the TV2 manufacturing phase, and the impact of the manufacturing process of QDEF. Furthermore, the impact of QDEF is provided as compared to the total life cycle of TV2 and on the TV2 manufacturing process respectively.

CML2001 indicator	Life cycle TV2	TV2	QDEF	%QDEF in life cycle	%QDEF in TV2
ADPe [kg Sb-eq.]	1,73E-02	4,52E-02	5,59E-05	0%	0%
ADPf [MJ]	2,39E+04	8,97E+03	4,83E+02	2%	5%
AP [kg SO2-eq.]	1,15E+01	4,90E+00	1,25E-01	1%	3%
EP [kg Phosphate-eq.]	2,26E+00	1,90E+00	1,39E+00	62%	73%
FAETP [kg DCB-eq.]	1,06E+01	7,78E+00	2,19E-01	2%	3%
GWPin [CO2-eq.]	2,29E+03	9,30E+02	3,36E+01	1%	4%
GWPex [CO2-eq.]	2,26E+03	9,05E+02	3,51E+01	2%	4%
HTP [kg DCB-eq.]	3,94E+02	3,65E+02	3,71E+00	1%	1%
MAETP [kg DCB-eq.]	4,17E+05	2,81E+05	1,62E+03	0%	1%
ODP [kg R11-eq.]	1,20E-06	1,52E-07	2,77E-08	2%	18%
POCP [kg Ethene-eq.]	8,38E-01	4,68E-01	1,12E-02	1%	2%
TETP [kg DCB-eq.]	6,60E+00	5,09E+00	4,03E-02	1%	1%

Table 24 - CML indicators for 3M QDEF

PEF indicator	Life cycle TV2	TV2	QDEF	%QDEF in life cycle	%QDEF in TV2
AC [Mole of H+ eq.]	1,33E+01	5,90E+00	1,18E-01	1%	2%
CC_ex [CO2-eq.]	2,27E+03	9,05E+02	3,52E+01	2%	4%
CC_in [CO2-eq.]	2,29E+03	9,30E+02	3,36E+01	1%	4%
ETF [CTUe]	3,03E+02	2,84E+02	2,31E+01	8%	8%
EPF [kg P-eq.]	1,19E-02	1,02E-02	4,08E-04	3%	4%
EPM [kg N-eq.]	1,43E-01	7,23E-02	8,17E-03	6%	11%
EPT [Mole of N-eq.]	2,37E+01	1,40E+01	2,46E-01	1%	2%
HT_c [CTUh]	8,37E-06	7,49E-06	1,92E-06	23%	26%
HT_nc [CTUh]	1,01E-04	7,91E-05	1,30E-06	1%	2%
IR [kBq U235-eq.]	3,20E+02	2,96E+01	1,85E+00	1%	6%
OD [kg R11-eq.]	1,21E-06	1,63E-07	2,77E-08	2%	17%
PM/RI [kg PM2,5-Eq.]	1,09E+00	6,63E-01	6,21E-03	1%	1%
POF [kg NMVOC]	6,53E+00	3,82E+00	6,53E-02	1%	2%
RDW [m³ eq.]	2,15E+01	5,93E+00	9,19E-01	4%	15%
RDMFR [kg Sb-eq.]	7,48E-02	1,06E-01	2,00E-04	0%	0%

Table 25 - PEF indicators for 3M QDEF

5.2.5 *Total environmental impact of QDs*

In order to be able to draw conclusions on QD technologies (Cd based vs. Cd free), it is important to understand the contribution of the QD manufacturing process on the environmental impact of QDEF, TV2 manufacturing, and the total life cycle of TV2. Similar to section 5.2.4, this information is provided in the tables below.

CML2001 indicator	Life cycle TV2	TV2	QDEF	QD	%QD in life cycle	%QD in TV2	%QD in QDEF
ADPe [kg Sb-eq.]	1,73E-02	4,52E-02	5,59E-05	4,03E-05	0,2%	0,1%	72,0%
ADPf [MJ]	2,39E+04	8,97E+03	4,83E+02	3,08E+01	0,1%	0,3%	6,4%
AP [kg SO2-eq.]	1,15E+01	4,90E+00	1,25E-01	3,82E-02	0,3%	0,8%	30,6%
EP [kg Phosphate-eq.]	2,26E+00	1,90E+00	1,39E+00	3,37E-03	0,1%	0,2%	0,2%
FAETP [kg DCB-eq.]	1,06E+01	7,78E+00	2,19E-01	5,86E-02	0,6%	0,8%	26,8%
GWPin [CO2-eq.]	2,29E+03	9,30E+02	3,36E+01	2,31E+00	0,1%	0,2%	6,9%
GWPex [CO2-eq.]	2,26E+03	9,05E+02	3,51E+01	2,69E+00	0,1%	0,3%	7,7%
HTP [kg DCB-eq.]	3,94E+02	3,65E+02	3,71E+00	3,25E-01	0,1%	0,1%	8,8%
MAETP [kg DCB-eq.]	4,17E+05	2,81E+05	1,62E+03	2,98E+02	0,1%	0,1%	18,4%
ODP [kg R11-eq.]	1,20E-06	1,52E-07	2,77E-08	2,19E-10	0,0%	0,1%	0,8%
POCP [kg Ethene-eq.]	8,38E-01	4,68E-01	1,12E-02	8,74E-04	0,1%	0,2%	7,8%
TETP [kg DCB-eq.]	6,60E+00	5,09E+00	4,03E-02	1,13E-02	0,2%	0,2%	28,0%

Table 26 - CML indicators for QDs

PEF indicator	Life cycle TV2	TV2	QDEF	QD	%QD in life cycle	%QD in TV2	%QD in QDEF
AC [Mole of H+ eq.]	1,33E+01	5,90E+00	1,18E-01	1,73E-02	0,1%	0,3%	14,6%
CC_ex [CO2-eq.]	2,27E+03	9,05E+02	3,52E+01	2,70E+00	0,1%	0,3%	7,7%
CC_in [CO2-eq.]	2,29E+03	9,30E+02	3,36E+01	2,31E+00	0,1%	0,2%	6,9%
ETF [CTUe]	3,03E+02	2,84E+02	2,31E+01	1,37E+00	0,5%	0,5%	5,9%
EPF [kg P-eq.]	1,19E-02	1,02E-02	4,08E-04	3,17E-04	2,7%	3,1%	77,6%
EPM [kg N-eq.]	1,43E-01	7,23E-02	8,17E-03	9,81E-04	0,7%	1,4%	12,0%
EPT [Mole of N-eq.]	2,37E+01	1,40E+01	2,46E-01	5,95E-02	0,3%	0,4%	24,2%
HT_c [CTUh]	8,37E-06	7,49E-06	1,92E-06	1,65E-08	0,2%	0,2%	0,9%
HT_nc [CTUh]	1,01E-04	7,91E-05	1,30E-06	2,83E-07	0,3%	0,4%	21,7%
IR [kBq U235-eq.]	3,20E+02	2,96E+01	1,85E+00	6,29E-02	0,0%	0,2%	3,4%
OD [kg R11-eq.]	1,21E-06	1,63E-07	2,77E-08	2,19E-10	0,0%	0,1%	0,8%
PM/RI [kg PM2,5-Eq.]	1,09E+00	6,63E-01	6,21E-03	1,28E-03	0,1%	0,2%	20,7%
POF [kg NMVOC]	6,53E+00	3,82E+00	6,53E-02	7,76E-03	0,1%	0,2%	11,9%
RDW [m³ eq.]	2,15E+01	5,93E+00	9,19E-01	2,43E-01	1,1%	4,1%	26,5%
RDMFR [kg Sb-eq.]	7,48E-02	1,06E-01	2,00E-04	1,49E-04	0,2%	0,1%	74,6%

Table 27 - PEF indicators for QDs

5.3 Data quality

The data quality rating (DQR) is calculated based on the data quality indicators based on the EU Product Environmental Footprint (PEF) Guidance. Six quality assessment areas are adopted for LCA studies, five relating to the data and one to the method. These are summarised in the representativeness (technological, geographical and time-related), and characterise the degree to which the processes and products selected are depicting the system under analysis. Once the processes and products representing the system under analysis are chosen, and the data collection and modelling are complete, the completeness criterion evaluates to what degree the data and the model of these processes and products covers all associated emissions and resources. For each indicator there are five scores ranging from very good to very poor. The LCI shall be completed according to these data quality indicators (DQIs) (see section 9).

The DQR is calculated based on the DQIs. For the most environmentally significant processes or activities, accounting for at least 70% of contributions to each impact category, specific as well as generic data shall achieve at least an overall good quality level (a DQR ≤ 3.0). A semi-quantitative assessment of data quality shall be performed and reported for these processes.

For environmentally significant processes accounting for at least 20% (i.e. 20% to 30%) of contributions to each impact category, at least fair quality data (a DQR ≤ 4.0) shall be used. Qualitative expert judgment is used to assess this kind of data.
The remaining data (beyond 90% contribution to the environmental impacts), used for approximation and filling data gaps, can be based on best available information.

The data quality for QDs, QDEF and LCD TVs assessment results are presented below for the different environmental impact calculation methodologies (see section 5 for more details). From these tables, it is apparent that for each impact indicator, as well as the data quality overall is at least "good". This means that each indicator for each type of product can be used and interpreted in this LCA study.

	% Good (or better) data quality	% Fair data quality	% Poor data quality	Overall PEF score	Overall PEF result
ADPe	100.00%	0.00%	0.00%	2.24	Good
ADPf	100.00%	0.00%	0.00%	1.95	Very good
AP	100.00%	0.00%	0.00%	1.42	Excellent
EP	100.00%	0.00%	0.00%	2.00	Very good
FAETP	100.00%	0.00%	0.00%	2.03	Good
GWPin	99.98%	0.02%	0.00%	2.05	Good
GWPex	100.00%	0.00%	0.00%	2.05	Good
HTP	100.00%	0.00%	0.00%	1.89	Very good
MAETP	100.00%	0.00%	0.00%	1.97	Very good
ODP	99.60%	0.40%	0.00%	2.37	Good
POCP	100.00%	0.00%	0.00%	1.92	Very good
TETP	100.00%	0.00%	0.00%	2.40	Good
Overall	Good data quality				

Table 28 - QD DQR, CML

	% Good (or better) data quality	% Fair data quality	% Poor data quality	Overall PEF score	Overall PEF result
Acid	100.00%	0.00%	0.00%	1.98	Very good
CC_ex	100.00%	0.00%	0.00%	2.05	Good
CC_in	99.98%	0.02%	0.00%	2.05	Good
ETF	100.00%	0.00%	0.00%	2.12	Good
EPF	100.00%	0.00%	0.00%	2.00	Very good
EPM	100.00%	0.00%	0.00%	2.08	Good
EPT	100.00%	0.00%	0.00%	1.99	Very good
HT_c	100.00%	0.00%	0.00%	1.21	Excellent
HT_nc	99.98%	0.02%	0.00%	2.43	Good
IR	100.00%	0.00%	0.00%	1.99	Very good
OD	99.60%	0.40%	0.00%	2.37	Good
PM/RI	100.00%	0.00%	0.00%	1.94	Very good
POF	100.00%	0.00%	0.00%	1.97	Very good
RDW	100.00%	0.00%	0.00%	2.02	Good
RDMFR	100.00%	0.00%	0.00%	2.14	Good
Overall	Good data quality				

Table 29 - QD DQR, PEF

	% Good (or better) data quality	% Fair data quality	% Poor data quality	Overall PEF score	Overall PEF result
ADPe	99.27%	0.73%	0.00%	2.28	Good
ADPf	99.98%	0.02%	0.00%	1.92	Very good
AP	99.89%	0.11%	0.00%	1.72	Very good
EP	100.00%	0.00%	0.00%	1.18	Excellent
FAETP	99.59%	0.41%	0.00%	2.08	Good
GWPin	99.97%	0.03%	0.00%	1.94	Very good
GWPex	99.97%	0.03%	0.00%	1.95	Very good
HTP	99.39%	0.61%	0.00%	1.92	Very good
MAETP	99.64%	0.36%	0.00%	1.96	Very good
ODP	96.22%	3.78%	0.00%	2.59	Good
POCP	99.91%	0.09%	0.00%	1.76	Very good
TETP	99.47%	0.53%	0.00%	2.09	Good
Overall	Very good data quality				

Table 30 - QDEF DQR, CML

	% Good (or better) data quality	% Fair data quality	% Poor data quality	Overall PEF score	Overall PEF result
Acid	99.87%	0.13%	0.00%	1.91	Very good
CC_ex	99.97%	0.03%	0.00%	1.94	Very good
CC_in	99.97%	0.03%	0.00%	1.93	Very good
ETF	99.90%	0.10%	0.00%	1.96	Very good
EPF	99.88%	0.12%	0.00%	2.03	Good
EPM	99.98%	0.02%	0.00%	2.50	Good
EPT	99.95%	0.05%	0.00%	1.95	Very good
HT_c	99.99%	0.01%	0.00%	1.92	Excellent
HT_nc	99.78%	0.22%	0.00%	2.06	Good
IR	99.98%	0.02%	0.00%	1.93	Very good
OD	96.22%	3.78%	0.00%	2.59	Good
PM/RI	99.87%	0.13%	0.00%	1.91	Very good
POF	99.94%	0.06%	0.00%	1.89	Very good
RDW	96.95%	3.05%	0.00%	2.39	Good
RDMFR	98.71%	1.29%	0.00%	2.12	Good
Overall	Good data quality				

Table 31 - QDEF DQR, PEF

	% Good (or better) data quality	% Fair data quality	% Poor data quality	Overall PEF score	Overall PEF result
ADPe	100.00%	0.00%	0.00%	2.16	Good
ADPf	100.00%	0.00%	0.00%	1.91	Very good
AP	100.00%	0.00%	0.00%	1.92	Very good
EP	100.00%	0.00%	0.00%	1.97	Very good
FAETP	100.00%	0.00%	0.00%	2.01	Good
GWPin	100.00%	0.00%	0.00%	1.92	Very good
GWPex	100.00%	0.00%	0.00%	1.92	Very good
HTP	100.00%	0.00%	0.00%	2.05	Good
MAETP	100.00%	0.00%	0.00%	1.99	Very good
ODP	100.00%	0.00%	0.00%	1.85	Very good
POCP	100.00%	0.00%	0.00%	1.96	Very good
TETP	100.00%	0.00%	0.00%	2.03	Good
Overall	Very good data quality				

Table 32 - TV1 DQR, CML

	% Good (or better) data quality	% Fair data quality	% Poor data quality	Overall PEF score	Overall PEF result
Acid	100.00%	0.00%	0.00%	1.92	Very good
CC_ex	100.00%	0.00%	0.00%	1.92	Very good
CC_in	100.00%	0.00%	0.00%	1.92	Very good
ETF	100.00%	0.00%	0.00%	2.07	Good
EPF	100.00%	0.00%	0.00%	2.09	Good
EPM	100.00%	0.00%	0.00%	1.95	Very good
EPT	100.00%	0.00%	0.00%	1.97	Very good
HT_c	100.00%	0.00%	0.00%	2.07	Good
HT_nc	100.00%	0.00%	0.00%	2.00	Very good
IR	100.00%	0.00%	0.00%	1.85	Very good
OD	100.00%	0.00%	0.00%	1.86	Very good
PM/RI	100.00%	0.00%	0.00%	1.97	Very good
POF	100.00%	0.00%	0.00%	1.97	Very good
RDW	100.00%	0.00%	0.00%	1.88	Very good
RDMFR	100.00%	0.00%	0.00%	2.13	Good
Overall	Very good data quality				

Table 33 - TV1 DQR, PEF

	% Good (or better) data quality	% Fair data quality	% Poor data quality	Overall PEF score	Overall PEF result
ADPe	100.00%	0.00%	0.00%	2.16	Good
ADPf	100.00%	0.00%	0.00%	1.92	Very good
AP	100.00%	0.00%	0.00%	1.95	Very good
EP	100.00%	0.00%	0.00%	1.50	Excellent
FAETP	99.99%	0.01%	0.00%	2.06	Good
GWPin	99.98%	0.02%	0.00%	1.96	Very good
GWPex	100.00%	0.00%	0.00%	1.96	Very good
HTP	99.99%	0.01%	0.00%	2.09	Good
MAETP	100.00%	0.00%	0.00%	2.03	Good
ODP	99.85%	0.15%	0.00%	1.87	Very good
POCP	100.00%	0.00%	0.00%	2.00	Very good
TETP	100.00%	0.00%	0.00%	2.07	Good
Overall	Very good data quality				

Table 34 - TV2 DQR, CML

	% Good (or better) data quality	% Fair data quality	% Poor data quality	Overall PEF score	Overall PEF result
Acid	100.00%	0.00%	0.00%	1.96	Very good
CC_ex	100.00%	0.00%	0.00%	1.96	Very good
CC_in	99.98%	0.02%	0.00%	1.96	Very good
ETF	99.99%	0.01%	0.00%	2.09	Good
EPF	100.00%	0.00%	0.00%	2.11	Good
EPM	100.00%	0.00%	0.00%	2.02	Good
EPT	99.99%	0.01%	0.00%	2.02	Good
HT_c	100.00%	0.00%	0.00%	2.06	Good
HT_nc	99.99%	0.01%	0.00%	2.05	Good
IR	100.00%	0.00%	0.00%	1.86	Very good
OD	99.85%	0.15%	0.00%	1.89	Very good
PM/RI	100.00%	0.00%	0.00%	2.02	Good
POF	100.00%	0.00%	0.00%	2.01	Good
RDW	99.87%	0.13%	0.00%	1.93	Very good
RDMFR	100.00%	0.00%	0.00%	2.15	Good
Overall	Very good data quality				

Table 35 - TV2 DQR, PEF

	% Good (or better) data quality	% Fair data quality	% Poor data quality	Overall PEF score	Overall PEF result
ADPe	100.00%	0.00%	0.00%	2.16	Good
ADPf	100.00%	0.00%	0.00%	1.93	Very good
AP	100.00%	0.00%	0.00%	1.94	Very good
EP	100.00%	0.00%	0.00%	2.00	Very good
FAETP	100.00%	0.00%	0.00%	2.04	Good
GWPin	100.00%	0.00%	0.00%	1.94	Very good
GWPex	100.00%	0.00%	0.00%	1.94	Very good
HTP	100.00%	0.00%	0.00%	2.08	Good
MAETP	100.00%	0.00%	0.00%	2.02	Good
ODP	100.00%	0.00%	0.00%	1.86	Very good
POCP	100.00%	0.00%	0.00%	1.98	Very good
TETP	100.00%	0.00%	0.00%	2.06	Good
Overall	Very good data quality				

Table 36 - TV3 DQR, CML

	% Good (or better) data quality	% Fair data quality	% Poor data quality	Overall PEF score	Overall PEF result
Acid	100.00%	0.00%	0.00%	1.95	Very good
CC_ex	100.00%	0.00%	0.00%	1.94	Very good
CC_in	100.00%	0.00%	0.00%	1.94	Very good
ETF	100.00%	0.00%	0.00%	2.09	Good
EPF	100.00%	0.00%	0.00%	2.10	Good
EPM	100.00%	0.00%	0.00%	1.97	Very good
EPT	100.00%	0.00%	0.00%	2.00	Very good
HT_c	100.00%	0.00%	0.00%	2.09	Good
HT_nc	100.00%	0.00%	0.00%	2.03	Good
IR	100.00%	0.00%	0.00%	1.86	Very good
OD	100.00%	0.00%	0.00%	1.87	Very good
PM/RI	100.00%	0.00%	0.00%	2.00	Very good
POF	100.00%	0.00%	0.00%	1.99	Very good
RDW	100.00%	0.00%	0.00%	1.90	Very good
RDMFR	100.00%	0.00%	0.00%	2.14	Good
Overall	Very good data quality				

Table 37 - TV3 DQR, PEF

5.4 Uncertainty of LCIA results

Data quality and uncertainty are mutually dependent. The precision of the data depends on measuring tolerance, assumption, completion, comprehensiveness of the considered system and the representativeness of the used data.

Uncertainty is also introduced in the impact assessment phase of the study – and this will vary according to the impact categories considered. Some impact categories, such as global warming, are considered relatively robust regarding the aspects completeness of potential contributing emissions. Impact categories for toxicity are much less developed.

At least +/-10% uncertainty appears to be the minimum overall uncertainty, even if the model is set up with data of high quality containing few errors. While interpreting the results this must be kept in mind.

To get an idea of the uncertainty of the LCIA, uncertainty is calculated for the LCA base scenario based on a pedigree matrix and Monte Carlo analysis. The same data quality indicators and evaluations as for the data quality assessment (see Section 3.10) are used. By applying a pedigree matrix to the different data quality indicators a geometric standard deviation is calculated. This standard deviation is then used in a Monte Carlo analysis. In the Monte Carlo analysis, the certainty range for each midpoint is calculated based on a certainty level of 95%, a log-normal distribution and 1000 trails. The tables below provide an overview of the uncertainty values for each midpoint.

	Min	Max	Base	Δ%
ADPe	1.40E-05	4.27E-05	2.83E-05	51%
ADPf	1.92E+01	2.44E+01	2.17E+01	12%
AP	2.61E-02	2.76E-02	2.68E-02	10% [2.99%]
EP	2.17E-03	2.57E-03	2.37E-03	10% [8.44%]
FAETP	3.81E-02	4.48E-02	4.12E-02	10% [8.74%]
GWPin	1.44E+00	1.82E+00	1.62E+00	12%
GWPex	1.72E+00	2.08E+00	1.89E+00	10%
HTP	2.16E-01	2.43E-01	2.28E-01	10% [6.58%]
MAETP	1.93E+02	2.27E+02	2.10E+02	10% [8.10%]
ODP	1.07E-10	2.23E-10	1.54E-10	45%
POCP	5.72E-04	6.60E-04	6.14E-04	10% [7.49%]
TETP	6.45E-03	1.03E-02	7.93E-03	30%

Table 38 - QD Uncertainty, CML

	Min	Max	Base	Δ%
Acid	1.14E-02	1.31E-02	1.22E-02	10% [7.38%]
CC_ex	1.72E+00	2.08E+00	1.90E+00	10% [9.47%]
CC_in	1.46E+00	1.81E+00	1.63E+00	11%
ETF	7.80E-01	1.14E+00	9.60E-01	19%
EPF	2.02E-04	2.45E-04	2.23E-04	10% [9.87%]
EPM	6.25E-04	7.59E-04	6.89E-04	10%
EPT	3.85E-02	4.54E-02	4.18E-02	10% [8.61%]
HT_c	-1.18E-09	2.39E-08	1.16E-08	106%
HT_nc	1.60E-07	2.52E-07	1.99E-07	27%
IR	3.76E-02	5.20E-02	4.42E-02	18%
OD	1.09E-10	2.22E-10	1.54E-10	44%
PM/RI	8.46E-04	9.74E-04	9.02E-04	10% [7.98%]
POF	5.08E-03	5.81E-03	5.45E-03	10% [6.61%]
RDW	1.56E-01	1.88E-01	1.71E-01	10% [9.94%]
RDMFR	-4.27E-04	5.90E-04	1.05E-04	462%

Table 39 - QD Uncertainty, PEF

	Min	Max	Base	Δ%
ADPe	3.93E-05	7.04E-05	5.59E-05	26%
ADPf	4.35E+02	5.30E+02	4.83E+02	10% [9.73%]
AP	1.13E-01	1.37E-01	1.25E-01	10% [9.60%]
EP	1.34E+00	1.44E+00	1.39E+00	10% [3.60%]
FAETP	1.98E-01	2.40E-01	2.19E-01	10% [9.59%]
GWPin	3.07E+01	3.69E+01	3.36E+01	10% [9.82%]
GWPex	3.20E+01	3.85E+01	3.51E+01	10% [9.69%]
HTP	3.31E+00	4.14E+00	3.71E+00	12%
MAETP	1.47E+03	1.78E+03	1.62E+03	10% [9.88%]
ODP	2.28E-08	3.41E-08	2.77E-08	23%
POCP	1.05E-02	1.21E-02	1.12E-02	10% [8.04%]
TETP	3.74E-02	4.33E-02	4.03E-02	10% [7.44%]

Table 40 - QDEF Uncertainty, CML

	Min	Max	Base	Δ%
Acid	1.07E-01	1.33E-01	1.18E-01	13%
CC_ex	3.23E+01	3.83E+01	3.52E+01	10% [8.81%]
CC_in	3.08E+01	3.68E+01	3.36E+01	10% [9.52%]
ETF	2.08E+01	2.54E+01	2.31E+01	10% [9.96%]
EPF	3.80E-04	4.37E-04	4.08E-04	10% [7.11%]
EPM	5.80E-03	1.18E-02	8.17E-03	44%
EPT	2.24E-01	2.71E-01	2.46E-01	10%
HT_c	1.72E-06	2.14E-06	1.92E-06	11%
HT_nc	1.21E-06	1.40E-06	1.30E-06	10% [7.69%]
IR	1.63E+00	2.11E+00	1.85E+00	14%
OD	2.29E-08	3.38E-08	2.77E-08	22%
PM/RI	5.54E-03	6.93E-03	6.21E-03	12%
POF	5.94E-02	7.17E-02	6.53E-02	10% [9.80%]
RDW	7.07E-01	1.22E+00	9.19E-01	33%
RDMFR	-3.49E-04	7.07E-04	2.00E-04	254%

Table 41 - QDEF Uncertainty, PEF

	Min	Max	Base	Δ%
ADPe	4.54E-03	3.07E-02	1.67E-02	84%
ADPf	2.95E+04	4.13E+04	3.50E+04	18%
AP	1.38E+01	1.96E+01	1.65E+01	19%
EP	9.64E-01	1.35E+00	1.15E+00	17%
FAETP	1.07E+01	1.52E+01	1.28E+01	19%
GWPin	2.73E+03	3.90E+03	3.29E+03	19%
GWPex	2.72E+03	3.86E+03	3.27E+03	18%
HTP	3.62E+02	5.39E+02	4.44E+02	21%
MAETP	4.50E+05	6.28E+05	5.32E+05	18%
ODP	1.58E-06	2.43E-06	1.94E-06	25%
POCP	9.45E-01	1.32E+00	1.13E+00	17%
TETP	6.47E+00	9.40E+00	7.83E+00	20%

Table 42 - TV1 Uncertainty, CML

	Min	Max	Base	Δ%
Acid	1.60E+01	2.26E+01	1.90E+01	19%
CC_ex	2.75E+03	3.86E+03	3.27E+03	18%
CC_in	2.77E+03	3.94E+03	3.29E+03	20%
ETF	2.58E+02	3.84E+02	3.13E+02	23%
EPF	1.06E-02	1.54E-02	1.28E-02	20%
EPM	1.53E-01	2.09E-01	1.80E-01	16%
EPT	2.65E+01	3.59E+01	3.10E+01	16%
HT_c	5.95E-06	8.62E-06	7.21E-06	20%
HT_nc	1.01E-04	1.44E-04	1.23E-04	17%
IR	4.36E+02	6.59E+02	5.34E+02	23%
OD	1.57E-06	2.39E-06	1.95E-06	23%
PM/RI	1.21E+00	1.69E+00	1.44E+00	17%
POF	7.19E+00	1.02E+01	8.61E+00	18%
RDW	2.62E+01	3.90E+01	3.23E+01	21%
RDMFR	5.14E-02	1.04E-01	7.57E-02	37%

Table 43 - TV1 Uncertainty, PEF

	Min	Max	Base	Δ%
ADPe	5.17E-03	2.98E-02	1.73E-02	72%
ADPf	2.00E+04	2.84E+04	2.39E+04	19%
AP	9.53E+00	1.35E+01	1.15E+01	17%
EP	2.12E+00	2.42E+00	2.26E+00	10% [7.08%]
FAETP	8.79E+00	1.27E+01	1.06E+01	20%
GWPin	1.95E+03	2.67E+03	2.29E+03	17%
GWPex	1.94E+03	2.63E+03	2.26E+03	16%
HTP	3.12E+02	4.87E+02	3.94E+02	24%
MAETP	3.49E+05	4.96E+05	4.17E+05	19%
ODP	1.01E-06	1.44E-06	1.20E-06	20%
POCP	7.11E-01	9.85E-01	8.38E-01	18%
TETP	5.44E+00	7.88E+00	6.60E+00	19%

Table 44 - TV2 Uncertainty, CML

	Min	Max	Base	Δ%
Acid	1.12E+01	1.55E+01	1.33E+01	17%
CC_ex	1.91E+03	2.64E+03	2.27E+03	16%
CC_in	1.95E+03	2.65E+03	2.29E+03	16%
ETF	2.48E+02	3.72E+02	3.03E+02	23%
EPF	9.72E-03	1.42E-02	1.19E-02	19%
EPM	1.24E-01	1.66E-01	1.43E-01	16%
EPT	2.01E+01	2.78E+01	2.37E+01	17%
HT_c	7.13E-06	9.73E-06	8.37E-06	16%
HT_nc	8.28E-05	1.21E-04	1.01E-04	20%
IR	2.64E+02	3.90E+02	3.20E+02	22%
OD	9.92E-07	1.44E-06	1.21E-06	19%
PM/RI	9.09E-01	1.29E+00	1.09E+00	18%
POF	5.57E+00	7.65E+00	6.53E+00	17%
RDW	1.83E+01	2.51E+01	2.15E+01	17%
RDMFR	4.99E-02	1.02E-01	7.48E-02	36%

Table 45 - TV2 Uncertainty, PEF

	Min	Max	Base	Δ%
ADPe	7.84E-03	3.49E-02	2.04E-02	71%
ADPf	2.49E+04	3.44E+04	2.93E+04	17%
AP	1.17E+01	1.64E+01	1.39E+01	18%
EP	8.59E-01	1.20E+00	1.02E+00	18%
FAETP	1.04E+01	1.47E+01	1.24E+01	19%
GWPin	2.33E+03	3.27E+03	2.77E+03	18%
GWPex	2.33E+03	3.25E+03	2.75E+03	18%
HTP	3.69E+02	5.68E+02	4.59E+02	24%
MAETP	4.12E+05	5.81E+05	4.89E+05	19%
ODP	1.25E-06	1.85E-06	1.52E-06	21%
POCP	8.30E-01	1.16E+00	9.80E-01	18%
TETP	6.29E+00	9.22E+00	7.62E+00	21%

Table 46 - TV3 Uncertainty, CML

	Min	Max	Base	Δ%
Acid	1.37E+01	1.92E+01	1.61E+01	19%
CC_ex	2.34E+03	3.29E+03	2.75E+03	20%
CC_in	2.35E+03	3.29E+03	2.77E+03	19%
ETF	2.50E+02	3.83E+02	3.13E+02	22%
EPF	9.93E-03	1.47E-02	1.21E-02	21%
EPM	1.37E-01	1.84E-01	1.60E-01	15%
EPT	2.30E+01	3.22E+01	2.74E+01	18%
HT_c	6.09E-06	9.10E-06	7.52E-06	21%
HT_nc	9.33E-05	1.39E-04	1.15E-04	21%
IR	3.42E+02	5.07E+02	4.16E+02	22%
OD	1.27E-06	1.87E-06	1.54E-06	21%
PM/RI	1.07E+00	1.49E+00	1.28E+00	16%
POF	6.41E+00	8.92E+00	7.59E+00	18%
RDW	2.16E+01	3.10E+01	2.61E+01	19%
RDMFR	5.71E-02	1.15E-01	8.31E-02	39%

Table 47 - TV3 Uncertainty, PEF

6 Interpretation

6.1 Graphical representation of environmental impacts

The figures below provide a graphical representation of the LCIA results provided in tabular form in the section above, and compares the overall environmental impacts of LCD TVs for each of the methodologies' impact indicators, whilst incorporating the uncertainty calculation.

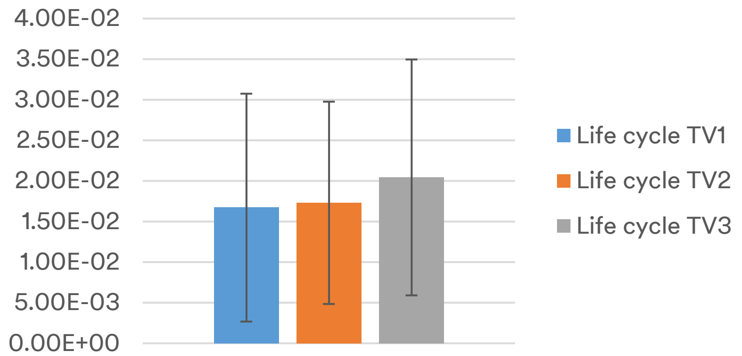

Figure 11 - CML ADPe comparison for LCD TVs [kg Sb-eq.]

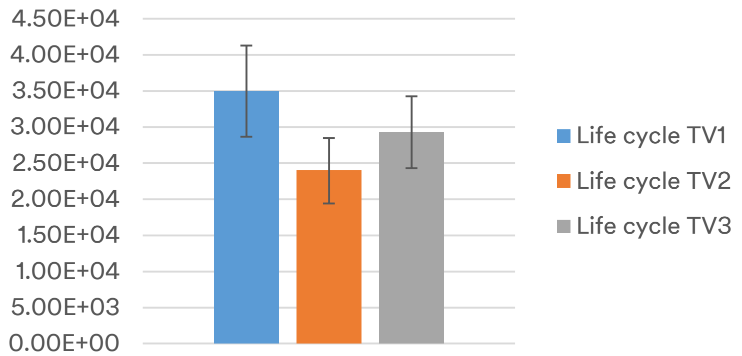

Figure 12 - CML ADPf comparison for LCD TVs [MJ]

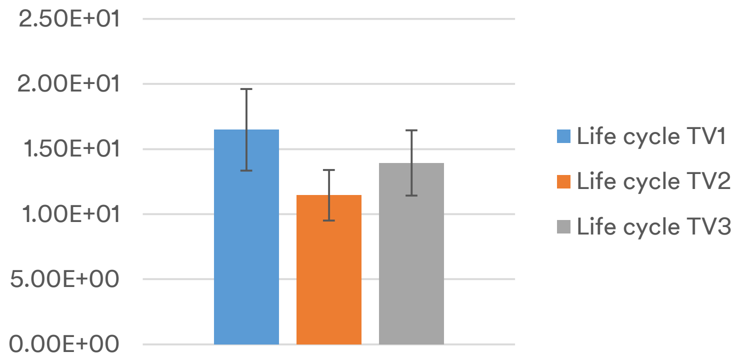

Figure 13 - CML AP comparison for LCD TVs [kg SO2-eq.]

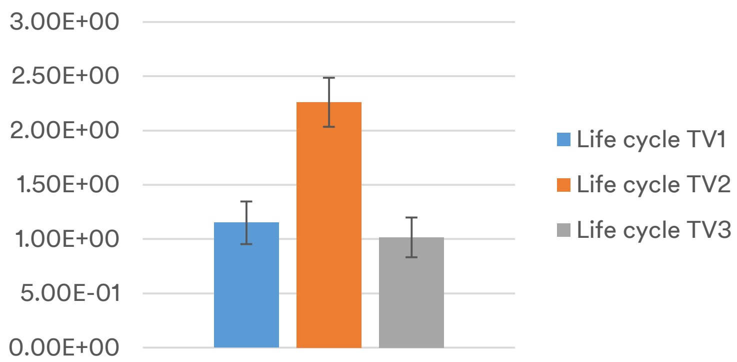

Figure 14 - CML EP comparison for LCD TVs [kg Phosphate-eq.]

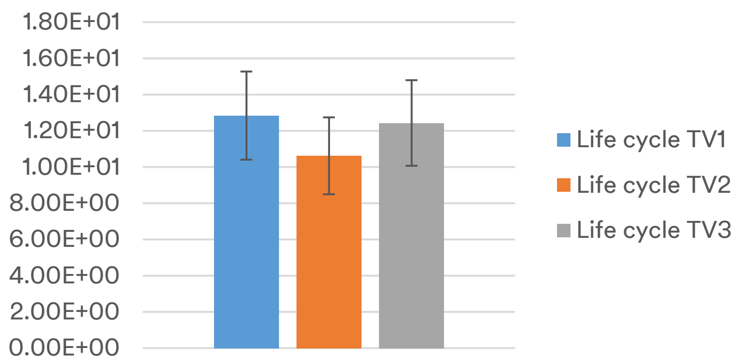

Figure 15 - CML FAETP comparison for LCD TVs [kg DCB-eq.]

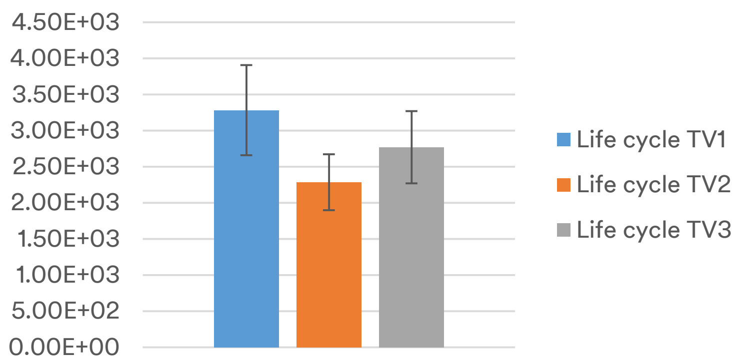

Figure 16 - CML GWPin comparison for LCD TVs [kg CO2-eq.]

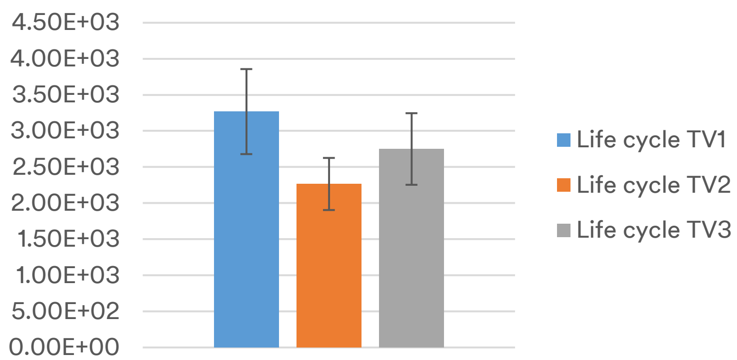

Figure 17 - CML GWPex comparison for LCD TVs [kg CO2-eq.]

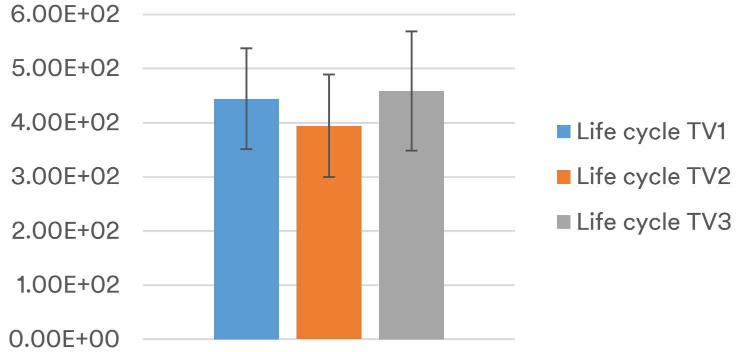

Figure 18 - CML HTP comparison for LCD TVs [kg DCB-eq.]

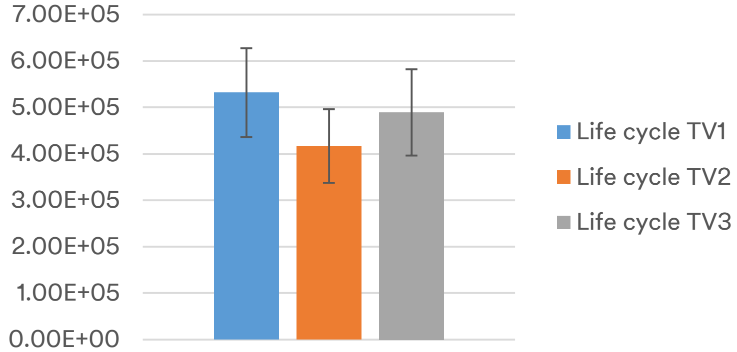

Figure 19 - CML MAETP comparison for LCD TVs [kg DCB-eq.]

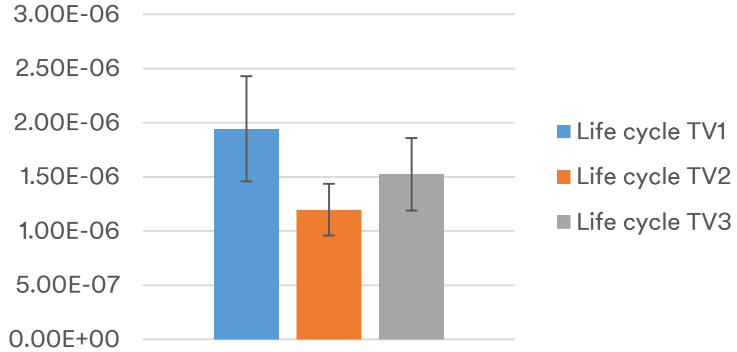

Figure 20 - CML ODP comparison for LCD TVs [kg R11-eq.]

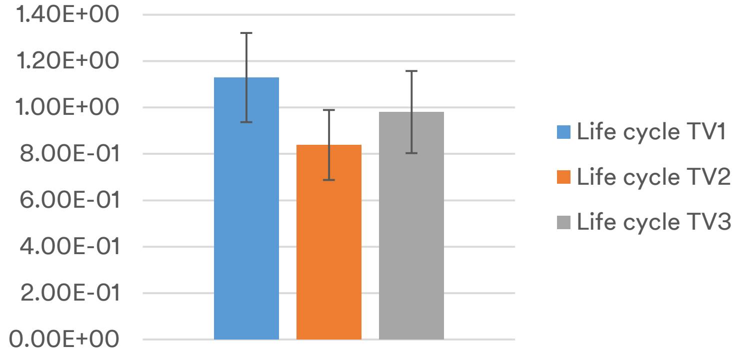

Figure 21 - CML POCP comparison for LCD TVs [kg Ethene-eq.]

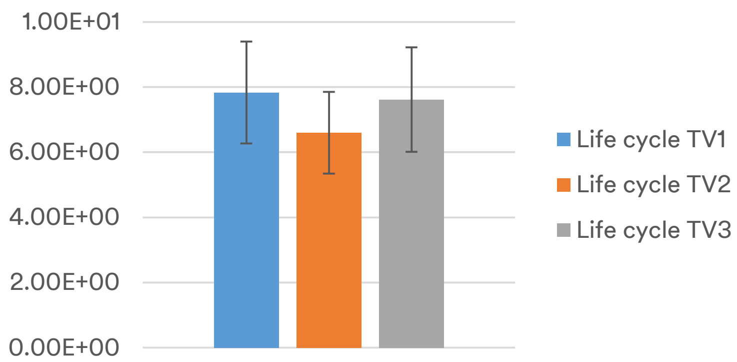

Figure 22 - CML TETP comparison for LCD TVs [kg DCB-eq.]

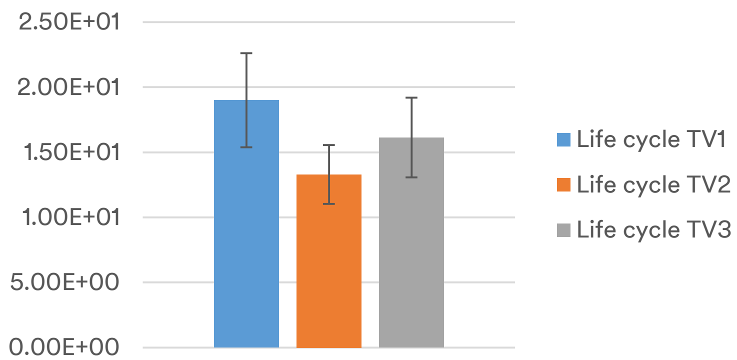

Figure 23 - PEF AC comparison for LCD TVs [Mole of H+ eq.]

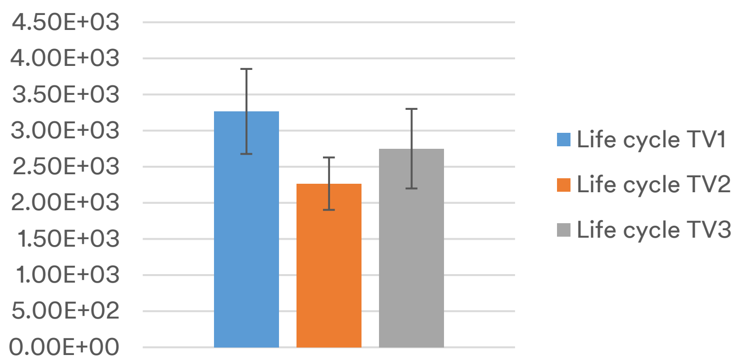

Figure 24 - PEF CC_ex comparison for LCD TVs [kg CO2-eq.]

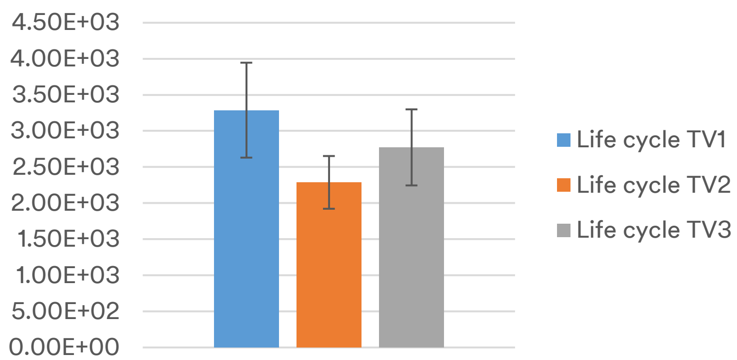

Figure 25 - PEF CC_in comparison for LCD TVs [kg CO2-eq.]

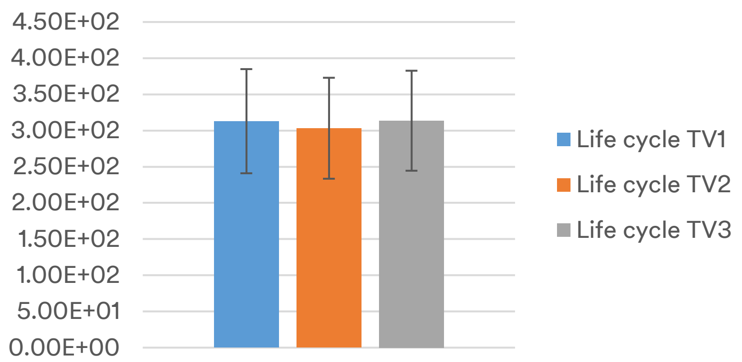

Figure 26 - PEF ETF comparison for LCD TVs [CTUe]

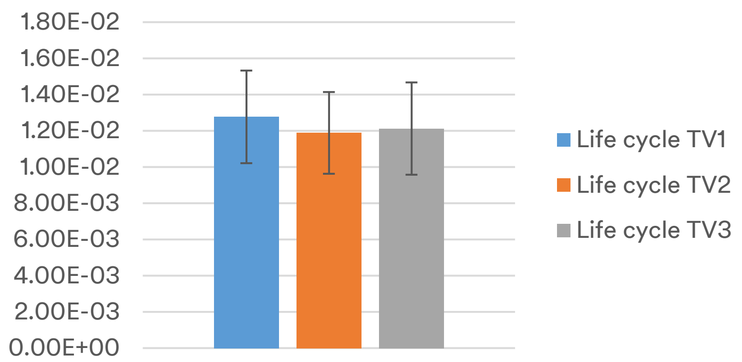

Figure 27 - PEF EPF comparison for LCD TVs [kg P-eq.]

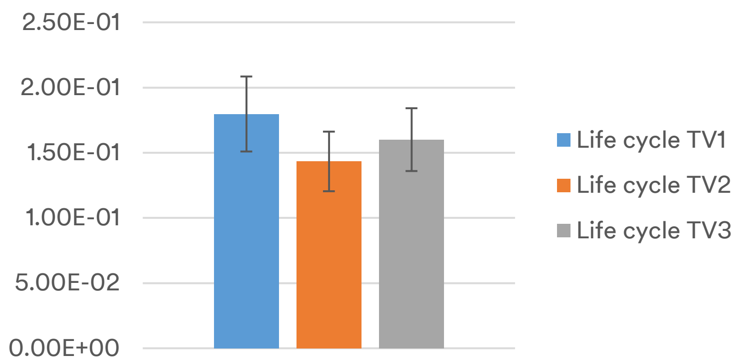

Figure 28 - PEF EPM comparison for LCD TVs [kg N-eq.]

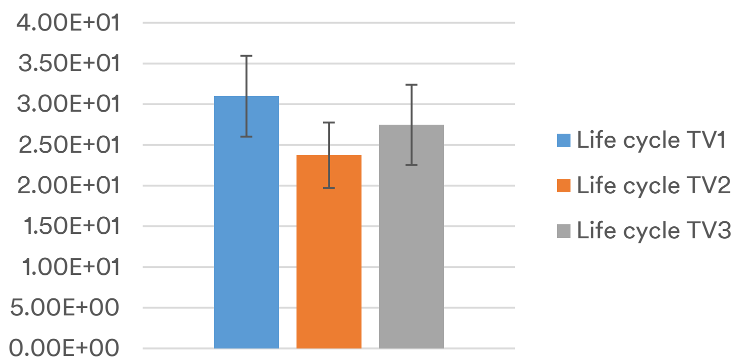

Figure 29 - PEF EPT comparison for LCD TVs [Mole of N-eq.]

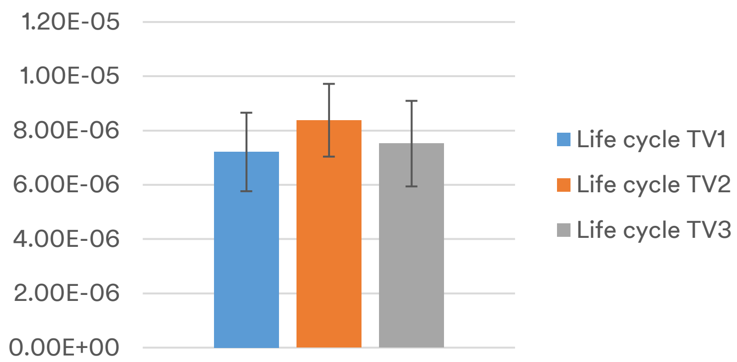

Figure 30 - PEF HT_c comparison for LCD TVs [CTUh]

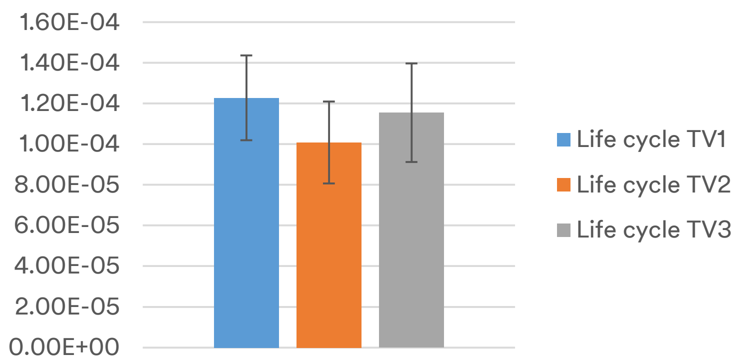

Figure 31 - PEF HT_nc comparison for LCD TVs [CTUh]

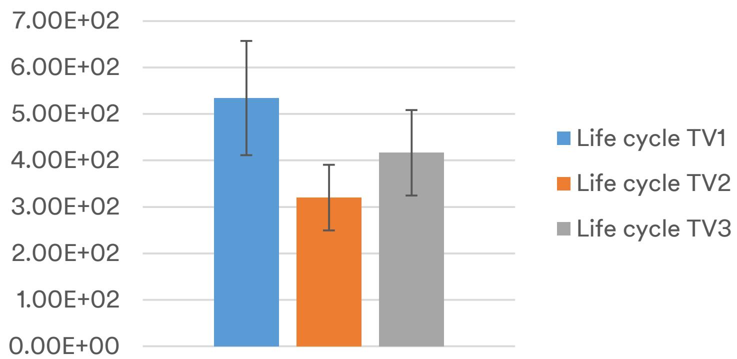

Figure 32 - PEF IR comparison for LCD TVs [kBq U235-eq.]

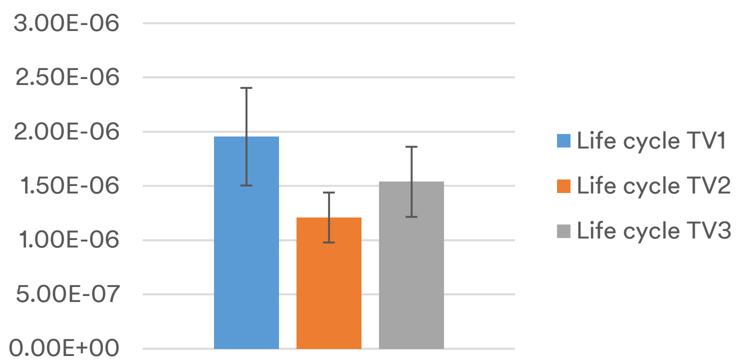

Figure 33 - PEF OD comparison for LCD TVs [kg R11-eq.]

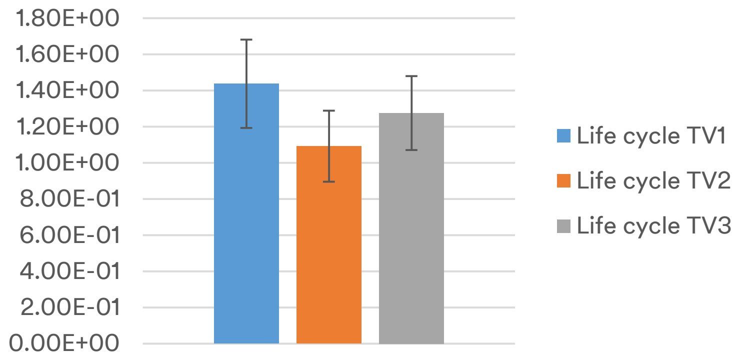

Figure 34 - PEF PM/RI comparison for LCD TVs [kg PM2,5-eq.]

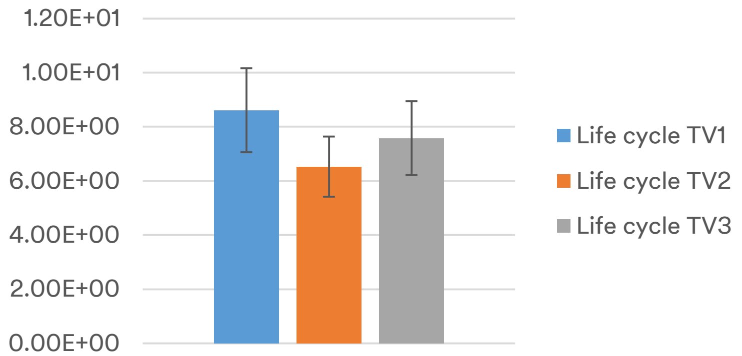

Figure 35 - PEF POF comparison for LCD TVs [kg NMVOC]

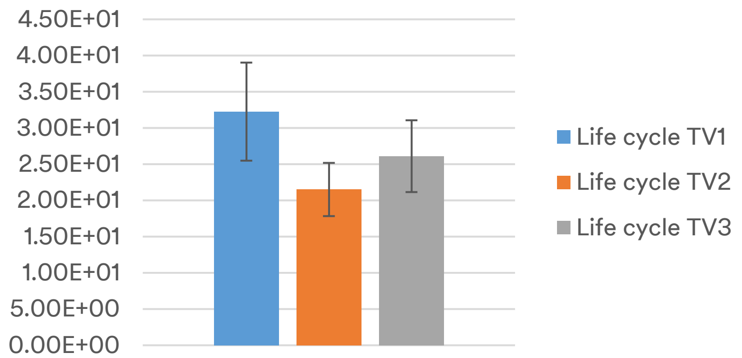

Figure 36 - PEF RDW comparison for LCD TVs [m^3 eq.]

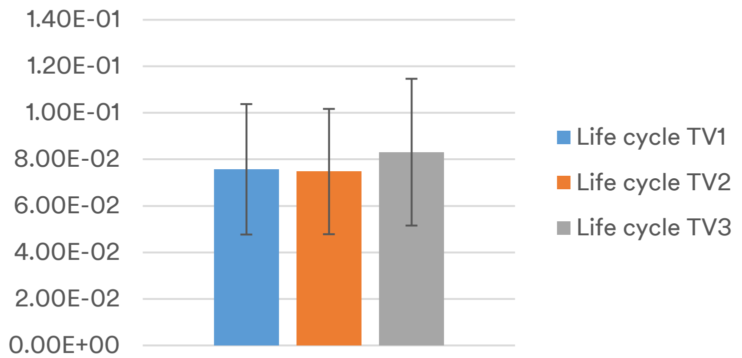

Figure 37 - PEF RDMFR comparison for LCD TVs [kg Sb-eq.]

The figures below provide a graphical representation of the normalised LCIA results provided in tabular form in the section above, and compares the overall environmental impacts of LCD TVs for each of the methodologies' impact indicators. Due to the fact that a number of impact categories apply across different methodologies, an additional visualisation was made, specifically on those impact categories in the different methodologies that have similar effects on the environment (see Table 7 for details on how environmental impacts correspond across methodologies).

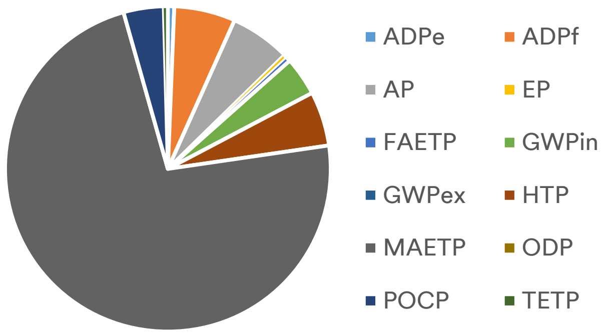

Figure 38 - Normalised environmental impact, CML, TV1

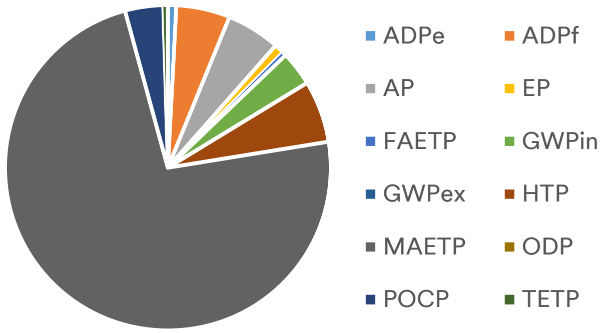

Figure 39 - Normalised environmental impact, CML, TV2

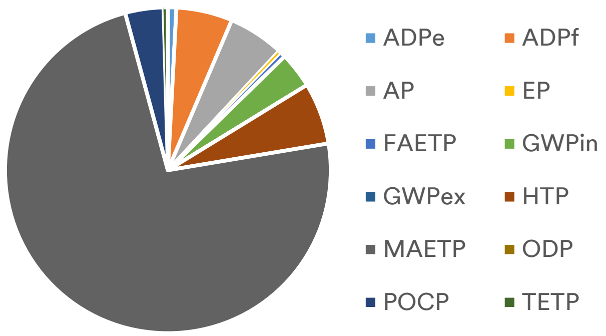

Figure 40 - Normalised environmental impact, CML, TV3

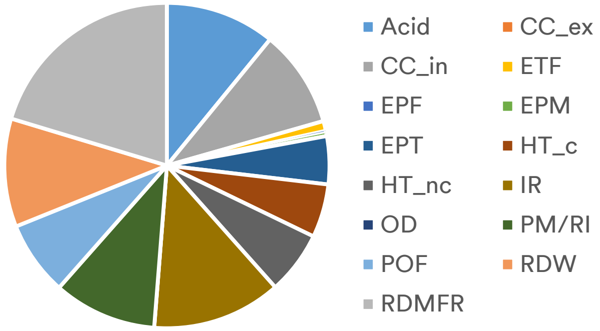

Figure 41 - Normalised environmental impact, PEF, TV1

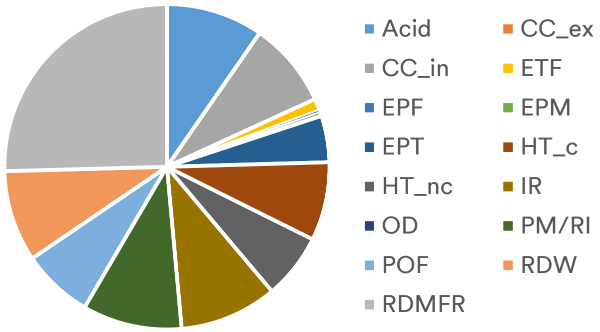

Figure 42 - Normalised environmental impact, PEF, TV2

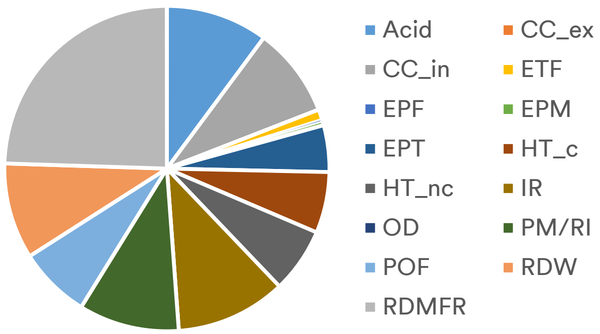

Figure 43 - Normalised environmental impact, PEF, TV3

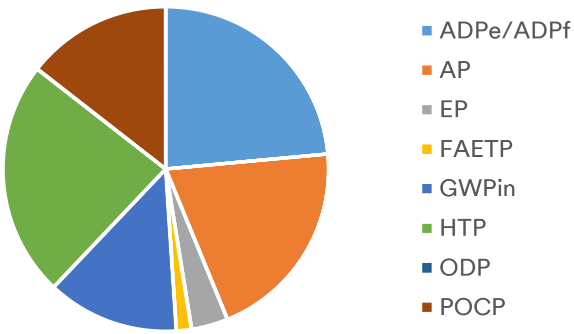

Figure 44 - Normalised environmental impact, comparable, CML, TV2 (same for TV1 and TV3)

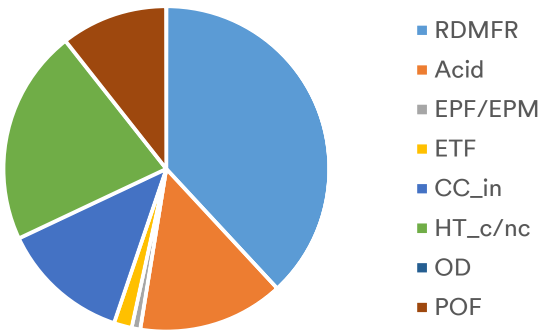

Figure 45 - Normalised environmental impact, comparable, PEF, TV2 (same for TV1 and TV3)

The figures below provide a graphical representation of the LCIA results provided in tabular form in the section above, and compares the environmental impacts of LCD TVs by life cycle stage for each of the methodologies' impact indicators.

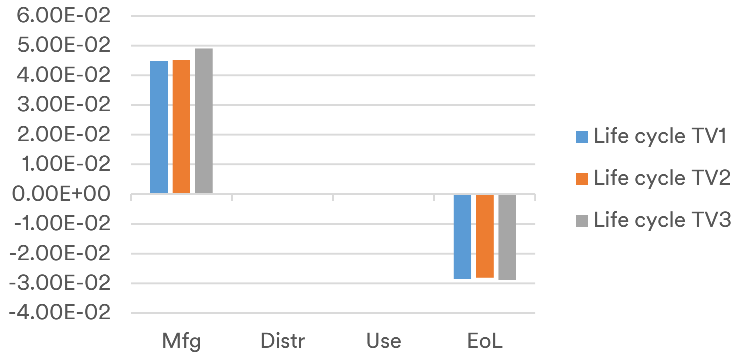

Figure 46 - CML ADPe comparison for LCD TVs by life cycle stage [kg Sb-eq.]

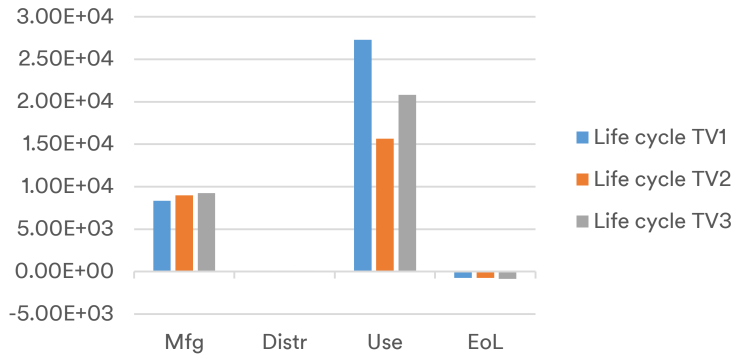

Figure 47 - CML ADPf comparison for LCD TVs by life cycle stage [MJ]

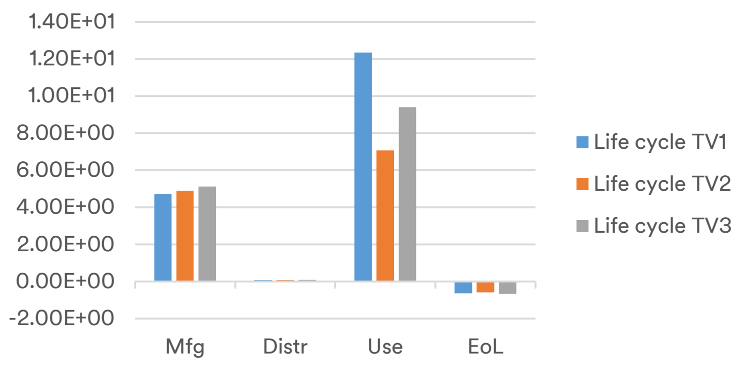

Figure 48 - CML AP comparison for LCD TVs by life cycle stage [kg SO2-eq.]

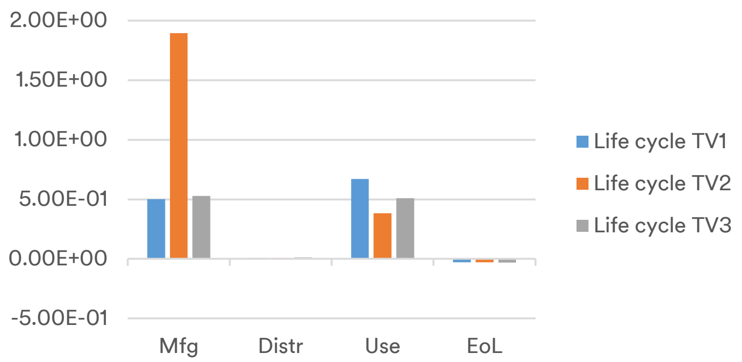

Figure 49 - CML EP comparison for LCD TVs by life cycle stage [kg Phosphate-eq.]

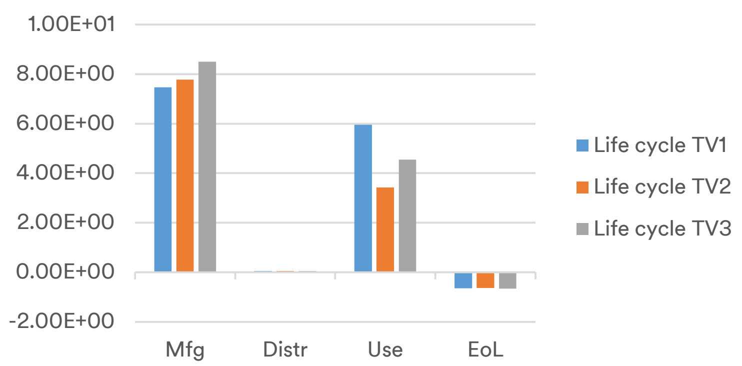

Figure 50 - CML FAETP comparison for LCD TVs by life cycle stage [kg DCB-eq.]

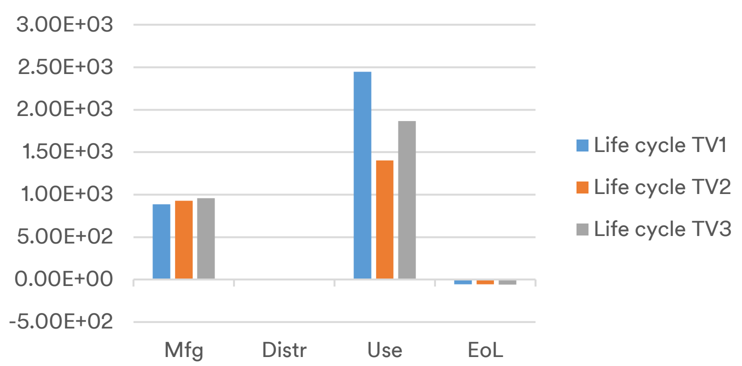

Figure 51 - CML GWPin comparison for LCD TVs by life cycle stage [kg CO2-eq.]

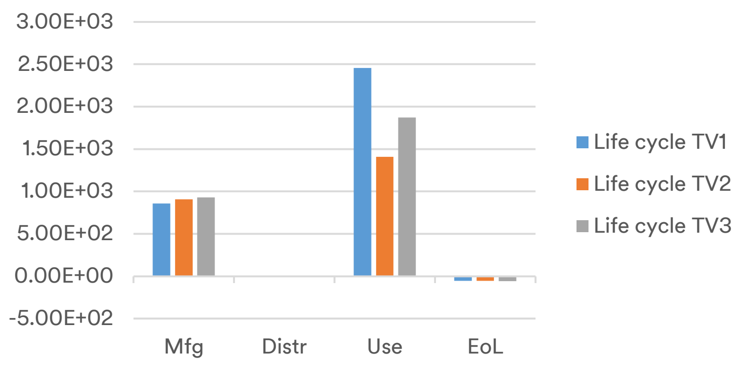

Figure 52 - CML GWPex comparison for LCD TVs by life cycle stage [kg CO2-eq.]

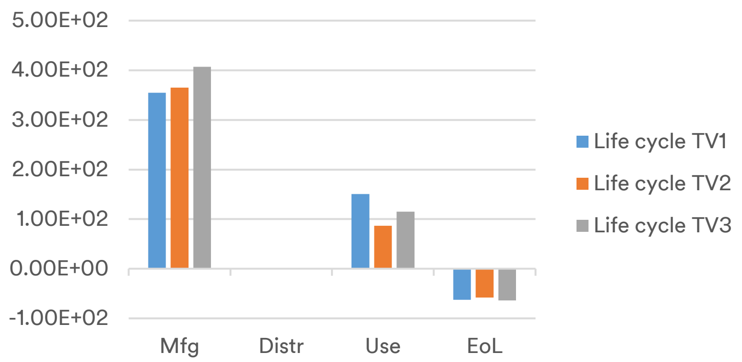

Figure 53 - CML HTP comparison for LCD TVs by life cycle stage [kg DCB-eq.]

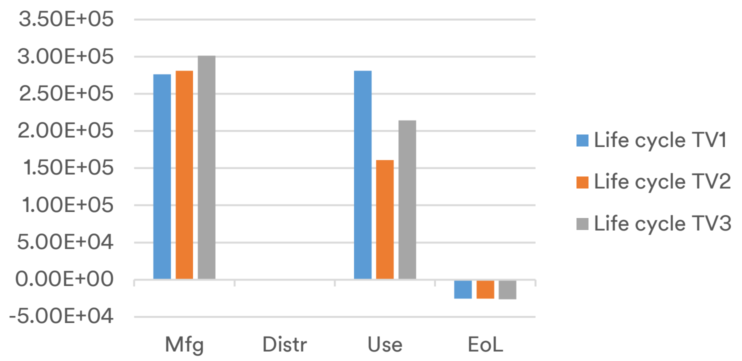

Figure 54 - CML MAETP comparison for LCD TVs by life cycle stage [kg DCB-eq.]

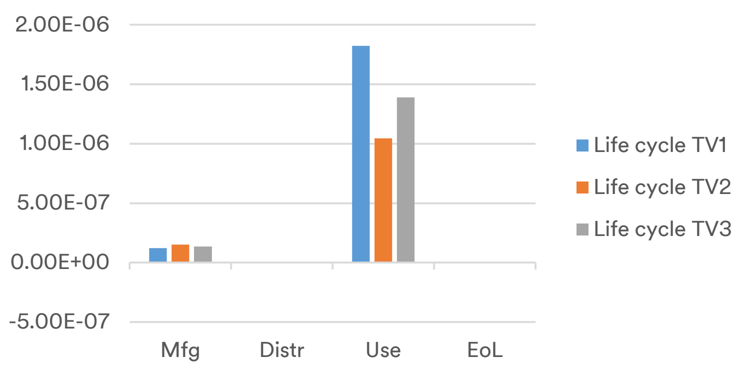

Figure 55 - CML ODP comparison for LCD TVs by life cycle stage [kg R11-eq.]

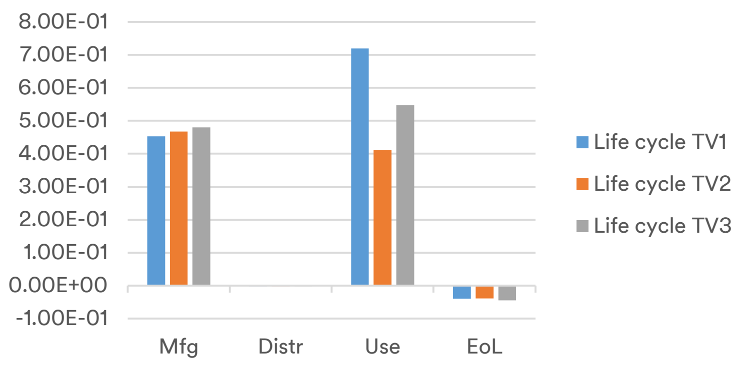

Figure 56 - CML POCP comparison for LCD TVs by life cycle stage [kg Ethene-eq.]

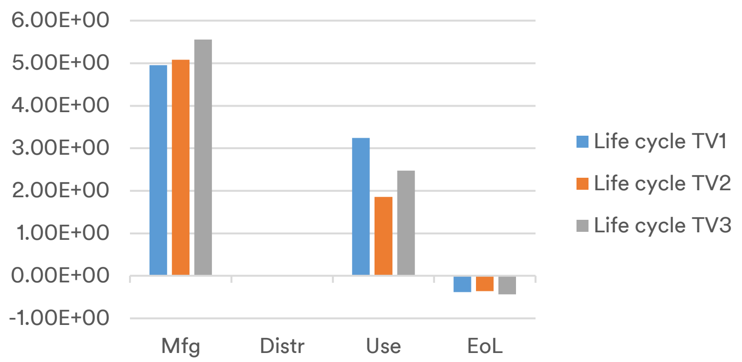

Figure 57 - CML TETP comparison for LCD TVs by life cycle stage [kg DCB-eq.]

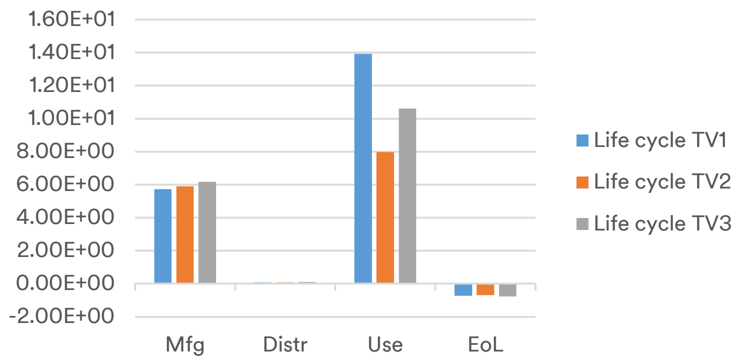

Figure 58 - PEF Acid comparison for LCD TVs by life cycle stage [Mole of H+ eq.]

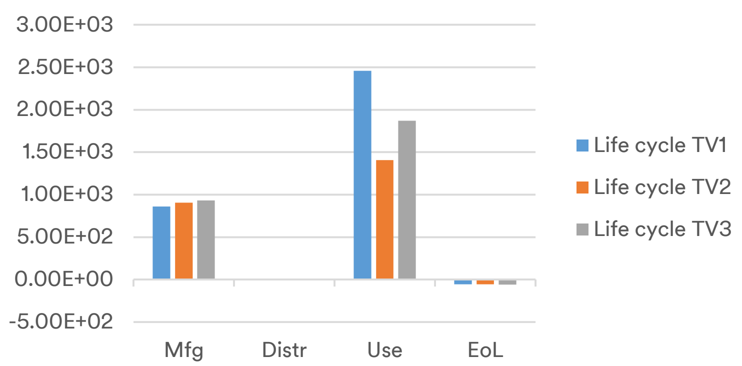

Figure 59 - PEF CC_ex comparison for LCD TVs by life cycle stage [kg CO2-eq.]

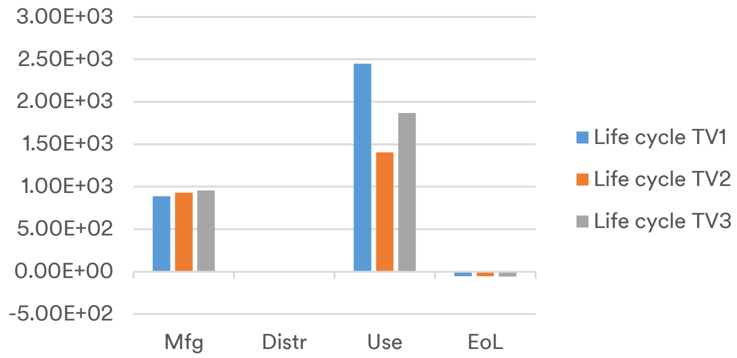

Figure 60 - PEF CC_in comparison for LCD TVs by life cycle stage [kg CO2-eq.]

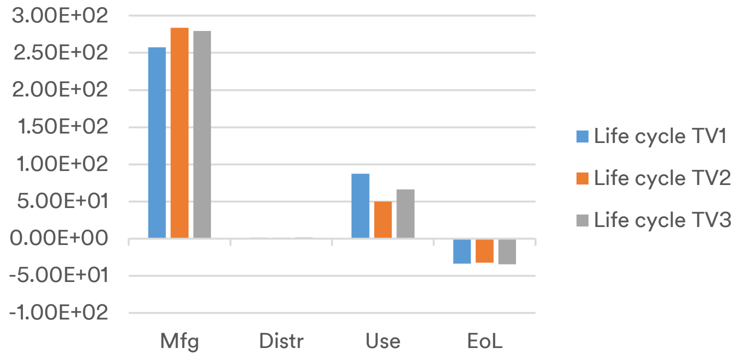

Figure 61 - PEF ETF comparison for LCD TVs by life cycle stage [CTUe]

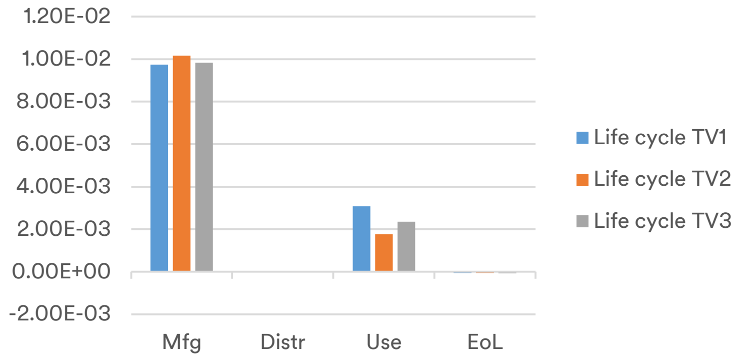

Figure 62 - PEF EPF comparison for LCD TVs by life cycle stage [kg P-eq.]

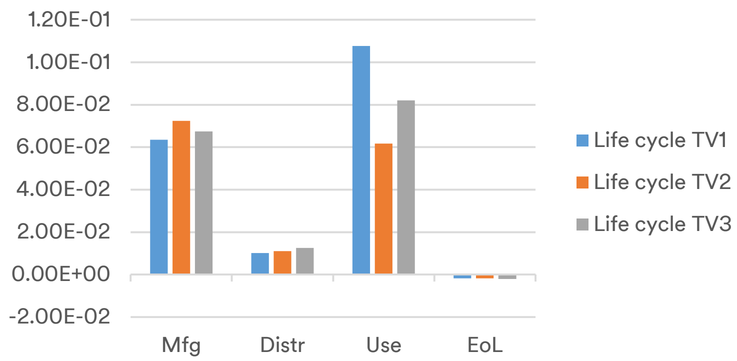

Figure 63 - PEF EPM comparison for LCD TVs by life cycle stage [kg N-eq.]

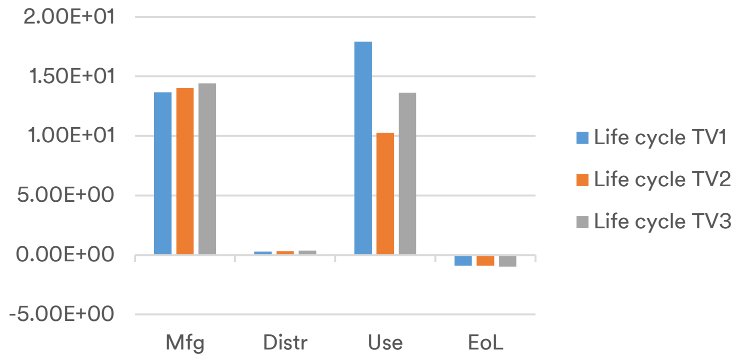

Figure 64 - PEF EPT comparison for LCD TVs by life cycle stage [Mole of N-eq.]

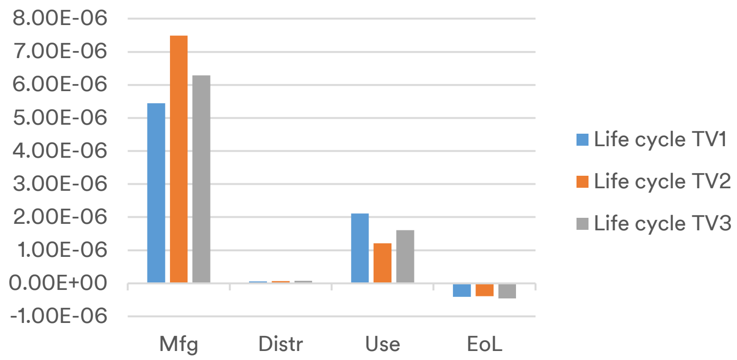

Figure 65 - PEF HT_c comparison for LCD by TVs by life cycle stage [CTUh]

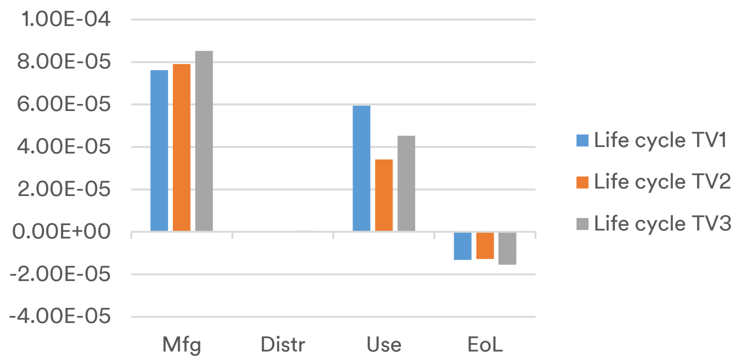

Figure 66 - PEF HT_nc comparison for LCD TVs by life cycle stage [CTUh]

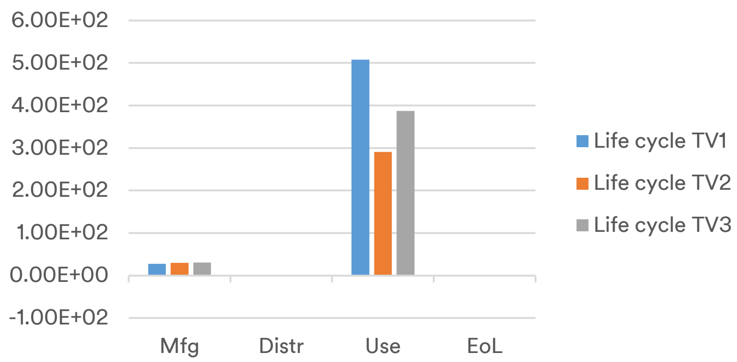

Figure 67 - PEF IR comparison for LCD TVs by life cycle stage [kBq U235-eq.]

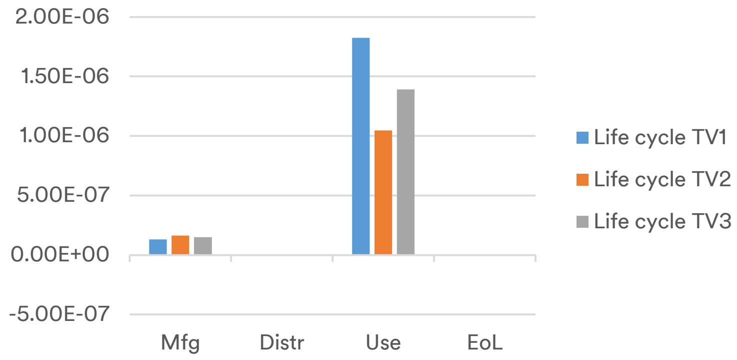

Figure 68 - PEF OD comparison for LCD TVs by life cycle stage [kg R11-eq.]

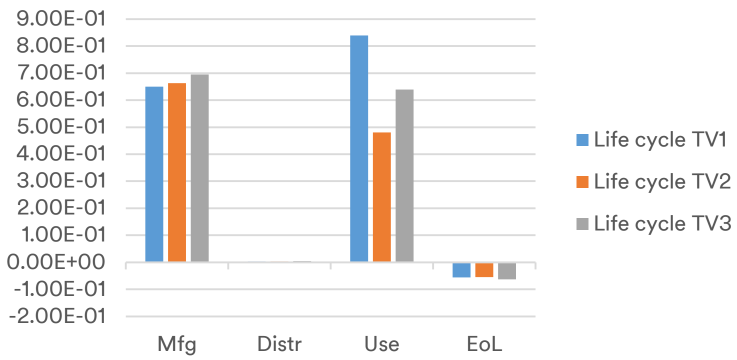

Figure 69 - PEF PM/RI comparison for LCD TVs by life cycle stage [kg PM2,5-eq.]

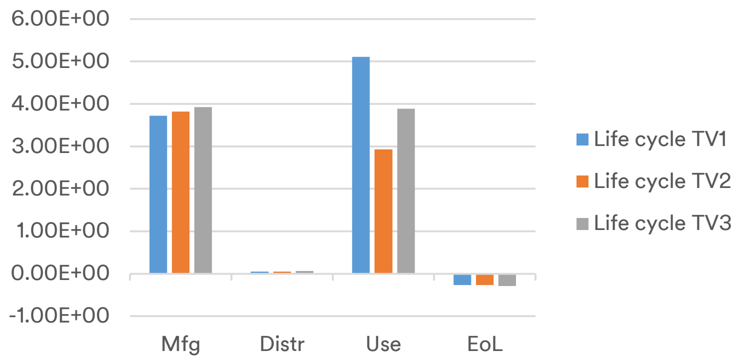

Figure 70 - PEF POF comparison for LCD TVs by life cycle stage [kg NMVOC]

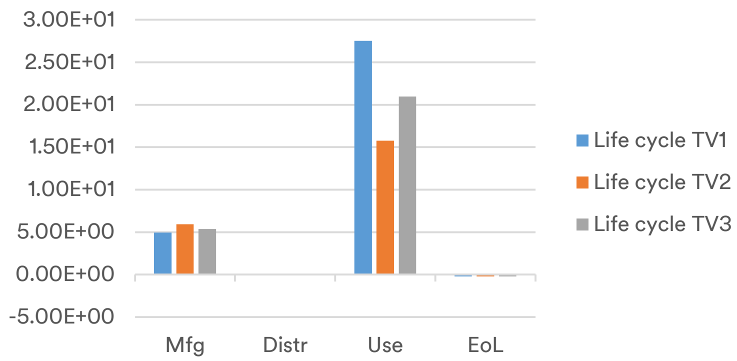

Figure 71 - PEF RDW comparison for LCD TVs by life cycle stage [m³ eq.]

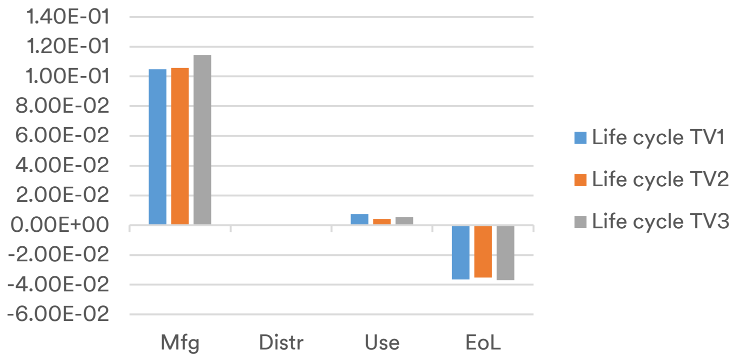

Figure 72 - PEF RDMFR comparison for LCD TVs by life cycle stage [kg Sb-eq.]

6.2 Scenario analysis

The base scenario for the study is defined by the functional unit and reference flow, and is as follows: 65" LCD TV, in operation for 5 hours per day (and on stand-by mode for 19 hours per day), 365 days per year, for a total period of 7 years. To ensure that the environmental impacts are comparable, the luminance of all TVs must be equivalent, and is set to 311 cd/m², whilst the colour gamut is 100% NTSC. The geographical coverage for the study is the European Union (EU-27).
As results may vary significantly in changing conditions, a number of different scenarios are evaluated to assess the robustness of the study, and the relevance and reliability of the results. The scenarios included in this study are:

- The impact of colour gamut: 89% NTSC and 72% NTSC vs. base scenario of 100% NTSC
- The impact of luminance: 100 cd/m² vs. base scenario of 311 cd/m²
- The impact of the electricity grid: a number of country specific grid mixes vs. base scenario of EU-27 grid mix
- The impact of EoL treatment: incineration and landfill vs. base scenario of WEEE treatment
- The impact of a TV's life span: 5 years and 10 years vs. base scenario of 7 years
- The impact of TV2's size: 48" TV vs. base scenario of 65" TV

The sections below describe the different scenarios, and provide LCIA results for the alternative scenarios as compared to the base scenario.

6.2.1 Impact of colour gamut on the environmental impact of LCD TVs

Colour gamut is an important indicator for the quality of imagery displayed by a device. A number of standards are widely used to govern these gamuts for electrical devices, NTSC being one of them. Another one is sRGB, often used for computers. As this standard typically covers 72% of the NTSC colour gamut standard, this is a scenario worthwhile investigating. LCDs for professional use must have a colour gamut of 80-90% of NTSC, therefore, the 89% is another scenario.
Due to the fact that colour gamut does not have an influence on electricity use during the use phase of the LCD TV, the impact of these scenarios will only affect TV1. For TV3, the difference in environmental impact is expected to be limited to the impact of QDEF manufacturing on the life cycle.

6.2.1.1 Colour gamut 89% NTSC

CML2001 indicator	Colour gamut 89% NTSC			Base (100% NTSC)			% Difference vs base		
	Life cycle TV1	Life cycle TV2	Life cycle TV3	Life cycle TV1	Life cycle TV2	Life cycle TV3	TV1	TV2	TV3
ADPe [kg Sb-eq.]	1,66E-02	1,73E-02	2,04E-02	1,67E-02	1,73E-02	2,04E-02	-1%	0%	0%
ADPf [MJ]	2,74E+04	2,39E+04	2,87E+04	3,50E+04	2,39E+04	2,93E+04	-22%	0%	-2%
AP [kg SO2-eq.]	1,31E+01	1,15E+01	1,37E+01	1,65E+01	1,15E+01	1,39E+01	-21%	0%	-2%
EP [kg Phosphate-eq.]	9,66E-01	2,26E+00	1,00E+00	1,15E+00	2,26E+00	1,02E+00	-16%	0%	-1%
FAETP [kg DCB-eq.]	1,12E+01	1,06E+01	1,23E+01	1,28E+01	1,06E+01	1,24E+01	-13%	0%	-1%
GWPin [CO2-eq.]	2,61E+03	2,29E+03	2,72E+03	3,29E+03	2,29E+03	2,77E+03	-21%	0%	-2%
GWPex [CO2-eq.]	2,59E+03	2,26E+03	2,70E+03	3,27E+03	2,26E+03	2,75E+03	-21%	0%	-2%
HTP [kg DCB-eq.]	4,02E+02	3,94E+02	4,56E+02	4,44E+02	3,94E+02	4,59E+02	-9%	0%	-1%
MAETP [kg DCB-eq.]	4,54E+05	4,17E+05	4,83E+05	5,32E+05	4,17E+05	4,89E+05	-15%	0%	-1%
ODP [kg R11-eq.]	1,44E-06	1,20E-06	1,49E-06	1,94E-06	1,20E-06	1,52E-06	-26%	0%	-3%
POCP [kg Ethene-eq.]	9,31E-01	8,38E-01	9,65E-01	1,13E+00	8,38E-01	9,80E-01	-18%	0%	-2%
TETP [kg DCB-eq.]	6,94E+00	6,60E+00	7,55E+00	7,83E+00	6,60E+00	7,62E+00	-11%	0%	-1%

Table 48 - CML indicators for LCD TVs, colour gamut 89% NTSC vs. base scenario

PEF indicator	Colour gamut 89% NTSC			Base (100% NTSC)			% Difference vs base		
	Life cycle TV1	Life cycle TV2	Life cycle TV3	Life cycle TV1	Life cycle TV2	Life cycle TV3	TV1	TV2	TV3
AC [Mole of H+ eq.]	1,52E+01	1,33E+01	1,58E+01	1,90E+01	1,33E+01	1,61E+01	-20%	0%	-2%
CC_ex [CO2-eq.]	2,59E+03	2,27E+03	2,70E+03	3,27E+03	2,27E+03	2,75E+03	-21%	0%	-2%
CC_in [CO2-eq.]	2,61E+03	2,29E+03	2,72E+03	3,29E+03	2,29E+03	2,77E+03	-21%	0%	-2%
ETF [CTUe]	2,89E+02	3,03E+02	3,12E+02	3,13E+02	3,03E+02	3,13E+02	-8%	0%	-1%
EPF [kg P-eq.]	1,19E-02	1,19E-02	1,21E-02	1,28E-02	1,19E-02	1,21E-02	-7%	0%	-1%
EPM [kg N-eq.]	1,50E-01	1,43E-01	1,58E-01	1,80E-01	1,43E-01	1,60E-01	-17%	0%	-1%
EPT [Mole of N-eq.]	2,60E+01	2,37E+01	2,71E+01	3,10E+01	2,37E+01	2,74E+01	-16%	0%	-1%
HT_c [CTUh]	6,63E-06	8,37E-06	7,47E-06	7,21E-06	8,37E-06	7,52E-06	-8%	0%	-1%
HT_nc [CTUh]	1,06E-04	1,01E-04	1,14E-04	1,23E-04	1,01E-04	1,15E-04	-13%	0%	-1%
IR [kBq U235-eq.]	3,94E+02	3,20E+02	4,06E+02	5,34E+02	3,20E+02	4,16E+02	-26%	0%	-3%
OD [kg R11-eq.]	1,45E-06	1,21E-06	1,50E-06	1,95E-06	1,21E-06	1,54E-06	-26%	0%	-2%
PM/RI [kg PM2,5-Eq.]	1,21E+00	1,09E+00	1,26E+00	1,44E+00	1,09E+00	1,28E+00	-16%	0%	-1%
POF [kg NMVOC]	7,20E+00	6,53E+00	7,48E+00	8,61E+00	6,53E+00	7,59E+00	-16%	0%	-1%
RDW [m³ eq.]	2,47E+01	2,15E+01	2,55E+01	3,23E+01	2,15E+01	2,61E+01	-24%	0%	-2%
RDMFR [kg Sb-eq.]	7,36E-02	7,48E-02	8,29E-02	7,57E-02	7,48E-02	8,31E-02	-3%	0%	0%

Table 49 - PEF indicators for LCD TVs, colour gamut 89% NTSC vs. base scenario

6.2.1.2 Colour gamut 72% NTSC

CML2001 indicator	Colour gamut 72% NTSC			Base (100% NTSC)			% Difference vs base		
	Life cycle TV1	Life cycle TV2	Life cycle TV3	Life cycle TV1	Life cycle TV2	Life cycle TV3	TV1	TV2	TV3
ADPe [kg Sb-eq.]	1,65E-02	1,73E-02	2,04E-02	1,67E-02	1,73E-02	2,04E-02	-1%	0%	0%
ADPf [MJ]	2,38E+04	2,39E+04	2,81E+04	3,50E+04	2,39E+04	2,93E+04	-32%	0%	-4%
AP [kg SO2-eq.]	1,14E+01	1,15E+01	1,34E+01	1,65E+01	1,15E+01	1,39E+01	-31%	0%	-4%
EP [kg Phosphate-eq.]	8,76E-01	2,26E+00	9,90E-01	1,15E+00	2,26E+00	1,02E+00	-24%	0%	-3%
FAETP [kg DCB-eq.]	1,04E+01	1,06E+01	1,22E+01	1,28E+01	1,06E+01	1,24E+01	-19%	0%	-2%
GWPin [CO2-eq.]	2,28E+03	2,29E+03	2,67E+03	3,29E+03	2,29E+03	2,77E+03	-31%	0%	-4%
GWPex [CO2-eq.]	2,26E+03	2,26E+03	2,65E+03	3,27E+03	2,26E+03	2,75E+03	-31%	0%	-4%
HTP [kg DCB-eq.]	3,82E+02	3,94E+02	4,52E+02	4,44E+02	3,94E+02	4,59E+02	-14%	0%	-1%
MAETP [kg DCB-eq.]	4,17E+05	4,17E+05	4,78E+05	5,32E+05	4,17E+05	4,89E+05	-22%	0%	-2%
ODP [kg R11-eq.]	1,20E-06	1,20E-06	1,45E-06	1,94E-06	1,20E-06	1,52E-06	-38%	0%	-5%
POCP [kg Ethene-eq.]	8,34E-01	8,38E-01	9,50E-01	1,13E+00	8,38E-01	9,80E-01	-26%	0%	-3%
TETP [kg DCB-eq.]	6,50E+00	6,60E+00	7,48E+00	7,83E+00	6,60E+00	7,62E+00	-17%	0%	-2%

Table 50 - CML indicators for LCD TVs, colour gamut 72% NTSC vs. base scenario

PEF indicator	Colour gamut 72% NTSC			Base (100% NTSC)			% Difference vs base		
	Life cycle TV1	Life cycle TV2	Life cycle TV3	Life cycle TV1	Life cycle TV2	Life cycle TV3	TV1	TV2	TV3
AC [Mole of H+ eq.]	1,33E+01	1,33E+01	1,56E+01	1,90E+01	1,33E+01	1,61E+01	-30%	0%	-4%
CC_ex [CO2-eq.]	2,26E+03	2,27E+03	2,65E+03	3,27E+03	2,27E+03	2,75E+03	-31%	0%	-4%
CC_in [CO2-eq.]	2,28E+03	2,29E+03	2,67E+03	3,29E+03	2,29E+03	2,77E+03	-31%	0%	-4%
ETF [CTUe]	2,77E+02	3,03E+02	3,10E+02	3,13E+02	3,03E+02	3,13E+02	-11%	0%	-1%
EPF [kg P-eq.]	1,15E-02	1,19E-02	1,20E-02	1,28E-02	1,19E-02	1,21E-02	-10%	0%	-1%
EPM [kg N-eq.]	1,36E-01	1,43E-01	1,56E-01	1,80E-01	1,43E-01	1,60E-01	-25%	0%	-3%
EPT [Mole of N-eq.]	2,36E+01	2,37E+01	2,67E+01	3,10E+01	2,37E+01	2,74E+01	-24%	0%	-3%
HT_c [CTUh]	6,35E-06	8,37E-06	7,43E-06	7,21E-06	8,37E-06	7,52E-06	-12%	0%	-1%
HT_nc [CTUh]	9,83E-05	1,01E-04	1,13E-04	1,23E-04	1,01E-04	1,15E-04	-20%	0%	-2%
IR [kBq U235-eq.]	3,26E+02	3,20E+02	3,95E+02	5,34E+02	3,20E+02	4,16E+02	-39%	0%	-5%
OD [kg R11-eq.]	1,21E-06	1,21E-06	1,46E-06	1,95E-06	1,21E-06	1,54E-06	-38%	0%	-5%
PM/RI [kg PM2,5-Eq.]	1,09E+00	1,09E+00	1,24E+00	1,44E+00	1,09E+00	1,28E+00	-24%	0%	-3%
POF [kg NMVOC]	6,52E+00	6,53E+00	7,37E+00	8,61E+00	6,53E+00	7,59E+00	-24%	0%	-3%
RDW [m³ eq.]	2,10E+01	2,15E+01	2,50E+01	3,23E+01	2,15E+01	2,61E+01	-35%	0%	-4%
RDMFR [kg Sb-eq.]	7,27E-02	7,48E-02	8,28E-02	7,57E-02	7,48E-02	8,31E-02	-4%	0%	0%

Table 51 - PEF indicators for LCD TVs, colour gamut 72% NTSC vs. base scenario

6.2.2 Impact of luminance on the environmental impact of LCD TVs

A monitor’s brightness, therefore the amount of light produced, is an important factor to assess the quality of image produced. With QDEF technology specifically designed for optimisation of luminance, it is worthwhile assessing the impact of the application of QDEF on a device with lower luminance.

CML2001 indicator	Luminance 100 cd/m²			Base (311 cd/m²)			% Difference vs base		
	Life cycle TV1	Life cycle TV2	Life cycle TV3	Life cycle TV1	Life cycle TV2	Life cycle TV3	TV1	TV2	TV3
ADPe [kg Sb-eq.]	1,65E-02	1,72E-02	2,03E-02	1,67E-02	1,73E-02	2,04E-02	-1%	-1%	-1%
ADPf [MJ]	2,09E+04	1,78E+04	1,96E+04	3,50E+04	2,39E+04	2,93E+04	-40%	-26%	-33%
AP [kg SO2-eq.]	1,01E+01	8,67E+00	9,58E+00	1,65E+01	1,15E+01	1,39E+01	-39%	-24%	-31%
EP [kg Phosphate-eq.]	8,05E-01	2,11E+00	7,80E-01	1,15E+00	2,26E+00	1,02E+00	-30%	-7%	-23%
FAETP [kg DCB-eq.]	9,76E+00	9,27E+00	1,03E+01	1,28E+01	1,06E+01	1,24E+01	-24%	-13%	-17%
GWPin [CO2-eq.]	2,02E+03	1,73E+03	1,90E+03	3,29E+03	2,29E+03	2,77E+03	-38%	-24%	-31%
GWPex [CO2-eq.]	2,00E+03	1,71E+03	1,88E+03	3,27E+03	2,26E+03	2,75E+03	-39%	-24%	-32%
HTP [kg DCB-eq.]	3,66E+02	3,60E+02	4,05E+02	4,44E+02	3,94E+02	4,59E+02	-18%	-9%	-12%
MAETP [kg DCB-eq.]	3,87E+05	3,53E+05	3,90E+05	5,32E+05	4,17E+05	4,89E+05	-27%	-15%	-20%
ODP [kg R11-eq.]	1,00E-06	7,85E-07	8,78E-07	1,94E-06	1,20E-06	1,52E-06	-48%	-34%	-42%
POCP [kg Ethene-eq.]	7,58E-01	6,76E-01	7,26E-01	1,13E+00	8,38E-01	9,80E-01	-33%	-19%	-26%
TETP [kg DCB-eq.]	6,16E+00	5,87E+00	6,47E+00	7,83E+00	6,60E+00	7,62E+00	-21%	-11%	-15%

Table 52 - CML indicators for LCD TVs, luminance 100 cd/m² vs. base scenario

PEF indicator	Luminance 100 cd/m²			Base (311 cd/m²)			% Difference vs base		
	Life cycle TV1	Life cycle TV2	Life cycle TV3	Life cycle TV1	Life cycle TV2	Life cycle TV3	TV1	TV2	TV3
AC [Mole of H+ eq.]	1,18E+01	1,02E+01	1,12E+01	1,90E+01	1,33E+01	1,61E+01	-38%	-24%	-31%
CC_ex [CO2-eq.]	2,00E+03	1,71E+03	1,88E+03	3,27E+03	2,27E+03	2,75E+03	-39%	-24%	-32%
CC_in [CO2-eq.]	2,02E+03	1,73E+03	1,90E+03	3,29E+03	2,29E+03	2,77E+03	-38%	-24%	-31%
ETF [CTUe]	2,68E+02	2,83E+02	2,83E+02	3,13E+02	3,03E+02	3,13E+02	-14%	-6%	-10%
EPF [kg P-eq.]	1,12E-02	1,12E-02	1,10E-02	1,28E-02	1,19E-02	1,21E-02	-12%	-6%	-9%
EPM [kg N-eq.]	1,24E-01	1,19E-01	1,22E-01	1,80E-01	1,43E-01	1,60E-01	-31%	-17%	-24%
EPT [Mole of N-eq.]	2,17E+01	1,97E+01	2,11E+01	3,10E+01	2,37E+01	2,74E+01	-30%	-17%	-23%
HT_c [CTUh]	6,12E-06	7,90E-06	6,77E-06	7,21E-06	8,37E-06	7,52E-06	-15%	-6%	-10%
HT_nc [CTUh]	9,21E-05	8,73E-05	9,44E-05	1,23E-04	1,01E-04	1,15E-04	-25%	-13%	-18%
IR [kBq U235-eq.]	2,73E+02	2,05E+02	2,37E+02	5,34E+02	3,20E+02	4,16E+02	-49%	-36%	-43%
OD [kg R11-eq.]	1,01E-06	7,97E-07	8,93E-07	1,95E-06	1,21E-06	1,54E-06	-48%	-34%	-42%
PM/RI [kg PM2,5-Eq.]	1,00E+00	9,03E-01	9,79E-01	1,44E+00	1,09E+00	1,28E+00	-30%	-17%	-23%
POF [kg NMVOC]	5,98E+00	5,38E+00	5,78E+00	8,61E+00	6,53E+00	7,59E+00	-31%	-18%	-24%
RDW [m³ eq.]	1,81E+01	1,53E+01	1,64E+01	3,23E+01	2,15E+01	2,61E+01	-44%	-29%	-37%
RDMFR [kg Sb-eq.]	7,19E-02	7,31E-02	8,05E-02	7,57E-02	7,48E-02	8,31E-02	-5%	-2%	-3%

Table 53 - PEF indicators for LCD TVs, luminance 100 cd/m² vs. base scenario

6.2.3 Impact of luminance and colour gamut on the environmental impact of LCD TVs

6.2.3.1 Colour gamut 89% NTSC, luminance 100 cd/m²

CML2001 indicator	Colour gamut 89% NTSC Luminance 100 cd/m²			Base (100% NTSC, 311 cd/m²)			% Difference vs base		
	Life cycle TV1	Life cycle TV2	Life cycle TV3	Life cycle TV1	Life cycle TV2	Life cycle TV3	TV1	TV2	TV3
ADPe [kg Sb-eq.]	2,03E-02	1,72E-02	1,64E-02	1,67E-02	1,73E-02	2,04E-02	21%	-1%	-20%
ADPf [MJ]	1,94E+04	1,78E+04	1,85E+04	3,50E+04	2,39E+04	2,93E+04	-44%	-26%	-37%
AP [kg SO2-eq.]	9,50E+00	8,67E+00	9,04E+00	1,65E+01	1,15E+01	1,39E+01	-42%	-24%	-35%
EP [kg Phosphate-eq.]	7,76E-01	2,11E+00	7,46E-01	1,15E+00	2,26E+00	1,02E+00	-33%	-7%	-27%
FAETP [kg DCB-eq.]	1,03E+01	9,27E+00	9,23E+00	1,28E+01	1,06E+01	1,24E+01	-20%	-13%	-26%
GWPin [CO2-eq.]	1,89E+03	1,73E+03	1,81E+03	3,29E+03	2,29E+03	2,77E+03	-43%	-24%	-35%
GWPex [CO2-eq.]	1,86E+03	1,71E+03	1,78E+03	3,27E+03	2,26E+03	2,75E+03	-43%	-24%	-35%
HTP [kg DCB-eq.]	4,04E+02	3,60E+02	3,53E+02	4,44E+02	3,94E+02	4,59E+02	-9%	-9%	-23%
MAETP [kg DCB-eq.]	3,88E+05	3,53E+05	3,62E+05	5,32E+05	4,17E+05	4,89E+05	-27%	-15%	-26%
ODP [kg R11-eq.]	8,66E-07	7,85E-07	8,42E-07	1,94E-06	1,20E-06	1,52E-06	-55%	-34%	-45%
POCP [kg Ethene-eq.]	7,21E-01	6,76E-01	6,95E-01	1,13E+00	8,38E-01	9,80E-01	-36%	-19%	-29%
TETP [kg DCB-eq.]	6,45E+00	5,87E+00	5,87E+00	7,83E+00	6,60E+00	7,62E+00	-18%	-11%	-23%

Table 54 - CML indicators for LCD TVs, 89% NTSC and luminance 100 cd/m² vs. base scenario

PEF indicator	Colour gamut 89% NTSC Luminance 100 cd/m²			Base (100% NTSC, 311 cd/m²)			% Difference vs base		
	Life cycle TV1	Life cycle TV2	Life cycle TV3	Life cycle TV1	Life cycle TV2	Life cycle TV3	TV1	TV2	TV3
AC [Mole of H+ eq.]	1,11E+01	1,02E+01	1,06E+01	1,90E+01	1,33E+01	1,61E+01	-42%	-24%	-34%
CC_ex [CO2-eq.]	1,86E+03	1,71E+03	1,78E+03	3,27E+03	2,27E+03	2,75E+03	-43%	-24%	-35%
CC_in [CO2-eq.]	1,89E+03	1,73E+03	1,81E+03	3,29E+03	2,29E+03	2,77E+03	-43%	-24%	-35%
ETF [CTUe]	2,82E+02	2,83E+02	2,60E+02	3,13E+02	3,03E+02	3,13E+02	-10%	-6%	-17%
EPF [kg P-eq.]	1,10E-02	1,12E-02	1,09E-02	1,28E-02	1,19E-02	1,21E-02	-14%	-6%	-10%
EPM [kg N-eq.]	1,21E-01	1,19E-01	1,15E-01	1,80E-01	1,43E-01	1,60E-01	-33%	-17%	-28%
EPT [Mole of N-eq.]	2,10E+01	1,97E+01	2,02E+01	3,10E+01	2,37E+01	2,74E+01	-32%	-17%	-27%
HT_c [CTUh]	6,76E-06	7,90E-06	5,94E-06	7,21E-06	8,37E-06	7,52E-06	-6%	-6%	-21%
HT_nc [CTUh]	9,40E-05	8,73E-05	8,68E-05	1,23E-04	1,01E-04	1,15E-04	-23%	-13%	-25%
IR [kBq U235-eq.]	2,33E+02	2,05E+02	2,28E+02	5,34E+02	3,20E+02	4,16E+02	-56%	-36%	-45%
OD [kg R11-eq.]	8,81E-07	7,97E-07	8,53E-07	1,95E-06	1,21E-06	1,54E-06	-55%	-34%	-45%
PM/RI [kg PM2,5-Eq.]	9,73E-01	9,03E-01	9,30E-01	1,44E+00	1,09E+00	1,28E+00	-32%	-17%	-27%
POF [kg NMVOC]	5,75E+00	5,38E+00	5,53E+00	8,61E+00	6,53E+00	7,59E+00	-33%	-18%	-27%
RDW [m³ eq.]	1,62E+01	1,53E+01	1,56E+01	3,23E+01	2,15E+01	2,61E+01	-50%	-29%	-40%
RDMFR [kg Sb-eq.]	8,04E-02	7,31E-02	7,12E-02	7,57E-02	7,48E-02	8,31E-02	6%	-2%	-14%

Table 55 - PEF indicators for LCD TVs, 89% NTSC and luminance 100 cd/m² vs. base scenario

6.2.3.2 Colour gamut 72% NTSC, luminance 100 cd/m²

CML2001 indicator	Colour gamut 72% NTSC Luminance 100 cd/m²			Base (100% NTSC, 311 cd/m²)			% Difference vs base		
	Life cycle TV1	Life cycle TV2	Life cycle TV3	Life cycle TV1	Life cycle TV2	Life cycle TV3	TV1	TV2	TV3
ADPe [kg Sb-eq.]	1,64E-02	1,72E-02	2,03E-02	1,67E-02	1,73E-02	2,04E-02	-2%	-1%	-1%
ADPf [MJ]	1,73E+04	1,78E+04	1,93E+04	3,50E+04	2,39E+04	2,93E+04	-51%	-26%	-34%
AP [kg SO2-eq.]	8,51E+00	8,67E+00	9,42E+00	1,65E+01	1,15E+01	1,39E+01	-48%	-24%	-32%
EP [kg Phosphate-eq.]	7,17E-01	2,11E+00	7,71E-01	1,15E+00	2,26E+00	1,02E+00	-38%	-7%	-24%
FAETP [kg DCB-eq.]	8,98E+00	9,27E+00	1,02E+01	1,28E+01	1,06E+01	1,24E+01	-30%	-13%	-18%
GWPin [CO2-eq.]	1,70E+03	1,73E+03	1,87E+03	3,29E+03	2,29E+03	2,77E+03	-48%	-24%	-32%
GWPex [CO2-eq.]	1,68E+03	1,71E+03	1,85E+03	3,27E+03	2,26E+03	2,75E+03	-49%	-24%	-33%
HTTP [kg DCB-eq.]	3,46E+02	3,60E+02	4,03E+02	4,44E+02	3,94E+02	4,59E+02	-22%	-9%	-12%
MAETP [kg DCB-eq.]	3,50E+05	3,53E+05	3,86E+05	5,32E+05	4,17E+05	4,89E+05	-34%	-15%	-21%
ODP [kg R11-eq.]	7,63E-07	7,85E-07	8,54E-07	1,94E-06	1,20E-06	1,52E-06	-61%	-34%	-44%
POCP [kg Ethene-eq.]	6,64E-01	6,76E-01	7,16E-01	1,13E+00	8,38E-01	9,80E-01	-41%	-19%	-27%
TETP [kg DCB-eq.]	5,73E+00	5,87E+00	6,43E+00	7,83E+00	6,60E+00	7,62E+00	-27%	-11%	-16%

Table 56 - CML indicators for LCD TVs, 72% NTSC and luminance 100 cd/m² vs. base scenario

PEF indicator	Colour gamut 72% NTSC Luminance 100 cd/m²			Base (100% NTSC, 311 cd/m²)			% Difference vs base		
	Life cycle TV1	Life cycle TV2	Life cycle TV3	Life cycle TV1	Life cycle TV2	Life cycle TV3	TV1	TV2	TV3
AC [Mole of H+ eq.]	1,00E+01	1,02E+01	1,10E+01	1,90E+01	1,33E+01	1,61E+01	-47%	-24%	-32%
CC_ex [CO2-eq.]	1,68E+03	1,71E+03	1,85E+03	3,27E+03	2,27E+03	2,75E+03	-49%	-24%	-33%
CC_in [CO2-eq.]	1,70E+03	1,73E+03	1,87E+03	3,29E+03	2,29E+03	2,77E+03	-48%	-24%	-32%
ETF [CTUe]	2,56E+02	2,83E+02	2,81E+02	3,13E+02	3,03E+02	3,13E+02	-18%	-6%	-10%
EPF [kg P-eq.]	1,08E-02	1,12E-02	1,10E-02	1,28E-02	1,19E-02	1,21E-02	-16%	-6%	-9%
EPM [kg N-eq.]	1,10E-01	1,19E-01	1,21E-01	1,80E-01	1,43E-01	1,60E-01	-39%	-17%	-25%
EPT [Mole of N-eq.]	1,94E+01	1,97E+01	2,09E+01	3,10E+01	2,37E+01	2,74E+01	-37%	-17%	-24%
HT_c [CTUh]	5,84E-06	7,90E-06	6,74E-06	7,21E-06	8,37E-06	7,52E-06	-19%	-6%	-10%
HT_nc [CTUh]	8,42E-05	8,73E-05	9,37E-05	1,23E-04	1,01E-04	1,15E-04	-31%	-13%	-19%
IR [kBq U235-eq.]	2,06E+02	2,05E+02	2,30E+02	5,34E+02	3,20E+02	4,16E+02	-61%	-36%	-45%
OD [kg R11-eq.]	7,74E-07	7,97E-07	8,69E-07	1,95E-06	1,21E-06	1,54E-06	-60%	-34%	-44%
PM/RI [kg PM2,5-Eq.]	8,94E-01	9,03E-01	9,68E-01	1,44E+00	1,09E+00	1,28E+00	-38%	-17%	-24%
POF [kg NMVOC]	5,31E+00	5,38E+00	5,71E+00	8,61E+00	6,53E+00	7,59E+00	-38%	-18%	-25%
RDW [m³ eq.]	1,45E+01	1,53E+01	1,60E+01	3,23E+01	2,15E+01	2,61E+01	-55%	-29%	-39%
RDMFR [kg Sb-eq.]	7,09E-02	7,31E-02	8,04E-02	7,57E-02	7,48E-02	8,31E-02	-6%	-2%	-3%

Table 57 - PEF indicators for LCD TVs, 72% NTSC and luminance 100 cd/m² vs. base scenario

6.2.4 Impact of energy grid mix on the environmental impact of LCD TVs

The geographical coverage of the study is the European Union. As a result, the electricity grid mix selected for the electricity required in the LCD TV's use phase is the European average.

A number of different scenarios were considered, typically scenarios that are largely different from the EU average, in order to evaluate whether different conclusions would have to be drawn if an electricity grid mix more specific than the EU-27 was to be selected. The scenarios evaluated are:

- Germany, France, UK and Italy, as the largest contributors to the EU-27 grid mix
- Sweden, due to the high amount of hydropower
- Malta, due to the sole source of electricity being heavy fuel oil
- Poland, due to the high amount of coal plants
- Bulgaria, due to high lignite dependency

6.2.4.1 German electricity grid mix

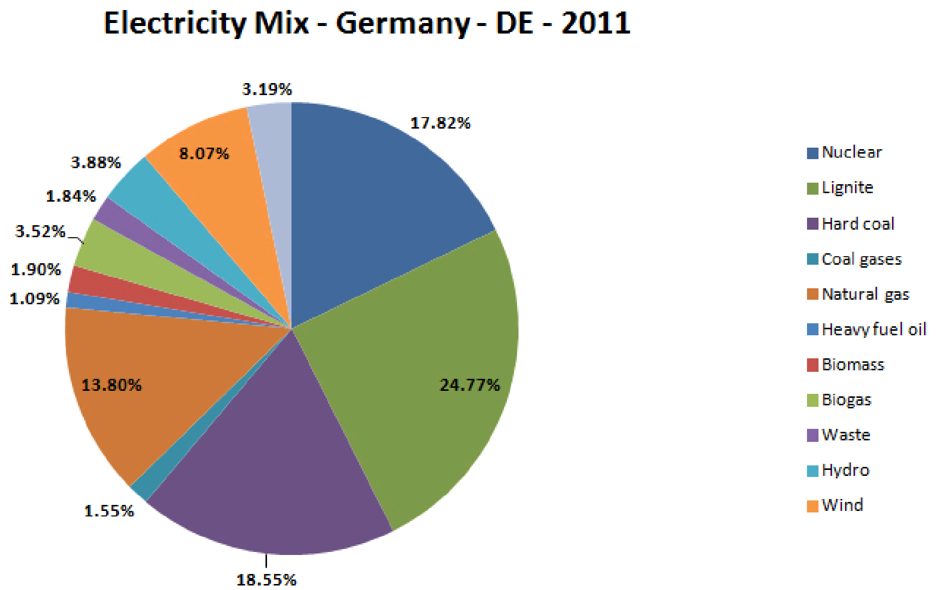

Figure 73 - German electricity grid mix, by electricity source

CML2001 indicator	German[2] grid mix for use			Base (EU-27 grid mix)			% Difference vs base		
	Life cycle TV1	Life cycle TV2	Life cycle TV3	Life cycle TV1	Life cycle TV2	Life cycle TV3	TV1	TV2	TV3
ADPe [kg Sb-eq.]	1,71E-02	1,75E-02	2,07E-02	1,67E-02	1,73E-02	2,04E-02	2%	1%	1%
ADPf [MJ]	3,96E+04	2,66E+04	3,28E+04	3,50E+04	2,39E+04	2,93E+04	13%	11%	12%
AP [kg SO2-eq.]	9,35E+00	7,36E+00	8,50E+00	1,65E+01	1,15E+01	1,39E+01	-43%	-36%	-39%
EP [kg Phosphate-eq.]	1,16E+00	2,26E+00	1,02E+00	1,15E+00	2,26E+00	1,02E+00	1%	0%	1%
FAETP [kg DCB-eq.]	1,13E+01	9,76E+00	1,13E+01	1,28E+01	1,06E+01	1,24E+01	-12%	-8%	-9%
GWPin [CO2-eq.]	4,00E+03	2,70E+03	3,32E+03	3,29E+03	2,29E+03	2,77E+03	22%	18%	20%
GWPex [CO2-eq.]	4,00E+03	2,68E+03	3,31E+03	3,27E+03	2,26E+03	2,75E+03	22%	19%	20%
HTP [kg DCB-eq.]	4,16E+02	3,78E+02	4,38E+02	4,44E+02	3,94E+02	4,59E+02	-6%	-4%	-5%
MAETP [kg DCB-eq.]	6,02E+05	4,57E+05	5,43E+05	5,32E+05	4,17E+05	4,89E+05	13%	10%	11%
ODP [kg R11-eq.]	4,36E-07	3,33E-07	3,75E-07	1,94E-06	1,20E-06	1,52E-06	-78%	-72%	-75%
POCP [kg Ethene-eq.]	7,99E-01	6,50E-01	7,29E-01	1,13E+00	8,38E-01	9,80E-01	-29%	-23%	-26%
TETP [kg DCB-eq.]	8,57E+00	7,03E+00	8,18E+00	7,83E+00	6,60E+00	7,62E+00	9%	6%	7%

Table 58 - CML indicators for LCD TVs, German grid mix vs. base scenario

PEF indicator	German grid mix for use			Base (EU-27 grid mix)			% Difference vs base		
	Life cycle TV1	Life cycle TV2	Life cycle TV3	Life cycle TV1	Life cycle TV2	Life cycle TV3	TV1	TV2	TV3
AC [Mole of H+ eq.]	1,13E+01	8,88E+00	1,03E+01	1,90E+01	1,33E+01	1,61E+01	-41%	-33%	-36%
CC_ex [CO2-eq.]	4,00E+03	2,69E+03	3,31E+03	3,27E+03	2,27E+03	2,75E+03	22%	19%	20%
CC_in [CO2-eq.]	4,00E+03	2,70E+03	3,32E+03	3,29E+03	2,29E+03	2,77E+03	22%	18%	20%
ETF [CTUe]	3,37E+02	3,17E+02	3,32E+02	3,13E+02	3,03E+02	3,13E+02	8%	5%	6%
EPF [kg P-eq.]	1,58E-02	1,36E-02	1,44E-02	1,28E-02	1,19E-02	1,21E-02	24%	15%	19%
EPM [kg N-eq.]	2,63E-01	1,91E-01	2,23E-01	1,80E-01	1,43E-01	1,60E-01	46%	33%	39%
EPT [Mole of N-eq.]	2,82E+01	2,21E+01	2,53E+01	3,10E+01	2,37E+01	2,74E+01	-9%	-7%	-8%
HT_c [CTUh]	7,35E-06	8,45E-06	7,62E-06	7,21E-06	8,37E-06	7,52E-06	2%	1%	1%
HT_nc [CTUh]	1,48E-04	1,15E-04	1,34E-04	1,23E-04	1,01E-04	1,15E-04	20%	14%	16%
IR [kBq U235-eq.]	3,84E+02	2,34E+02	3,02E+02	5,34E+02	3,20E+02	4,16E+02	-28%	-27%	-28%
OD [kg R11-eq.]	4,47E-07	3,44E-07	3,90E-07	1,95E-06	1,21E-06	1,54E-06	-77%	-71%	-75%
PM/RI [kg PM2,5-Eq.]	8,96E-01	7,82E-01	8,63E-01	1,44E+00	1,09E+00	1,28E+00	-38%	-28%	-32%
POF [kg NMVOC]	7,35E+00	5,81E+00	6,63E+00	8,61E+00	6,53E+00	7,59E+00	-15%	-11%	-13%
RDW [m³ eq.]	3,97E+01	2,58E+01	3,18E+01	3,23E+01	2,15E+01	2,61E+01	23%	20%	22%
RDMFR [kg Sb-eq.]	7,52E-02	7,45E-02	8,27E-02	7,57E-02	7,48E-02	8,31E-02	-1%	0%	0%

Table 59 - PEF indicators for LCD TVs, German grid mix vs. base scenario

[2] Note that due to German policy to phase out nuclear energy, the 2011 grid mix may not be fully representative anymore.

6.2.4.2 French electricity grid mix

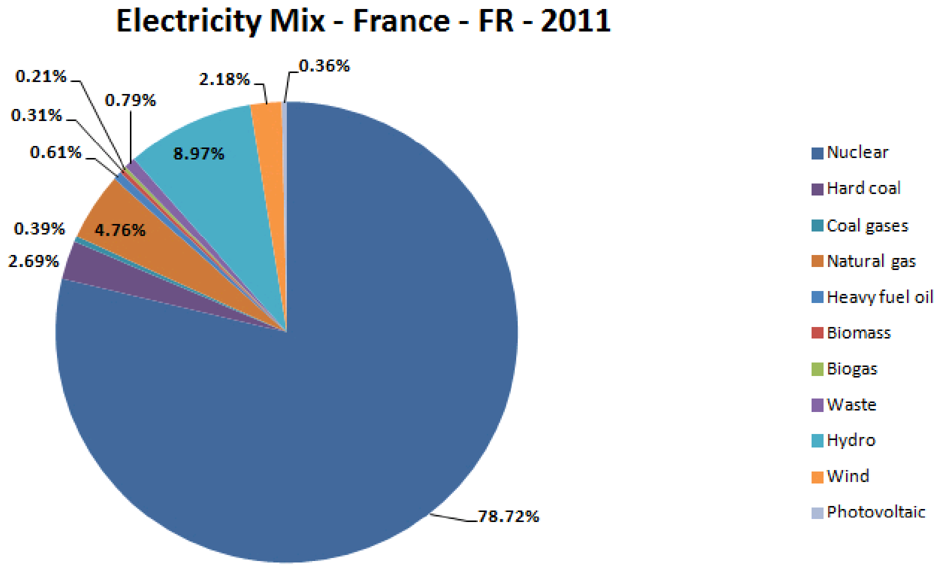

Figure 74 - French electricity grid mix, by electricity source

CML2001 indicator	French grid mix for use			Base (EU-27 grid mix)			% Difference vs base		
	Life cycle TV1	Life cycle TV2	Life cycle TV3	Life cycle TV1	Life cycle TV2	Life cycle TV3	TV1	TV2	TV3
ADPe [kg Sb-eq.]	1,66E-02	1,72E-02	2,04E-02	1,67E-02	1,73E-02	2,04E-02	-1%	0%	0%
ADPf [MJ]	1,38E+04	1,18E+04	1,31E+04	3,50E+04	2,39E+04	2,93E+04	-61%	-51%	-55%
AP [kg SO2-eq.]	5,67E+00	5,25E+00	5,70E+00	1,65E+01	1,15E+01	1,39E+01	-66%	-54%	-59%
EP [kg Phosphate-eq.]	6,42E-01	1,97E+00	6,30E-01	1,15E+00	2,26E+00	1,02E+00	-44%	-13%	-38%
FAETP [kg DCB-eq.]	1,44E+01	1,15E+01	1,36E+01	1,28E+01	1,06E+01	1,24E+01	12%	8%	10%
GWPin [CO2-eq.]	1,33E+03	1,16E+03	1,28E+03	3,29E+03	2,29E+03	2,77E+03	-60%	-49%	-54%
GWPex [CO2-eq.]	1,30E+03	1,14E+03	1,25E+03	3,27E+03	2,26E+03	2,75E+03	-60%	-50%	-54%
HTP [kg DCB-eq.]	3,42E+02	3,36E+02	3,81E+02	4,44E+02	3,94E+02	4,59E+02	-23%	-15%	-17%
MAETP [kg DCB-eq.]	3,14E+05	2,92E+05	3,23E+05	5,32E+05	4,17E+05	4,89E+05	-41%	-30%	-34%
ODP [kg R11-eq.]	8,42E-06	4,91E-06	6,46E-06	1,94E-06	1,20E-06	1,52E-06	333%	310%	324%
POCP [kg Ethene-eq.]	5,30E-01	4,95E-01	5,24E-01	1,13E+00	8,38E-01	9,80E-01	-53%	-41%	-47%
TETP [kg DCB-eq.]	5,10E+00	5,03E+00	5,53E+00	7,83E+00	6,60E+00	7,62E+00	-35%	-24%	-27%

Table 60 - CML indicators for LCD TVs, French grid mix vs. base scenario

PEF indicator	French grid mix for use			Base (EU-27 grid mix)			% Difference vs base		
	Life cycle TV1	Life cycle TV2	Life cycle TV3	Life cycle TV1	Life cycle TV2	Life cycle TV3	TV1	TV2	TV3
AC [Mole of H+ eq.]	6,90E+00	6,35E+00	6,90E+00	1,90E+01	1,33E+01	1,61E+01	-64%	-52%	-57%
CC_ex [CO2-eq.]	1,30E+03	1,14E+03	1,25E+03	3,27E+03	2,27E+03	2,75E+03	-60%	-50%	-54%
CC_in [CO2-eq.]	1,33E+03	1,16E+03	1,28E+03	3,29E+03	2,29E+03	2,77E+03	-60%	-49%	-54%
ETF [CTUe]	2,60E+02	2,73E+02	2,73E+02	3,13E+02	3,03E+02	3,13E+02	-17%	-10%	-13%
EPF [kg P-eq.]	1,05E-02	1,06E-02	1,04E-02	1,28E-02	1,19E-02	1,21E-02	-17%	-11%	-14%
EPM [kg N-eq.]	1,30E-01	1,15E-01	1,22E-01	1,80E-01	1,43E-01	1,60E-01	-28%	-20%	-24%
EPT [Mole of N-eq.]	1,71E+01	1,57E+01	1,69E+01	3,10E+01	2,37E+01	2,74E+01	-45%	-34%	-39%
HT_c [CTUh]	5,77E-06	7,55E-06	6,42E-06	7,21E-06	8,37E-06	7,52E-06	-20%	-10%	-15%
HT_nc [CTUh]	7,39E-05	7,28E-05	7,83E-05	1,23E-04	1,01E-04	1,15E-04	-40%	-28%	-32%
IR [kBq U235-eq.]	1,36E+03	7,94E+02	1,05E+03	5,34E+02	3,20E+02	4,16E+02	155%	148%	151%
OD [kg R11-eq.]	8,43E-06	4,92E-06	6,47E-06	1,95E-06	1,21E-06	1,54E-06	331%	307%	321%
PM/RI [kg PM2,5-Eq.]	6,94E-01	6,66E-01	7,10E-01	1,44E+00	1,09E+00	1,28E+00	-52%	-39%	-44%
POF [kg NMVOC]	4,60E+00	4,23E+00	4,53E+00	8,61E+00	6,53E+00	7,59E+00	-47%	-35%	-40%
RDW [m³ eq.]	2,85E+01	1,94E+01	2,33E+01	3,23E+01	2,15E+01	2,61E+01	-12%	-10%	-11%
RDMFR [kg Sb-eq.]	8,50E-02	8,01E-02	9,02E-02	7,57E-02	7,48E-02	8,31E-02	12%	7%	9%

Table 61 - PEF indicators for LCD TVs, French grid mix vs. base scenario

6.2.4.3 UK electricity grid mix

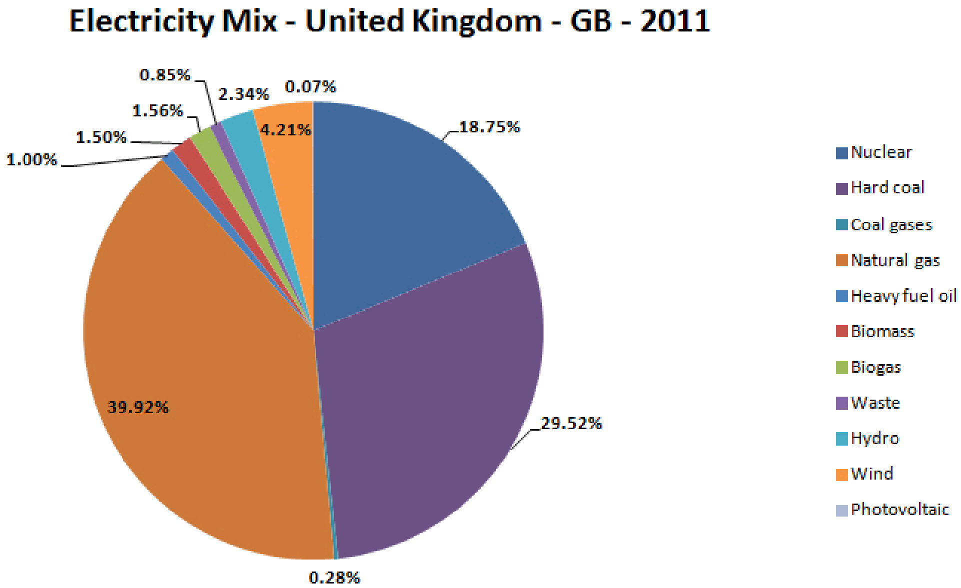

Figure 75 - UK electricity grid mix, by electricity source

CML2001 indicator	UK grid mix for use			Base (EU-27 grid mix)			% Difference vs base		
	Life cycle TV1	Life cycle TV2	Life cycle TV3	Life cycle TV1	Life cycle TV2	Life cycle TV3	TV1	TV2	TV3
ADPe [kg Sb-eq.]	1,64E-02	1,71E-02	2,02E-02	1,67E-02	1,73E-02	2,04E-02	-2%	-1%	-1%
ADPf [MJ]	4,32E+04	2,86E+04	3,55E+04	3,50E+04	2,39E+04	2,93E+04	23%	20%	21%
AP [kg SO2-eq.]	1,44E+01	1,03E+01	1,24E+01	1,65E+01	1,15E+01	1,39E+01	-12%	-10%	-11%
EP [kg Phosphate-eq.]	1,35E+00	2,37E+00	1,17E+00	1,15E+00	2,26E+00	1,02E+00	17%	5%	15%
FAETP [kg DCB-eq.]	1,06E+01	9,32E+00	1,07E+01	1,28E+01	1,06E+01	1,24E+01	-18%	-12%	-14%
GWPin [CO2-eq.]	3,68E+03	2,51E+03	3,07E+03	3,29E+03	2,29E+03	2,77E+03	12%	10%	11%
GWPex [CO2-eq.]	3,65E+03	2,48E+03	3,04E+03	3,27E+03	2,26E+03	2,75E+03	12%	10%	11%
HTP [kg DCB-eq.]	4,25E+02	3,83E+02	4,44E+02	4,44E+02	3,94E+02	4,59E+02	-4%	-3%	-3%
MAETP [kg DCB-eq.]	4,14E+05	3,49E+05	3,99E+05	5,32E+05	4,17E+05	4,89E+05	-22%	-16%	-18%
ODP [kg R11-eq.]	2,76E-07	2,41E-07	2,52E-07	1,94E-06	1,20E-06	1,52E-06	-86%	-80%	-83%
POCP [kg Ethene-eq.]	1,01E+00	7,72E-01	8,92E-01	1,13E+00	8,38E-01	9,80E-01	-10%	-8%	-9%
TETP [kg DCB-eq.]	6,92E+00	6,08E+00	6,92E+00	7,83E+00	6,60E+00	7,62E+00	-12%	-8%	-9%

Table 62 - CML indicators for LCD TVs, UK grid mix vs. base scenario

PEF indicator	UK grid mix for use			Base (EU-27 grid mix)			% Difference vs base		
	Life cycle TV1	Life cycle TV2	Life cycle TV3	Life cycle TV1	Life cycle TV2	Life cycle TV3	TV1	TV2	TV3
AC [Mole of H+ eq.]	1,63E+01	1,17E+01	1,41E+01	1,90E+01	1,33E+01	1,61E+01	-14%	-12%	-13%
CC_ex [CO2-eq.]	3,66E+03	2,49E+03	3,05E+03	3,27E+03	2,27E+03	2,75E+03	12%	10%	11%
CC_in [CO2-eq.]	3,69E+03	2,52E+03	3,08E+03	3,29E+03	2,29E+03	2,77E+03	12%	10%	11%
ETF [CTUe]	2,76E+02	2,82E+02	2,86E+02	3,13E+02	3,03E+02	3,13E+02	-12%	-7%	-9%
EPF [kg P-eq.]	1,10E-02	1,09E-02	1,08E-02	1,28E-02	1,19E-02	1,21E-02	-14%	-8%	-11%
EPM [kg N-eq.]	1,16E-01	1,07E-01	1,11E-01	1,80E-01	1,43E-01	1,60E-01	-36%	-26%	-30%
EPT [Mole of N-eq.]	4,00E+01	2,89E+01	3,43E+01	3,10E+01	2,37E+01	2,74E+01	29%	22%	25%
HT_c [CTUh]	6,90E-06	8,19E-06	7,28E-06	7,21E-06	8,37E-06	7,52E-06	-4%	-2%	-3%
HT_nc [CTUh]	1,19E-04	9,86E-05	1,13E-04	1,23E-04	1,01E-04	1,15E-04	-3%	-2%	-3%
IR [kBq U235-eq.]	4,09E+02	2,48E+02	3,21E+02	5,34E+02	3,20E+02	4,16E+02	-24%	-23%	-23%
OD [kg R11-eq.]	2,86E-07	2,52E-07	2,67E-07	1,95E-06	1,21E-06	1,54E-06	-85%	-79%	-83%
PM/RI [kg PM2,5-Eq.]	1,09E+00	8,93E-01	1,01E+00	1,44E+00	1,09E+00	1,28E+00	-24%	-18%	-21%
POF [kg NMVOC]	1,05E+01	7,63E+00	9,04E+00	8,61E+00	6,53E+00	7,59E+00	22%	17%	19%
RDW [m³ eq.]	9,21E+00	8,29E+00	8,54E+00	3,23E+01	2,15E+01	2,61E+01	-71%	-61%	-67%
RDMFR [kg Sb-eq.]	7,28E-02	7,31E-02	8,09E-02	7,57E-02	7,48E-02	8,31E-02	-4%	-2%	-3%

Table 63 - PEF indicators for LCD TVs, UK grid mix vs. base scenario

6.2.4.4 Italian electricity grid mix

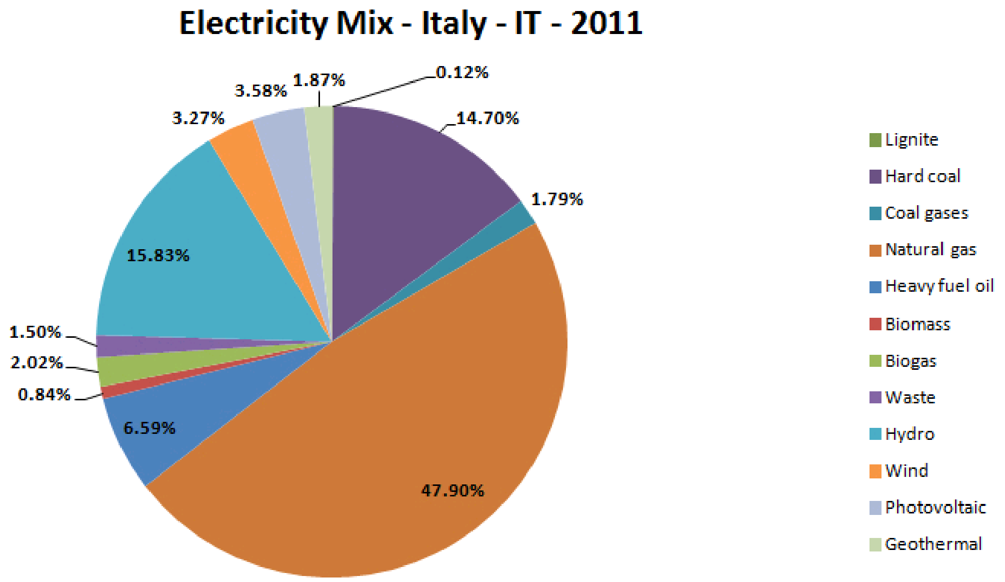

Figure 76 - Italian electricity grid mix, by electricity source

CML2001 indicator	Italian grid mix for use			Base (EU-27 grid mix)			% Difference vs base		
	Life cycle TV1	Life cycle TV2	Life cycle TV3	Life cycle TV1	Life cycle TV2	Life cycle TV3	TV1	TV2	TV3
ADPe [kg Sb-eq.]	1,70E-02	1,74E-02	2,06E-02	1,67E-02	1,73E-02	2,04E-02	2%	1%	1%
ADPf [MJ]	4,17E+04	2,78E+04	3,44E+04	3,50E+04	2,39E+04	2,93E+04	19%	16%	18%
AP [kg SO2-eq.]	1,08E+01	8,20E+00	9,62E+00	1,65E+01	1,15E+01	1,39E+01	-34%	-28%	-31%
EP [kg Phosphate-eq.]	1,03E+00	2,19E+00	9,22E-01	1,15E+00	2,26E+00	1,02E+00	-11%	-3%	-9%
FAETP [kg DCB-eq.]	1,20E+01	1,01E+01	1,18E+01	1,28E+01	1,06E+01	1,24E+01	-7%	-5%	-5%
GWPin [CO2-eq.]	3,48E+03	2,40E+03	2,92E+03	3,29E+03	2,29E+03	2,77E+03	6%	5%	5%
GWPex [CO2-eq.]	3,47E+03	2,38E+03	2,90E+03	3,27E+03	2,26E+03	2,75E+03	6%	5%	6%
HTP [kg DCB-eq.]	4,00E+02	3,69E+02	4,25E+02	4,44E+02	3,94E+02	4,59E+02	-10%	-6%	-7%
MAETP [kg DCB-eq.]	4,03E+05	3,43E+05	3,91E+05	5,32E+05	4,17E+05	4,89E+05	-24%	-18%	-20%
ODP [kg R11-eq.]	6,81E-07	4,73E-07	5,61E-07	1,94E-06	1,20E-06	1,52E-06	-65%	-60%	-63%
POCP [kg Ethene-eq.]	9,59E-01	7,41E-01	8,50E-01	1,13E+00	8,38E-01	9,80E-01	-15%	-12%	-13%
TETP [kg DCB-eq.]	7,20E+00	6,24E+00	7,13E+00	7,83E+00	6,60E+00	7,62E+00	-8%	-6%	-6%

Table 64 - CML indicators for LCD TVs, Italian grid mix vs. base scenario

PEF indicator	Italian grid mix for use			Base (EU-27 grid mix)			% Difference vs base		
	Life cycle TV1	Life cycle TV2	Life cycle TV3	Life cycle TV1	Life cycle TV2	Life cycle TV3	TV1	TV2	TV3
AC [Mole of H+ eq.]	1,21E+01	9,32E+00	1,08E+01	1,90E+01	1,33E+01	1,61E+01	-36%	-30%	-33%
CC_ex [CO2-eq.]	3,47E+03	2,38E+03	2,90E+03	3,27E+03	2,27E+03	2,75E+03	6%	5%	6%
CC_in [CO2-eq.]	3,48E+03	2,40E+03	2,92E+03	3,29E+03	2,29E+03	2,77E+03	6%	5%	5%
ETF [CTUe]	3,16E+02	3,05E+02	3,16E+02	3,13E+02	3,03E+02	3,13E+02	1%	1%	1%
EPF [kg P-eq.]	1,35E-02	1,23E-02	1,27E-02	1,28E-02	1,19E-02	1,21E-02	6%	4%	5%
EPM [kg N-eq.]	1,75E-01	1,41E-01	1,56E-01	1,80E-01	1,43E-01	1,60E-01	-3%	-2%	-2%
EPT [Mole of N-eq.]	2,76E+01	2,18E+01	2,49E+01	3,10E+01	2,37E+01	2,74E+01	-11%	-8%	-9%
HT_c [CTUh]	7,86E-06	8,75E-06	8,01E-06	7,21E-06	8,37E-06	7,52E-06	9%	4%	7%
HT_nc [CTUh]	1,01E-04	8,83E-05	9,89E-05	1,23E-04	1,01E-04	1,15E-04	-18%	-12%	-14%
IR [kBq U235-eq.]	1,52E+02	1,01E+02	1,25E+02	5,34E+02	3,20E+02	4,16E+02	-72%	-68%	-70%
OD [kg R11-eq.]	6,92E-07	4,85E-07	5,76E-07	1,95E-06	1,21E-06	1,54E-06	-65%	-60%	-63%
PM/RI [kg PM2,5-Eq.]	9,21E-01	7,96E-01	8,83E-01	1,44E+00	1,09E+00	1,28E+00	-36%	-27%	-31%
POF [kg NMVOC]	7,61E+00	5,96E+00	6,82E+00	8,61E+00	6,53E+00	7,59E+00	-12%	-9%	-10%
RDW [m³ eq.]	2,66E+01	1,83E+01	2,18E+01	3,23E+01	2,15E+01	2,61E+01	-17%	-15%	-16%
RDMFR [kg Sb-eq.]	7,23E-02	7,28E-02	8,06E-02	7,57E-02	7,48E-02	8,31E-02	-4%	-3%	-3%

Table 65 - PEF indicators for LCD TVs, Italian grid mix vs. base scenario

6.2.4.5 Swedish electricity grid mix

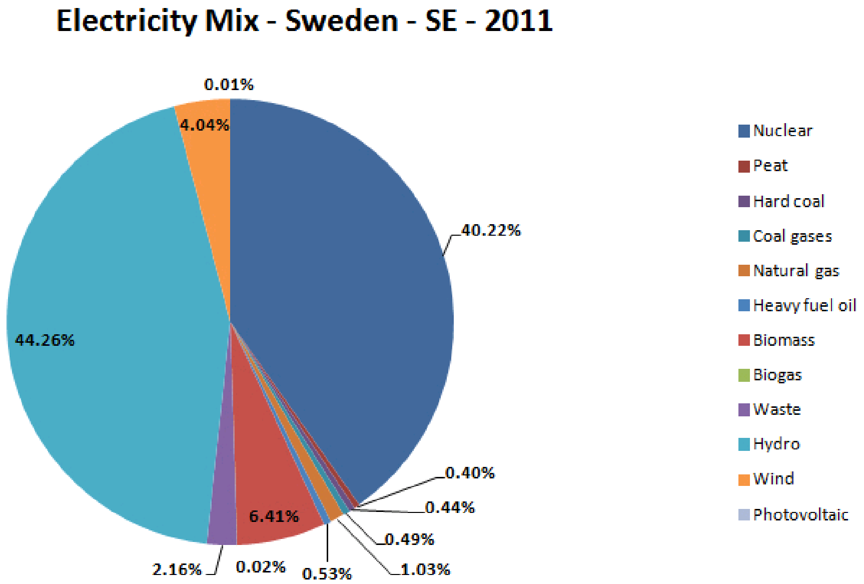

Figure 77 - Swedish electricity grid mix, by electricity source

CML2001 indicator	Swedish grid mix for use			Base (EU-27 grid mix)			% Difference vs base		
	Life cycle TV1	Life cycle TV2	Life cycle TV3	Life cycle TV1	Life cycle TV2	Life cycle TV3	TV1	TV2	TV3
ADPe [kg Sb-eq.]	1,67E-02	1,73E-02	2,04E-02	1,67E-02	1,73E-02	2,04E-02	0%	0%	0%
ADPf [MJ]	1,04E+04	9,89E+03	1,06E+04	3,50E+04	2,39E+04	2,93E+04	-70%	-59%	-64%
AP [kg SO2-eq.]	5,26E+00	5,02E+00	5,39E+00	1,65E+01	1,15E+01	1,39E+01	-68%	-56%	-61%
EP [kg Phosphate-eq.]	6,57E-01	1,98E+00	6,41E-01	1,15E+00	2,26E+00	1,02E+00	-43%	-13%	-37%
FAETP [kg DCB-eq.]	1,19E+01	1,01E+01	1,17E+01	1,28E+01	1,06E+01	1,24E+01	-8%	-5%	-6%
GWPin [CO2-eq.]	1,18E+03	1,08E+03	1,17E+03	3,29E+03	2,29E+03	2,77E+03	-64%	-53%	-58%
GWPex [CO2-eq.]	1,15E+03	1,05E+03	1,14E+03	3,27E+03	2,26E+03	2,75E+03	-65%	-53%	-59%
HTP [kg DCB-eq.]	3,33E+02	3,31E+02	3,74E+02	4,44E+02	3,94E+02	4,59E+02	-25%	-16%	-18%
MAETP [kg DCB-eq.]	5,06E+05	4,02E+05	4,69E+05	5,32E+05	4,17E+05	4,89E+05	-5%	-4%	-4%
ODP [kg R11-eq.]	1,38E-07	1,62E-07	1,48E-07	1,94E-06	1,20E-06	1,52E-06	-93%	-86%	-90%
POCP [kg Ethene-eq.]	5,43E-01	5,02E-01	5,34E-01	1,13E+00	8,38E-01	9,80E-01	-52%	-40%	-46%
TETP [kg DCB-eq.]	5,72E+00	5,39E+00	6,00E+00	7,83E+00	6,60E+00	7,62E+00	-27%	-18%	-21%

Table 66 - CML indicators for LCD TVs, Swedish grid mix vs. base scenario

PEF indicator	Swedish grid mix for use			Base (EU-27 grid mix)			% Difference vs base		
	Life cycle TV1	Life cycle TV2	Life cycle TV3	Life cycle TV1	Life cycle TV2	Life cycle TV3	TV1	TV2	TV3
AC [Mole of H+ eq.]	6,25E+00	5,98E+00	6,41E+00	1,90E+01	1,33E+01	1,61E+01	-67%	-55%	-60%
CC_ex [CO2-eq.]	1,16E+03	1,05E+03	1,14E+03	3,27E+03	2,27E+03	2,75E+03	-65%	-53%	-59%
CC_in [CO2-eq.]	1,18E+03	1,08E+03	1,17E+03	3,29E+03	2,29E+03	2,77E+03	-64%	-53%	-58%
ETF [CTUe]	2,59E+02	2,72E+02	2,72E+02	3,13E+02	3,03E+02	3,13E+02	-17%	-10%	-13%
EPF [kg P-eq.]	1,36E-02	1,24E-02	1,28E-02	1,28E-02	1,19E-02	1,21E-02	7%	4%	5%
EPM [kg N-eq.]	2,07E-01	1,59E-01	1,81E-01	1,80E-01	1,43E-01	1,60E-01	15%	11%	13%
EPT [Mole of N-eq.]	1,64E+01	1,54E+01	1,64E+01	3,10E+01	2,37E+01	2,74E+01	-47%	-35%	-40%
HT_c [CTUh]	5,54E-06	7,42E-06	6,24E-06	7,21E-06	8,37E-06	7,52E-06	-23%	-11%	-17%
HT_nc [CTUh]	8,37E-05	7,84E-05	8,58E-05	1,23E-04	1,01E-04	1,15E-04	-32%	-22%	-26%
IR [kBq U235-eq.]	8,88E+02	5,23E+02	6,86E+02	5,34E+02	3,20E+02	4,16E+02	66%	63%	65%
OD [kg R11-eq.]	1,49E-07	1,74E-07	1,63E-07	1,95E-06	1,21E-06	1,54E-06	-92%	-86%	-89%
PM/RI [kg PM2,5-Eq.]	6,47E-01	6,39E-01	6,74E-01	1,44E+00	1,09E+00	1,28E+00	-55%	-41%	-47%
POF [kg NMVOC]	4,36E+00	4,10E+00	4,35E+00	8,61E+00	6,53E+00	7,59E+00	-49%	-37%	-43%
RDW [m³ eq.]	1,16E+01	9,66E+00	1,04E+01	3,23E+01	2,15E+01	2,61E+01	-64%	-55%	-60%
RDMFR [kg Sb-eq.]	7,65E-02	7,52E-02	8,37E-02	7,57E-02	7,48E-02	8,31E-02	1%	1%	1%

Table 67 - PEF indicators for LCD TVs, Swedish grid mix vs. base scenario

6.2.4.6 Maltese electricity grid mix

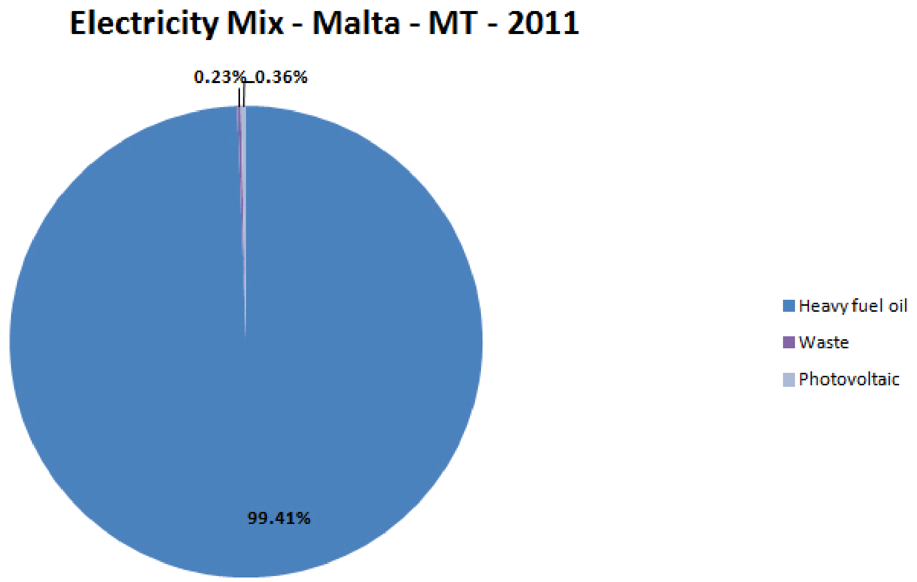

Figure 78 - Maltese electricity grid mix, by electricity source

CML2001 indicator	Maltese grid mix for use			Base (EU-27 grid mix)			% Difference vs base		
	Life cycle TV1	Life cycle TV2	Life cycle TV3	Life cycle TV1	Life cycle TV2	Life cycle TV3	TV1	TV2	TV3
ADPe [kg Sb-eq.]	1,65E-02	1,72E-02	2,03E-02	1,67E-02	1,73E-02	2,04E-02	-1%	-1%	-1%
ADPf [MJ]	8,43E+04	5,22E+04	6,69E+04	3,50E+04	2,39E+04	2,93E+04	141%	118%	128%
AP [kg SO2-eq.]	5,43E+01	3,31E+01	4,28E+01	1,65E+01	1,15E+01	1,39E+01	229%	189%	207%
EP [kg Phosphate-eq.]	2,65E+00	3,12E+00	2,16E+00	1,15E+00	2,26E+00	1,02E+00	130%	38%	112%
FAETP [kg DCB-eq.]	6,39E+01	3,99E+01	5,13E+01	1,28E+01	1,06E+01	1,24E+01	398%	276%	313%
GWPin [CO2-eq.]	6,94E+03	4,38E+03	5,56E+03	3,29E+03	2,29E+03	2,77E+03	111%	92%	101%
GWPex [CO2-eq.]	6,92E+03	4,36E+03	5,53E+03	3,27E+03	2,26E+03	2,75E+03	112%	92%	101%
HTP [kg DCB-eq.]	9,42E+02	6,80E+02	8,39E+02	4,44E+02	3,94E+02	4,59E+02	112%	73%	83%
MAETP [kg DCB-eq.]	5,54E+05	4,29E+05	5,06E+05	5,32E+05	4,17E+05	4,89E+05	4%	3%	3%
ODP [kg R11-eq.]	1,30E-07	1,57E-07	1,42E-07	1,94E-06	1,20E-06	1,52E-06	-93%	-87%	-91%
POCP [kg Ethene-eq.]	3,16E+00	2,00E+00	2,53E+00	1,13E+00	8,38E-01	9,80E-01	180%	139%	158%
TETP [kg DCB-eq.]	1,85E+01	1,27E+01	1,58E+01	7,83E+00	6,60E+00	7,62E+00	136%	93%	107%

Table 68 - CML indicators for LCD TVs, Maltese grid mix vs. base scenario

PEF indicator	Maltese grid mix for use			Base (EU-27 grid mix)			% Difference vs base		
	Life cycle TV1	Life cycle TV2	Life cycle TV3	Life cycle TV1	Life cycle TV2	Life cycle TV3	TV1	TV2	TV3
AC [Mole of H+ eq.]	6,30E+01	3,85E+01	4,97E+01	1,90E+01	1,33E+01	1,61E+01	231%	190%	208%
CC_ex [CO2-eq.]	6,92E+03	4,36E+03	5,53E+03	3,27E+03	2,27E+03	2,75E+03	112%	92%	101%
CC_in [CO2-eq.]	6,94E+03	4,38E+03	5,56E+03	3,29E+03	2,29E+03	2,77E+03	111%	92%	101%
ETF [CTUe]	9,45E+02	6,65E+02	7,95E+02	3,13E+02	3,03E+02	3,13E+02	202%	120%	154%
EPF [kg P-eq.]	1,09E-02	1,08E-02	1,07E-02	1,28E-02	1,19E-02	1,21E-02	-15%	-9%	-12%
EPM [kg N-eq.]	1,02E-01	9,87E-02	1,01E-01	1,80E-01	1,43E-01	1,60E-01	-43%	-31%	-37%
EPT [Mole of N-eq.]	8,25E+01	5,32E+01	6,67E+01	3,10E+01	2,37E+01	2,74E+01	166%	125%	143%
HT_c [CTUh]	4,05E-05	2,75E-05	3,29E-05	7,21E-06	8,37E-06	7,52E-06	462%	228%	338%
HT_nc [CTUh]	2,08E-04	1,50E-04	1,80E-04	1,23E-04	1,01E-04	1,15E-04	69%	48%	56%
IR [kBq U235-eq.]	3,04E+01	3,11E+01	3,25E+01	5,34E+02	3,20E+02	4,16E+02	-94%	-90%	-92%
OD [kg R11-eq.]	1,41E-07	1,69E-07	1,57E-07	1,95E-06	1,21E-06	1,54E-06	-93%	-86%	-90%
PM/RI [kg PM2,5-Eq.]	3,63E+00	2,35E+00	2,94E+00	1,44E+00	1,09E+00	1,28E+00	152%	115%	131%
POF [kg NMVOC]	2,38E+01	1,53E+01	1,92E+01	8,61E+00	6,53E+00	7,59E+00	177%	134%	153%
RDW [m³ eq.]	6,45E+00	6,71E+00	6,43E+00	3,23E+01	2,15E+01	2,61E+01	-80%	-69%	-75%
RDMFR [kg Sb-eq.]	6,96E-02	7,13E-02	7,85E-02	7,57E-02	7,48E-02	8,31E-02	-8%	-5%	-6%

Table 69 - PEF indicators for LCD TVs, Maltese grid mix vs. base scenario

6.2.4.7 Polish electricity grid mix

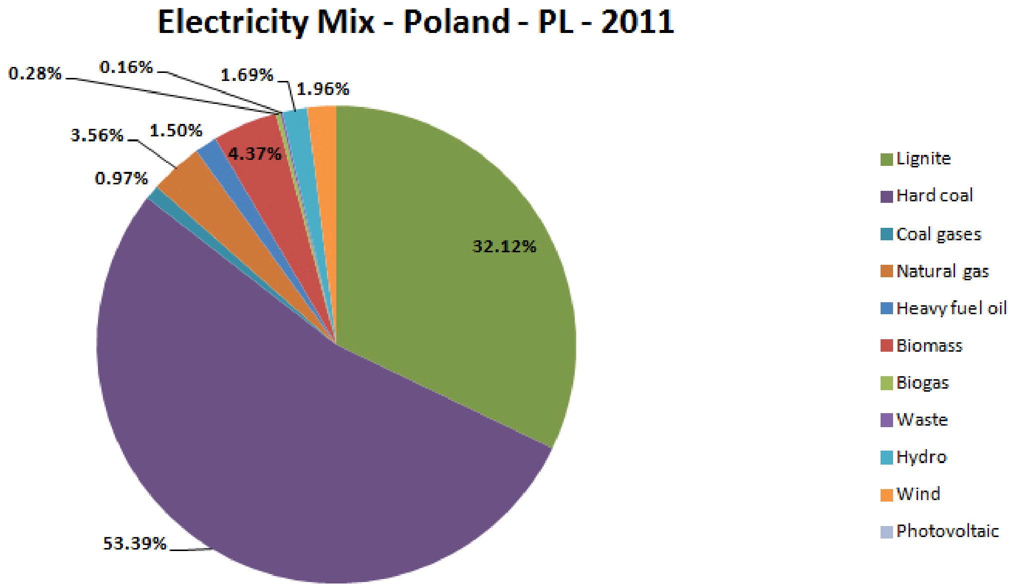

Figure 79 - Polish electricity grid mix, by electricity source

CML2001 indicator	Polish grid mix for use			Base (EU-27 grid mix)			% Difference vs base		
	Life cycle TV1	Life cycle TV2	Life cycle TV3	Life cycle TV1	Life cycle TV2	Life cycle TV3	TV1	TV2	TV3
ADPe [kg Sb-eq.]	1,64E-02	1,71E-02	2,02E-02	1,67E-02	1,73E-02	2,04E-02	-2%	-1%	-1%
ADPf [MJ]	6,20E+04	3,94E+04	4,98E+04	3,50E+04	2,39E+04	2,93E+04	77%	65%	70%
AP [kg SO2-eq.]	3,77E+01	2,36E+01	3,01E+01	1,65E+01	1,15E+01	1,39E+01	128%	106%	116%
EP [kg Phosphate-eq.]	2,28E+00	2,91E+00	1,88E+00	1,15E+00	2,26E+00	1,02E+00	98%	29%	85%
FAETP [kg DCB-eq.]	1,34E+01	1,09E+01	1,29E+01	1,28E+01	1,06E+01	1,24E+01	4%	3%	3%
GWPin [CO2-eq.]	6,33E+03	4,03E+03	5,09E+03	3,29E+03	2,29E+03	2,77E+03	93%	76%	84%
GWPex [CO2-eq.]	6,31E+03	4,01E+03	5,07E+03	3,27E+03	2,26E+03	2,75E+03	93%	77%	84%
HTP [kg DCB-eq.]	6,45E+02	5,09E+02	6,12E+02	4,44E+02	3,94E+02	4,59E+02	45%	29%	33%
MAETP [kg DCB-eq.]	8,61E+05	6,06E+05	7,40E+05	5,32E+05	4,17E+05	4,89E+05	62%	45%	51%
ODP [kg R11-eq.]	1,34E-07	1,59E-07	1,44E-07	1,94E-06	1,20E-06	1,52E-06	-93%	-87%	-91%
POCP [kg Ethene-eq.]	2,41E+00	1,57E+00	1,96E+00	1,13E+00	8,38E-01	9,80E-01	114%	88%	100%
TETP [kg DCB-eq.]	1,04E+01	8,08E+00	9,59E+00	7,83E+00	6,60E+00	7,62E+00	33%	22%	26%

Table 70 - CML indicators for LCD TVs, Polish grid mix vs. base scenario

PEF indicator	Polish grid mix for use			Base (EU-27 grid mix)			% Difference vs base		
	Life cycle TV1	Life cycle TV2	Life cycle TV3	Life cycle TV1	Life cycle TV2	Life cycle TV3	TV1	TV2	TV3
AC [Mole of H+ eq.]	4,37E+01	2,75E+01	3,49E+01	1,90E+01	1,33E+01	1,61E+01	130%	106%	117%
CC_ex [CO2-eq.]	6,31E+03	4,01E+03	5,07E+03	3,27E+03	2,27E+03	2,75E+03	93%	77%	84%
CC_in [CO2-eq.]	6,34E+03	4,03E+03	5,09E+03	3,29E+03	2,29E+03	2,77E+03	93%	76%	84%
ETF [CTUe]	3,89E+02	3,47E+02	3,71E+02	3,13E+02	3,03E+02	3,13E+02	24%	14%	18%
EPF [kg P-eq.]	1,31E-02	1,21E-02	1,24E-02	1,28E-02	1,19E-02	1,21E-02	3%	2%	2%
EPM [kg N-eq.]	2,19E-01	1,66E-01	1,90E-01	1,80E-01	1,43E-01	1,60E-01	22%	16%	19%
EPT [Mole of N-eq.]	6,21E+01	4,16E+01	5,12E+01	3,10E+01	2,37E+01	2,74E+01	101%	75%	86%
HT_c [CTUh]	8,05E-06	8,85E-06	8,15E-06	7,21E-06	8,37E-06	7,52E-06	12%	6%	8%
HT_nc [CTUh]	1,90E-04	1,39E-04	1,66E-04	1,23E-04	1,01E-04	1,15E-04	55%	38%	44%
IR [kBq U235-eq.]	5,06E+01	4,26E+01	4,79E+01	5,34E+02	3,20E+02	4,16E+02	-91%	-87%	-88%
OD [kg R11-eq.]	1,45E-07	1,71E-07	1,59E-07	1,95E-06	1,21E-06	1,54E-06	-93%	-86%	-90%
PM/RI [kg PM2,5-Eq.]	3,00E+00	1,99E+00	2,47E+00	1,44E+00	1,09E+00	1,28E+00	109%	82%	93%
POF [kg NMVOC]	1,73E+01	1,15E+01	1,42E+01	8,61E+00	6,53E+00	7,59E+00	101%	76%	87%
RDW [m³ eq.]	4,74E+01	3,02E+01	3,76E+01	3,23E+01	2,15E+01	2,61E+01	47%	40%	44%
RDMFR [kg Sb-eq.]	6,92E-02	7,10E-02	7,81E-02	7,57E-02	7,48E-02	8,31E-02	-9%	-5%	-6%

Table 71 - PEF indicators for LCD TVs, Polish grid mix vs. base scenario

6.2.4.8 Bulgarian electricity grid mix

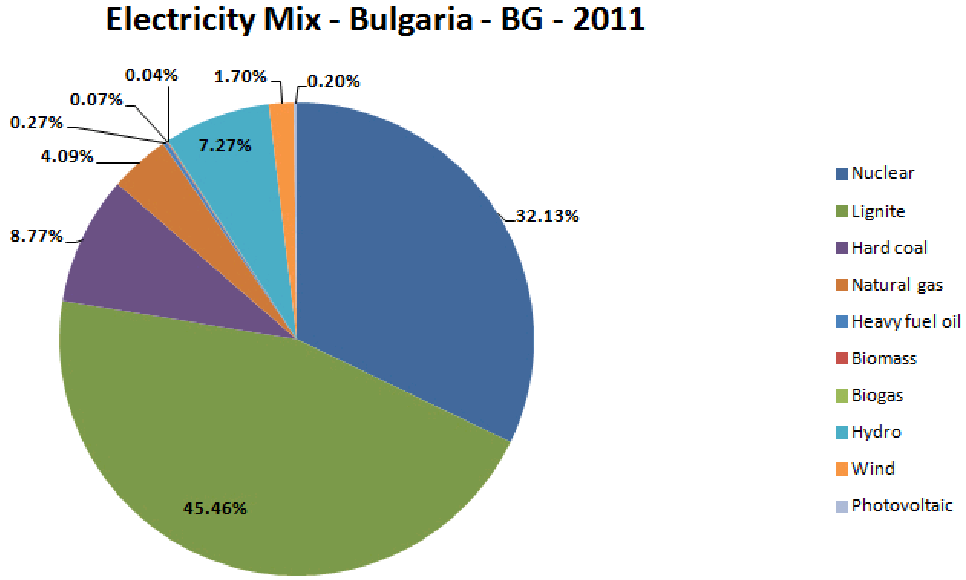

Figure 80 - Bulgarian electricity grid mix, by electricity source

CML2001 indicator	Bulgarian grid mix for use			Base (EU-27 grid mix)			% Difference vs base		
	Life cycle TV1	Life cycle TV2	Life cycle TV3	Life cycle TV1	Life cycle TV2	Life cycle TV3	TV1	TV2	TV3
ADPe [kg Sb-eq.]	1,65E-02	1,72E-02	2,03E-02	1,67E-02	1,73E-02	2,04E-02	-1%	-1%	-1%
ADPf [MJ]	5,19E+04	3,36E+04	4,21E+04	3,50E+04	2,39E+04	2,93E+04	48%	40%	44%
AP [kg SO2-eq.]	1,55E+02	9,11E+01	1,20E+02	1,65E+01	1,15E+01	1,39E+01	843%	695%	759%
EP [kg Phosphate-eq.]	1,69E+00	2,57E+00	1,43E+00	1,15E+00	2,26E+00	1,02E+00	47%	14%	40%
FAETP [kg DCB-eq.]	1,66E+01	1,27E+01	1,53E+01	1,28E+01	1,06E+01	1,24E+01	29%	20%	23%
GWPin [CO2-eq.]	5,43E+03	3,52E+03	4,41E+03	3,29E+03	2,29E+03	2,77E+03	65%	54%	59%
GWPex [CO2-eq.]	5,41E+03	3,49E+03	4,38E+03	3,27E+03	2,26E+03	2,75E+03	66%	54%	59%
HTP [kg DCB-eq.]	1,01E+03	7,17E+02	8,88E+02	4,44E+02	3,94E+02	4,59E+02	127%	82%	94%
MAETP [kg DCB-eq.]	4,85E+05	3,90E+05	4,53E+05	5,32E+05	4,17E+05	4,89E+05	-9%	-6%	-7%
ODP [kg R11-eq.]	1,64E-07	1,77E-07	1,67E-07	1,94E-06	1,20E-06	1,52E-06	-92%	-85%	-89%
POCP [kg Ethene-eq.]	6,78E+00	4,08E+00	5,29E+00	1,13E+00	8,38E-01	9,80E-01	501%	386%	439%
TETP [kg DCB-eq.]	1,67E+01	1,17E+01	1,44E+01	7,83E+00	6,60E+00	7,62E+00	113%	77%	89%

Table 72 - CML indicators for LCD TVs, Bulgarian grid mix vs. base scenario

PEF indicator	Bulgarian grid mix for use			Base (EU-27 grid mix)			% Difference vs base		
	Life cycle TV1	Life cycle TV2	Life cycle TV3	Life cycle TV1	Life cycle TV2	Life cycle TV3	TV1	TV2	TV3
AC [Mole of H+ eq.]	1,72E+02	1,01E+02	1,32E+02	1,90E+01	1,33E+01	1,61E+01	803%	658%	721%
CC_ex [CO2-eq.]	5,41E+03	3,49E+03	4,38E+03	3,27E+03	2,27E+03	2,75E+03	65%	54%	59%
CC_in [CO2-eq.]	5,43E+03	3,52E+03	4,41E+03	3,29E+03	2,29E+03	2,77E+03	65%	54%	59%
ETF [CTUe]	4,87E+02	4,03E+02	4,47E+02	3,13E+02	3,03E+02	3,13E+02	56%	33%	42%
EPF [kg P-eq.]	1,01E-02	1,04E-02	1,01E-02	1,28E-02	1,19E-02	1,21E-02	-21%	-13%	-17%
EPM [kg N-eq.]	1,30E-01	1,15E-01	1,23E-01	1,80E-01	1,43E-01	1,60E-01	-27%	-20%	-23%
EPT [Mole of N-eq.]	4,33E+01	3,08E+01	3,69E+01	3,10E+01	2,37E+01	2,74E+01	40%	30%	34%
HT_c [CTUh]	1,19E-05	1,10E-05	1,11E-05	7,21E-06	8,37E-06	7,52E-06	65%	32%	47%
HT_nc [CTUh]	2,11E-04	1,52E-04	1,83E-04	1,23E-04	1,01E-04	1,15E-04	72%	50%	58%
IR [kBq U235-eq.]	5,57E+02	3,33E+02	4,34E+02	5,34E+02	3,20E+02	4,16E+02	4%	4%	4%
OD [kg R11-eq.]	1,75E-07	1,88E-07	1,82E-07	1,95E-06	1,21E-06	1,54E-06	-91%	-84%	-88%
PM/RI [kg PM2,5-Eq.]	1,11E+01	6,64E+00	8,65E+00	1,44E+00	1,09E+00	1,28E+00	673%	508%	578%
POF [kg NMVOC]	2,09E+01	1,36E+01	1,69E+01	8,61E+00	6,53E+00	7,59E+00	143%	108%	123%
RDW [m³ eq.]	9,83E+01	5,93E+01	7,64E+01	3,23E+01	2,15E+01	2,61E+01	205%	176%	193%
RDMFR [kg Sb-eq.]	7,67E-02	7,53E-02	8,39E-02	7,57E-02	7,48E-02	8,31E-02	1%	1%	1%

Table 73 - PEF indicators for LCD TVs, Bulgarian grid mix vs. base scenario

6.2.5 *Impact of EoL scenarios on the environmental impact of LCD TVs*

Even though treatment of waste of electrical and electronic equipment has been regulated by the European Union for a number of years now, the techniques used for recycling and re-use are still very recent, and for many instances still under development. Therefore, the more common scenarios of landfill and incineration are assess, to evaluate if there is a significant impact on the LCIA results.

6.2.5.1 Incineration

CML2001 indicator	EoL incineration			Base (WEEE)			% Difference vs base		
	Life cycle TV1	Life cycle TV2	Life cycle TV3	Life cycle TV1	Life cycle TV2	Life cycle TV3	TV1	TV2	TV3
ADPe [kg Sb-eq.]	4,53E-02	4,54E-02	4,93E-02	1,67E-02	1,73E-02	2,04E-02	171%	163%	141%
ADPf [MJ]	3,56E+04	2,46E+04	3,00E+04	3,50E+04	2,39E+04	2,93E+04	2%	3%	2%
AP [kg SO2-eq.]	1,71E+01	1,20E+01	1,46E+01	1,65E+01	1,15E+01	1,39E+01	4%	5%	5%
EP [kg Phosphate-eq.]	1,18E+00	2,29E+00	1,05E+00	1,15E+00	2,26E+00	1,02E+00	3%	1%	3%
FAETP [kg DCB-eq.]	1,35E+01	1,12E+01	1,31E+01	1,28E+01	1,06E+01	1,24E+01	5%	6%	5%
GWPin [CO2-eq.]	3,36E+03	2,36E+03	2,86E+03	3,29E+03	2,29E+03	2,77E+03	2%	3%	3%
GWPex [CO2-eq.]	3,34E+03	2,34E+03	2,84E+03	3,27E+03	2,26E+03	2,75E+03	2%	3%	3%
HTP [kg DCB-eq.]	5,06E+02	4,52E+02	5,22E+02	4,44E+02	3,94E+02	4,59E+02	14%	15%	14%
MAETP [kg DCB-eq.]	5,57E+05	4,42E+05	5,15E+05	5,32E+05	4,17E+05	4,89E+05	5%	6%	5%
ODP [kg R11-eq.]	1,94E-06	1,19E-06	1,52E-06	1,94E-06	1,20E-06	1,52E-06	0%	0%	0%
POCP [kg Ethene-eq.]	1,17E+00	8,75E-01	1,02E+00	1,13E+00	8,38E-01	9,80E-01	3%	4%	4%
TETP [kg DCB-eq.]	8,22E+00	6,96E+00	8,06E+00	7,83E+00	6,60E+00	7,62E+00	5%	6%	6%

Table 74 - CML indicators for LCD TVs, incineration EoL

PEF indicator	EoL incineration			Base (WEEE)			% Difference vs base		
	Life cycle TV1	Life cycle TV2	Life cycle TV3	Life cycle TV1	Life cycle TV2	Life cycle TV3	TV1	TV2	TV3
AC [Mole of H+ eq.]	1,97E+01	1,40E+01	1,69E+01	1,90E+01	1,33E+01	1,61E+01	4%	5%	5%
CC_ex [CO2-eq.]	3,34E+03	2,34E+03	2,84E+03	3,27E+03	2,27E+03	2,75E+03	2%	3%	3%
CC_in [CO2-eq.]	3,36E+03	2,36E+03	2,86E+03	3,29E+03	2,29E+03	2,77E+03	2%	3%	3%
ETF [CTUe]	3,47E+02	3,36E+02	3,48E+02	3,13E+02	3,03E+02	3,13E+02	11%	11%	11%
EPF [kg P-eq.]	1,28E-02	1,19E-02	1,22E-02	1,28E-02	1,19E-02	1,21E-02	0%	0%	1%
EPM [kg N-eq.]	1,81E-01	1,45E-01	1,62E-01	1,80E-01	1,43E-01	1,60E-01	1%	1%	1%
EPT [Mole of N-eq.]	3,19E+01	2,46E+01	2,85E+01	3,10E+01	2,37E+01	2,74E+01	3%	4%	4%
HT_c [CTUh]	7,62E-06	8,76E-06	7,97E-06	7,21E-06	8,37E-06	7,52E-06	6%	5%	6%
HT_nc [CTUh]	1,36E-04	1,14E-04	1,31E-04	1,23E-04	1,01E-04	1,15E-04	11%	13%	14%
IR [kBq U235-eq.]	5,34E+02	3,20E+02	4,16E+02	5,34E+02	3,20E+02	4,16E+02	0%	0%	0%
OD [kg R11-eq.]	1,95E-06	1,21E-06	1,54E-06	1,95E-06	1,21E-06	1,54E-06	0%	0%	0%
PM/RI [kg PM2,5-Eq.]	1,49E+00	1,15E+00	1,34E+00	1,44E+00	1,09E+00	1,28E+00	4%	5%	5%
POF [kg NMVOC]	8,88E+00	6,80E+00	7,88E+00	8,61E+00	6,53E+00	7,59E+00	3%	4%	4%
RDW [m³ eq.]	3,25E+01	2,17E+01	2,63E+01	3,23E+01	2,15E+01	2,61E+01	1%	1%	1%
RDMFR [kg Sb-eq.]	1,12E-01	1,10E-01	1,20E-01	7,57E-02	7,48E-02	8,31E-02	48%	47%	44%

Table 75 - PEF indicators for LCD TVs, incineration EoL

6.2.5.2 Landfill

CML2001 indicator	EoL landfill			Base (WEEE)			% Difference vs base		
	Life cycle TV1	Life cycle TV2	Life cycle TV3	Life cycle TV1	Life cycle TV2	Life cycle TV3	TV1	TV2	TV3
ADPe [kg Sb-eq.]	4,53E-02	4,54E-02	4,93E-02	1,67E-02	1,73E-02	2,04E-02	171%	163%	141%
ADPf [MJ]	3,57E+04	2,47E+04	3,01E+04	3,50E+04	2,39E+04	2,93E+04	2%	3%	3%
AP [kg SO2-eq.]	1,71E+01	1,20E+01	1,46E+01	1,65E+01	1,15E+01	1,39E+01	4%	5%	5%
EP [kg Phosphate-eq.]	1,18E+00	2,29E+00	1,05E+00	1,15E+00	2,26E+00	1,02E+00	3%	1%	3%
FAETP [kg DCB-eq.]	1,35E+01	1,12E+01	1,31E+01	1,28E+01	1,06E+01	1,24E+01	5%	6%	5%
GWPin [CO2-eq.]	3,34E+03	2,34E+03	2,83E+03	3,29E+03	2,29E+03	2,77E+03	2%	2%	2%
GWPex [CO2-eq.]	3,32E+03	2,32E+03	2,81E+03	3,27E+03	2,26E+03	2,75E+03	2%	2%	2%
HTP [kg DCB-eq.]	5,06E+02	4,52E+02	5,22E+02	4,44E+02	3,94E+02	4,59E+02	14%	15%	14%
MAETP [kg DCB-eq.]	5,58E+05	4,43E+05	5,16E+05	5,32E+05	4,17E+05	4,89E+05	5%	6%	5%
ODP [kg R11-eq.]	1,94E-06	1,20E-06	1,52E-06	1,94E-06	1,20E-06	1,52E-06	0%	0%	0%
POCP [kg Ethene-eq.]	1,17E+00	8,77E-01	1,02E+00	1,13E+00	8,38E-01	9,80E-01	4%	5%	5%
TETP [kg DCB-eq.]	8,23E+00	6,97E+00	8,06E+00	7,83E+00	6,60E+00	7,62E+00	5%	6%	6%

Table 76 - CML indicators for LCD TVs, landfill EoL

PEF indicator	EoL landfill			Base (WEEE)			% Difference vs base		
	Life cycle TV1	Life cycle TV2	Life cycle TV3	Life cycle TV1	Life cycle TV2	Life cycle TV3	TV1	TV2	TV3
AC [Mole of H+ eq.]	1,97E+01	1,40E+01	1,69E+01	1,90E+01	1,33E+01	1,61E+01	4%	5%	5%
CC_ex [CO2-eq.]	3,32E+03	2,32E+03	2,81E+03	3,27E+03	2,27E+03	2,75E+03	2%	2%	2%
CC_in [CO2-eq.]	3,34E+03	2,34E+03	2,83E+03	3,29E+03	2,29E+03	2,77E+03	2%	2%	2%
ETF [CTUe]	3,46E+02	3,35E+02	3,48E+02	3,13E+02	3,03E+02	3,13E+02	11%	11%	11%
EPF [kg P-eq.]	1,28E-02	1,20E-02	1,22E-02	1,28E-02	1,19E-02	1,21E-02	1%	1%	1%
EPM [kg N-eq.]	1,82E-01	1,45E-01	1,62E-01	1,80E-01	1,43E-01	1,60E-01	1%	1%	1%
EPT [Mole of N-eq.]	3,19E+01	2,46E+01	2,84E+01	3,10E+01	2,37E+01	2,74E+01	3%	4%	4%
HT_c [CTUh]	7,62E-06	8,77E-06	7,98E-06	7,21E-06	8,37E-06	7,52E-06	6%	5%	6%
HT_nc [CTUh]	1,36E-04	1,14E-04	1,31E-04	1,23E-04	1,01E-04	1,15E-04	11%	13%	14%
IR [kBq U235-eq.]	5,35E+02	3,21E+02	4,17E+02	5,34E+02	3,20E+02	4,16E+02	0%	0%	0%
OD [kg R11-eq.]	1,96E-06	1,21E-06	1,54E-06	1,95E-06	1,21E-06	1,54E-06	0%	0%	0%
PM/RI [kg PM2,5-Eq.]	1,49E+00	1,15E+00	1,34E+00	1,44E+00	1,09E+00	1,28E+00	4%	5%	5%
POF [kg NMVOC]	8,88E+00	6,80E+00	7,88E+00	8,61E+00	6,53E+00	7,59E+00	3%	4%	4%
RDW [m³ eq.]	3,25E+01	2,17E+01	2,63E+01	3,23E+01	2,15E+01	2,61E+01	1%	1%	1%
RDMFR [kg Sb-eq.]	1,12E-01	1,10E-01	1,20E-01	7,57E-02	7,48E-02	8,31E-02	48%	47%	44%

Table 77 - PEF indicators for LCD TVs, landfill EoL

6.2.6 Impact of LCD TV's life span on their environmental impact

The average life span of a TV is estimated to be around 5-10 years, with a typical life span of around 7 years. As a result of this market information, the two extreme scenarios are evaluated.

6.2.6.1 <u>5 year life span</u>

CML2001 indicator	5 year life span			Base (7 year life span)			% Difference vs base		
	Life cycle TV1	Life cycle TV2	Life cycle TV3	Life cycle TV1	Life cycle TV2	Life cycle TV3	TV1	TV2	TV3
ADPe [kg Sb-eq.]	1,66E-02	1,72E-02	2,03E-02	1,67E-02	1,73E-02	2,04E-02	-1%	0%	0%
ADPf [MJ]	2,72E+04	1,95E+04	2,33E+04	3,50E+04	2,39E+04	2,93E+04	-22%	-19%	-20%
AP [kg SO2-eq.]	1,30E+01	9,43E+00	1,13E+01	1,65E+01	1,15E+01	1,39E+01	-21%	-18%	-19%
EP [kg Phosphate-eq.]	9,59E-01	2,15E+00	8,71E-01	1,15E+00	2,26E+00	1,02E+00	-17%	-5%	-14%
FAETP [kg DCB-eq.]	1,11E+01	9,64E+00	1,11E+01	1,28E+01	1,06E+01	1,24E+01	-13%	-9%	-10%
GWPin [CO2-eq.]	2,59E+03	1,89E+03	2,24E+03	3,29E+03	2,29E+03	2,77E+03	-21%	-18%	-19%
GWPex [CO2-eq.]	2,56E+03	1,86E+03	2,21E+03	3,27E+03	2,26E+03	2,75E+03	-21%	-18%	-19%
HTP [kg DCB-eq.]	4,01E+02	3,69E+02	4,26E+02	4,44E+02	3,94E+02	4,59E+02	-10%	-6%	-7%
MAETP [kg DCB-eq.]	4,52E+05	3,71E+05	4,28E+05	5,32E+05	4,17E+05	4,89E+05	-15%	-11%	-13%
ODP [kg R11-eq.]	1,42E-06	8,98E-07	1,13E-06	1,94E-06	1,20E-06	1,52E-06	-27%	-25%	-26%
POCP [kg Ethene-eq.]	9,24E-01	7,21E-01	8,24E-01	1,13E+00	8,38E-01	9,80E-01	-18%	-14%	-16%
TETP [kg DCB-eq.]	6,90E+00	6,07E+00	6,91E+00	7,83E+00	6,60E+00	7,62E+00	-12%	-8%	-9%

Table 78 - CML indicators for lifespan of 5 yr

PEF indicator	5 year life span			Base (7 year life span)			% Difference vs base		
	Life cycle TV1	Life cycle TV2	Life cycle TV3	Life cycle TV1	Life cycle TV2	Life cycle TV3	TV1	TV2	TV3
AC [Mole of H+ eq.]	1,50E+01	1,10E+01	1,31E+01	1,90E+01	1,33E+01	1,61E+01	-21%	-17%	-19%
CC_ex [CO2-eq.]	2,57E+03	1,86E+03	2,22E+03	3,27E+03	2,27E+03	2,75E+03	-21%	-18%	-19%
CC_in [CO2-eq.]	2,59E+03	1,89E+03	2,24E+03	3,29E+03	2,29E+03	2,77E+03	-21%	-18%	-19%
ETF [CTUe]	2,88E+02	2,89E+02	2,94E+02	3,13E+02	3,03E+02	3,13E+02	-8%	-5%	-6%
EPF [kg P-eq.]	1,19E-02	1,14E-02	1,15E-02	1,28E-02	1,19E-02	1,21E-02	-7%	-4%	-6%
EPM [kg N-eq.]	1,49E-01	1,26E-01	1,37E-01	1,80E-01	1,43E-01	1,60E-01	-17%	-12%	-15%
EPT [Mole of N-eq.]	2,59E+01	2,08E+01	2,35E+01	3,10E+01	2,37E+01	2,74E+01	-17%	-12%	-14%
HT_c [CTUh]	6,61E-06	8,03E-06	7,06E-06	7,21E-06	8,37E-06	7,52E-06	-8%	-4%	-6%
HT_nc [CTUh]	1,06E-04	9,10E-05	1,03E-04	1,23E-04	1,01E-04	1,15E-04	-14%	-10%	-11%
IR [kBq U235-eq.]	3,89E+02	2,37E+02	3,06E+02	5,34E+02	3,20E+02	4,16E+02	-27%	-26%	-27%
OD [kg R11-eq.]	1,43E-06	9,10E-07	1,14E-06	1,95E-06	1,21E-06	1,54E-06	-27%	-25%	-26%
PM/RI [kg PM2,5-Eq.]	1,20E+00	9,55E-01	1,09E+00	1,44E+00	1,09E+00	1,28E+00	-17%	-13%	-14%
POF [kg NMVOC]	7,15E+00	5,70E+00	6,47E+00	8,61E+00	6,53E+00	7,59E+00	-17%	-13%	-15%
RDW [m³ eq.]	2,44E+01	1,70E+01	2,01E+01	3,23E+01	2,15E+01	2,61E+01	-24%	-21%	-23%
RDMFR [kg Sb-eq.]	7,36E-02	7,35E-02	8,15E-02	7,57E-02	7,48E-02	8,31E-02	-3%	-2%	-2%

Table 79 - PEF indicators for lifespan of 5 yr

6.2.6.2 10 year life span

CML2001 indicator	10 year life span			Base (7 year life span)			% Difference vs base		
	Life cycle TV1	Life cycle TV2	Life cycle TV3	Life cycle TV1	Life cycle TV2	Life cycle TV3	TV1	TV2	TV3
ADPe [kg Sb-eq.]	1,69E-02	1,74E-02	2,06E-02	1,67E-02	1,73E-02	2,04E-02	1%	1%	1%
ADPf [MJ]	4,67E+04	3,07E+04	3,82E+04	3,50E+04	2,39E+04	2,93E+04	33%	28%	30%
AP [kg SO2-eq.]	2,18E+01	1,45E+01	1,80E+01	1,65E+01	1,15E+01	1,39E+01	32%	26%	29%
EP [kg Phosphate-eq.]	1,44E+00	2,42E+00	1,24E+00	1,15E+00	2,26E+00	1,02E+00	25%	7%	22%
FAETP [kg DCB-eq.]	1,54E+01	1,21E+01	1,44E+01	1,28E+01	1,06E+01	1,24E+01	20%	14%	16%
GWPin [CO2-eq.]	4,34E+03	2,89E+03	3,57E+03	3,29E+03	2,29E+03	2,77E+03	32%	26%	29%
GWPex [CO2-eq.]	4,32E+03	2,87E+03	3,55E+03	3,27E+03	2,26E+03	2,75E+03	32%	27%	29%
HTP [kg DCB-eq.]	5,08E+02	4,31E+02	5,08E+02	4,44E+02	3,94E+02	4,59E+02	15%	9%	11%
MAETP [kg DCB-eq.]	6,52E+05	4,86E+05	5,81E+05	5,32E+05	4,17E+05	4,89E+05	23%	17%	19%
ODP [kg R11-eq.]	2,73E-06	1,64E-06	2,12E-06	1,94E-06	1,20E-06	1,52E-06	40%	37%	39%
POCP [kg Ethene-eq.]	1,44E+00	1,01E+00	1,21E+00	1,13E+00	8,38E-01	9,80E-01	27%	21%	24%
TETP [kg DCB-eq.]	9,22E+00	7,40E+00	8,68E+00	7,83E+00	6,60E+00	7,62E+00	18%	12%	14%

Table 80 - CML indicators for lifespan of 10 yr

PEF indicator	10 year life span			Base (7 year life span)			% Difference vs base		
	Life cycle TV1	Life cycle TV2	Life cycle TV3	Life cycle TV1	Life cycle TV2	Life cycle TV3	TV1	TV2	TV3
AC [Mole of H+ eq.]	2,50E+01	1,67E+01	2,07E+01	1,90E+01	1,33E+01	1,61E+01	31%	26%	28%
CC_ex [CO2-eq.]	4,32E+03	2,87E+03	3,55E+03	3,27E+03	2,27E+03	2,75E+03	32%	27%	29%
CC_in [CO2-eq.]	4,34E+03	2,89E+03	3,57E+03	3,29E+03	2,29E+03	2,77E+03	32%	26%	29%
ETF [CTUe]	3,50E+02	3,24E+02	3,42E+02	3,13E+02	3,03E+02	3,13E+02	12%	7%	9%
EPF [kg P-eq.]	1,41E-02	1,26E-02	1,31E-02	1,28E-02	1,19E-02	1,21E-02	10%	6%	8%
EPM [kg N-eq.]	2,26E-01	1,70E-01	1,95E-01	1,80E-01	1,43E-01	1,60E-01	26%	18%	22%
EPT [Mole of N-eq.]	3,86E+01	2,81E+01	3,33E+01	3,10E+01	2,37E+01	2,74E+01	25%	19%	21%
HT_c [CTUh]	8,12E-06	8,89E-06	8,21E-06	7,21E-06	8,37E-06	7,52E-06	13%	6%	9%
HT_nc [CTUh]	1,48E-04	1,15E-04	1,35E-04	1,23E-04	1,01E-04	1,15E-04	21%	14%	17%
IR [kBq U235-eq.]	7,52E+02	4,45E+02	5,82E+02	5,34E+02	3,20E+02	4,16E+02	41%	39%	40%
OD [kg R11-eq.]	2,74E-06	1,66E-06	2,13E-06	1,95E-06	1,21E-06	1,54E-06	40%	37%	39%
PM/RI [kg PM2,5-Eq.]	1,80E+00	1,30E+00	1,55E+00	1,44E+00	1,09E+00	1,28E+00	25%	19%	21%
POF [kg NMVOC]	1,08E+01	7,79E+00	9,25E+00	8,61E+00	6,53E+00	7,59E+00	25%	19%	22%
RDW [m³ eq.]	4,41E+01	2,83E+01	3,51E+01	3,23E+01	2,15E+01	2,61E+01	37%	31%	34%
RDMFR [kg Sb-eq.]	7,88E-02	7,66E-02	8,55E-02	7,57E-02	7,48E-02	8,31E-02	4%	2%	3%

Table 81 - PEF indicators for lifespan of 10 yr

6.2.7 Impact of TV2's size on its the environmental impact

The functional unit of the system under analysis is a 65" TV, but in order to evaluate whether the conclusions drawn in this study are relevant for other sizes of TVs as well, the scenario of a 48" TV was also assessed. The main difference to evaluate the effect of a smaller TV on the environmental impact, and whether or not the relative environmental impact by life cycle stage remains unchanged.

CML2001 indicator	48" TV2	Base (65" TV2)	% Difference vs base
ADPe [kg Sb-eq.]	1.29E-02	1.73E-02	-25%
ADPf [MJ]	1.66E+04	2.39E+04	-31%
AP [kg SO2-eq.]	7.97E+00	1.15E+01	-30%
EP [kg Phosphate-eq.]	1.12E+00	2.26E+00	-50%
FAETP [kg DCB-eq.]	7.61E+00	1.06E+01	-28%
GWPin [CO2-eq.]	1.63E+03	2.29E+03	-29%
GWPex [CO2-eq.]	1.61E+03	2.26E+03	-29%
HTTP [kg DCB-eq.]	2.55E+02	3.94E+02	-35%
MAETP [kg DCB-eq.]	3.28E+05	4.17E+05	-21%
ODP [kg R11-eq.]	8.14E-07	1.20E-06	-32%
POCP [kg Ethene-eq.]	6.15E-01	8.38E-01	-27%
TETP [kg DCB-eq.]	4.14E+00	6.60E+00	-37%

Table 82 - CML indicators for 48" TV2

CML2001 indicator	Total TV2 48"	Manufacturing	Distribution	Use	EoL
ADPe [kg Sb-eq.]	1.29E-02	3.46E-02	1.33E-07	1.68E-04	-2.18E-02
ADPf [MJ]	1.66E+04	6.39E+03	4.44E+01	1.07E+04	-5.55E+02
AP [kg SO2-eq.]	7.97E+00	3.56E+00	4.30E-02	4.84E+00	-4.69E-01
EP [kg Phosphate-eq.]	1.12E+00	8.76E-01	5.84E-03	2.63E-01	-2.30E-02
FAETP [kg DCB-eq.]	7.61E+00	5.68E+00	2.70E-02	2.34E+00	-4.36E-01
GWPin [CO2-eq.]	1.63E+03	7.06E+02	3.58E+00	9.60E+02	-4.17E+01
GWPex [CO2-eq.]	1.61E+03	6.88E+02	3.19E+00	9.63E+02	-4.16E+01
HTP [kg DCB-eq.]	2.55E+02	2.47E+02	7.50E-02	5.92E+01	-5.08E+01
MAETP [kg DCB-eq.]	3.28E+05	2.39E+05	1.52E+01	1.10E+05	-2.13E+04
ODP [kg R11-eq.]	8.14E-07	9.80E-08	4.20E-10	7.15E-07	3.54E-11
POCP [kg Ethene-eq.]	6.15E-01	3.63E-01	-1.86E-03	2.82E-01	-2.88E-02
TETP [kg DCB-eq.]	4.14E+00	3.12E+00	8.60E-03	1.27E+00	-2.60E-01

Table 83 - CML indicators by life cycle stage, TV2 48"

CML2001 indicator	Manufacturing	Distribution	Use	EoL
ADPe	61%	0%	0%	(39%)
ADPf	36%	0%	60%	(3%)
AP	40%	0%	54%	(5%)
EP	75%	0%	22%	(2%)
FAETP	67%	0%	28%	(5%)
GWPin	41%	0%	56%	(2%)
GWPex	41%	0%	57%	(2%)
HTP	69%	0%	17%	(14%)
MAETP	64%	0%	30%	(6%)
ODP	12%	0%	88%	(0%)
POCP	54%	(0%)	42%	(4%)
TETP	67%	0%	27%	(6%)

Table 84 - Relative impact CML indicators by life cycle stage, TV2 48"

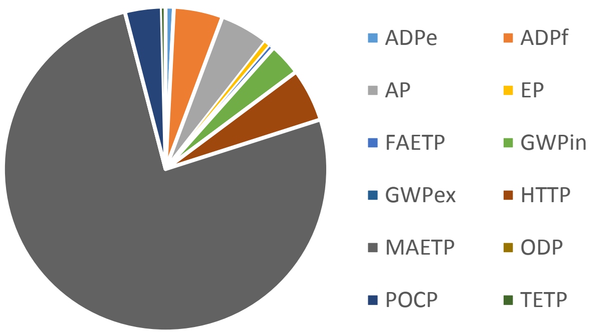

Figure 81 - Normalised environmental impact, CML, TV2 48"

PEF indicator	48" TV2	Base (65" TV2)	% Difference vs base
AC [Mole of H+ eq.]	9.26E+00	1.33E+01	-30%
CC_ex [CO2-eq.]	1.61E+03	2.27E+03	-29%
CC_in [CO2-eq.]	1.63E+03	2.29E+03	-29%
ETF [CTUe]	2.04E+02	3.03E+02	-33%
EPF [kg P-eq.]	8.32E-03	1.19E-02	-30%
EPM [kg N-eq.]	9.76E-02	1.43E-01	-32%
EPT [Mole of N-eq.]	1.65E+01	2.37E+01	-30%
HT_c [CTUh]	5.39E-06	8.37E-06	-36%
HT_nc [CTUh]	6.68E-05	1.01E-04	-34%
IR [kBq U235-eq.]	2.24E+02	3.20E+02	-30%
OD [kg R11-eq.]	8.24E-07	1.21E-06	-32%
PM/RI [kg PM2,5-Eq.]	7.43E-01	1.09E+00	-32%
POF [kg NMVOC]	4.62E+00	6.53E+00	-29%
RDW [m³ eq.]	1.49E+01	2.15E+01	-31%
RDMFR [kg Sb-eq.]	6.23E-02	7.48E-02	-17%

Table 85 - PEF indicators for 48" TV2

PEF indicator	Total TV2 48"	Manufacturing	Distribution	Use	EoL
AC [Mole of H+ eq.]	9.26E+00	4.29E+00	5.55E-02	5.46E+00	-5.43E-01
CC_ex [CO2-eq.]	1.61E+03	6.88E+02	3.20E+00	9.63E+02	-4.17E+01
CC_in [CO2-eq.]	1.63E+03	7.06E+02	3.58E+00	9.61E+02	-4.17E+01
ETF [CTUe]	2.04E+02	1.90E+02	8.43E-01	3.42E+01	-2.09E+01
EPF [kg P-eq.]	8.32E-03	7.14E-03	9.90E-06	1.21E-03	-4.37E-05
EPM [kg N-eq.]	9.76E-02	5.00E-02	6.59E-03	4.22E-02	-1.26E-03
EPT [Mole of N-eq.]	1.65E+01	1.00E+01	1.85E-01	7.02E+00	-7.00E-01
HT_c [CTUh]	5.39E-06	4.80E-06	3.78E-08	8.28E-07	-2.78E-07
HT_nc [CTUh]	6.68E-05	5.17E-05	2.19E-07	2.33E-05	-8.47E-06
IR [kBq U235-eq.]	2.24E+02	2.56E+01	3.20E-03	1.99E+02	-6.76E-01
OD [kg R11-eq.]	8.24E-07	1.09E-07	4.20E-10	7.15E-07	3.54E-11
PM/RI [kg PM2,5-Eq.]	7.43E-01	4.52E-01	1.79E-03	3.29E-01	-3.97E-02
POF [kg NMVOC]	4.62E+00	2.79E+00	3.09E-02	2.00E+00	-2.05E-01
RDW [m³ eq.]	1.49E+01	4.27E+00	5.26E-04	1.08E+01	-1.71E-01
RDMFR [kg Sb-eq.]	6.23E-02	8.48E-02	8.16E-07	2.89E-03	-2.54E-02

Table 86 - PEF indicators by life cycle stage, TV2 48"

PEF indicator	Manufacturing	Distribution	Use	EoL
Acid	41%	1%	53%	(5%)
CC_ex	41%	0%	57%	(2%)
CC_in	41%	0%	56%	(2%)
ETF	77%	0%	14%	(9%)
EPF	85%	0%	14%	(1%)
EPM	50%	7%	42%	(1%)
EPT	56%	1%	39%	(4%)
HT_c	81%	1%	14%	(5%)
HT_nc	62%	0%	28%	(10%)
IR	11%	0%	88%	(0%)
OD	13%	0%	87%	0%
PM/RI	55%	0%	40%	(5%)
POF	56%	1%	40%	(4%)
RDW	28%	0%	71%	(1%)
RDMFR	75%	0%	3%	(22%)

Table 87 - Relative impact PEF indicators by life cycle stage, TV2 48"

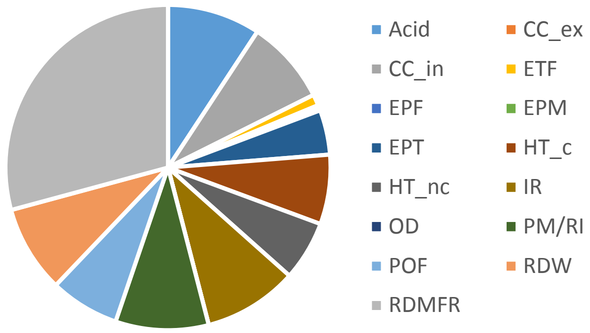

Figure 82 - Normalised environmental impact, PEF, TV2 48"

6.3 Sensitivity analysis

In order to ensure that certain modelling choices do not result in distorted results, or ambiguous conclusions, robustness of the model is key. Therefore, it is important to assess how sensitive certain modelling decisions are, and what the impact of these choices is.

6.3.1 Avoided burden vs. cut-off

Where relevant, and based on data availability related to energy recuperation, recycling, etc. the affected processes got credited with these benefits, as the environmental impacts of these burdens would be carried by another life cycle, outside of the goal, scope and boundaries of the system under analysis. Below tables provide an overview of what the environmental impact would have been if the avoided burden approach had not been used, and all credits had been cut off.

CML2001 indicator	Cut-off	Base (Avoided burden)	% Difference vs base
ADPe [kg Sb-eq.]	1,73E-02	1,73E-02	0%
ADPf [MJ]	2,41E+04	2,39E+04	1%
AP [kg SO2-eq.]	1,15E+01	1,15E+01	0%
EP [kg Phosphate-eq.]	2,47E+00	2,26E+00	9%
FAETP [kg DCB-eq.]	1,07E+01	1,06E+01	1%
GWPin [CO2-eq.]	2,30E+03	2,29E+03	0%
GWPex [CO2-eq.]	2,27E+03	2,26E+03	0%
HTTP [kg DCB-eq.]	3,95E+02	3,94E+02	0%
MAETP [kg DCB-eq.]	4,17E+05	4,17E+05	0%
ODP [kg R11-eq.]	1,20E-06	1,20E-06	0%
POCP [kg Ethene-eq.]	8,41E-01	8,38E-01	0%
TETP [kg DCB-eq.]	6,61E+00	6,60E+00	0%

Table 88 - CML indicators for cut-of vs avoided burden in QDEF model

PEF indicator	Cut-off	Base (Avoided burden)	% Difference vs base
AC [Mole of H+ eq.]	1,33E+01	1,33E+01	0%
CC_ex [CO2-eq.]	2,28E+03	2,27E+03	0%
CC_in [CO2-eq.]	2,30E+03	2,29E+03	0%
ETF [CTUe]	3,16E+02	3,03E+02	4%
EPF [kg P-eq.]	1,19E-02	1,19E-02	0%
EPM [kg N-eq.]	1,44E-01	1,43E-01	0%
EPT [Mole of N-eq.]	2,38E+01	2,37E+01	0%
HT_c [CTUh]	9,64E-06	8,37E-06	15%
HT_nc [CTUh]	1,01E-04	1,01E-04	0%
IR [kBq U235-eq.]	3,20E+02	3,20E+02	0%
OD [kg R11-eq.]	1,21E-06	1,21E-06	0%
PM/RI [kg PM2,5-Eq.]	1,09E+00	1,09E+00	0%
POF [kg NMVOC]	6,55E+00	6,53E+00	0%
RDW [m³ eq.]	2,15E+01	2,15E+01	0%
RDMFR [kg Sb-eq.]	7,48E-02	7,48E-02	0%

Table 89 - PEF indicators for cut-of vs avoided burden in QDEF model

6.3.2 *"Zero-impact" assumption for TV3*

Due to the fact that no information is available for the QDEF used in TV3, a zero impact was assumed in the base scenario. In reality, no QDEF manufacturing process will have a zero impact, and therefore the impact of QDEF manufacturing was assessed in conjunction with all other inputs from TV3. Due to the fact that the impact of 3M QDEF on the overall environmental impact of TV2, the expectation is that the differences for TV3 will be negligible.

CML2001 indicator	Life cycle TV1	Life cycle TV2	Life cycle TV3 with QDEF	% Diff TV2 vs TV1	% diff T3 with film vs TV1	% Diff TV3 without film vs TV1
ADPe [kg Sb-eq.]	1,67E-02	1,73E-02	2,05E-02	3%	23%	22%
ADPf [MJ]	3,50E+04	2,39E+04	2,98E+04	-32%	-15%	-16%
AP [kg SO2-eq.]	1,65E+01	1,15E+01	1,42E+01	-31%	-14%	-15%
EP [kg Phosphate-eq.]	1,15E+00	2,26E+00	2,42E+00	96%	110%	-12%
FAETP [kg DCB-eq.]	1,28E+01	1,06E+01	1,27E+01	-17%	-1%	-3%
GWPin [CO2-eq.]	3,29E+03	2,29E+03	2,81E+03	-30%	-14%	-16%
GWPex [CO2-eq.]	3,27E+03	2,26E+03	2,79E+03	-31%	-15%	-16%
HTP [kg DCB-eq.]	4,44E+02	3,94E+02	4,63E+02	-11%	4%	3%
MAETP [kg DCB-eq.]	5,32E+05	4,17E+05	4,91E+05	-22%	-8%	-8%
ODP [kg R11-eq.]	1,94E-06	1,20E-06	1,55E-06	-38%	-20%	-22%
POCP [kg Ethene-eq.]	1,13E+00	8,38E-01	9,88E-01	-26%	-12%	-13%
TETP [kg DCB-eq.]	7,83E+00	6,60E+00	7,68E+00	-16%	-2%	-3%

Table 90 - CML indicators for TV3 with QDEF

PEF indicator	Life cycle TV1	Life cycle TV2	Life cycle TV3 with QDEF	% Diff TV2 vs TV1	% diff TV3 with film vs TV1	% Diff TV3 without film vs TV1
AC [Mole of H+ eq.]	1,90E+01	1,33E+01	1,64E+01	-30%	-14%	-15%
CC_ex [CO2-eq.]	3,27E+03	2,27E+03	2,79E+03	-31%	-15%	-16%
CC_in [CO2-eq.]	3,29E+03	2,29E+03	2,81E+03	-30%	-14%	-16%
ETF [CTUe]	3,13E+02	3,03E+02	3,38E+02	-3%	8%	0%
EPF [kg P-eq.]	1,28E-02	1,19E-02	1,25E-02	-7%	-2%	-5%
EPM [kg N-eq.]	1,80E-01	1,43E-01	1,81E-01	-20%	1%	-11%
EPT [Mole of N-eq.]	3,10E+01	2,37E+01	2,81E+01	-23%	-9%	-11%
HT_c [CTUh]	7,21E-06	8,37E-06	9,51E-06	16%	32%	4%
HT_nc [CTUh]	1,23E-04	1,01E-04	1,17E-04	-18%	-4%	-6%
IR [kBq U235-eq.]	5,34E+02	3,20E+02	4,18E+02	-40%	-22%	-22%
OD [kg R11-eq.]	1,95E-06	1,21E-06	1,57E-06	-38%	-20%	-21%
PM/RI [kg PM2,5-Eq.]	1,44E+00	1,09E+00	1,29E+00	-24%	-10%	-11%
POF [kg NMVOC]	8,61E+00	6,53E+00	7,71E+00	-24%	-10%	-12%
RDW [m³ eq.]	3,23E+01	2,15E+01	2,70E+01	-33%	-16%	-19%
RDMFR [kg Sb-eq.]	7,57E-02	7,48E-02	8,33E-02	-1%	10%	10%

Table 91 - PEF indicators for TV3 with QDEF

7 Conclusions, limitations and recommendations

This LCA is conducted in support of 3M's DMSD request for exemptions to Directive 2011/65/EU on the restriction of the use of certain hazardous substances in electrical and electronic equipment, also referred to as RoHS II:

- Ex. Re. No. 2013-2 for "Cadmium in color converting II-VI LEDs (< 10µg Cd per mm² of light-emitting area) for use in solid state illumination or display systems" (Request for renewal of Exemption 39 of Annex III of Directive 2011/65/EU);
- Ex. Re. No. 2013-5 for "Cadmium in light control materials used for display devices".

The intent of the study is to compare the environmental impact of certain electrical and electronic devices incorporating 3M QDEF with devices not incorporating 3M QDEF, over the lifetime of the device. In particular, the focus is on the following topics:

- The contribution of 3M QDEF to the overall environmental impact of the devices;
- Comparison of the environmental impact of devices with and without 3M QDEF, including production, use and end-of-life treatment;
- The effect of Cd on the overall environmental impact of devices incorporating 3M QDEF.

The functional unit in this assessment is a 65" LCD TV, in operation for 5 hours per day (and on stand-by mode for 19 hours per day), 365 days per year, for a total period of 7 years. To ensure that the environmental impacts are comparable, the luminance of all TVs must be equivalent, and is set to 311 cd/m², whilst the colour gamut is 100% NTSC.

The following situations are compared:

- The environmental impact of a standard LCD TV, not using QDEF (TV1);
- The environmental impact of an LCD TV, incorporating 3M QDEF (TV2);
- The environmental impact of an LCD TV, incorporating an alternative, non-3M light control film (TV3). Note that due to the lack of knowledge related to the alternative technology, the environmental impact of the light control film is assumed to be negligible.

The geographical scope of the study is the European Union, whilst the default end-of-life (EoL) scenario is the waste treatment process in line with European Directive 2002/96/EC on Waste of Electrical and Electronic Equipment, as amended.

The results presented in this report are unique to the assumptions and practices of the 3M Company. The results are not meant as a tool for comparability to other companies and/or products examined in other LCA studies. Even for similar products, differences in functional unit, boundaries, assumptions and data quality may produce results which are not appropriate for comparison. The reader is referred to the commissioner of the study for more information on this study and to the ISO 14040:2006 on 'Environmental Management – Life Cycle Assessment – Principles and Framework' for the framework of LCA and EPD and additional insight into the LCA principles.

7.1 Conclusions

Based on the goal and scope of the study, LCI data was gathered, and a life cycle model was created for each of the situations described above. After completion of the LCIA and assessing sensitivity and different scenarios, the following sections list a number of conclusions that can be drawn based on this model.

7.1.1 Environmental impact of LCD TVs

The overall environmental impacts of the LCD TVs appear to be in the same order of magnitude, an expected outcome. Even though the use of statistical comparison tests would probably result in more outspoken conclusions, there are already a number of remarkable outcomes of the analysis:

- There is a tendency for the environmental impact of TV3 to be lower than TV1. Having said that, when taking into account the uncertainty determination, which provides a range in which the environmental impacts are likely to be found (see section 5.4), there is an overlap in all environmental impact categories of TV1 and TV3. This can also be verified by comparing TV1's minimum value in the uncertainty tables, with TV3's maximum value in these tables. Even though there are clear energy efficiency benefits in the use stage of TV3 as compared to TV1, no clear conclusions can be drawn related to the overall environmental impact of both TVs.
- There is a tendency for the environmental impact of TV2 to be lower than TV3. The conservative assumption of a zero environmental impact of the indium-based light control film in TV3 would make this tendency more outspoken. Having said that, given the assumptions of the base scenario, and when taking into account the uncertainty determination, which provides a range in which the environmental impacts are likely to be found (see section 5.4), there is an overlap in all environmental impact categories of TV2 and TV3. This can also be verified by comparing TV3's minimum value in the uncertainty tables, with TV2's maximum value in these tables. Even though there are clear energy efficiency benefits in the use stage of TV2 as compared to TV3, no clear conclusions can be drawn related to the overall environmental impact of both TVs.
- There is one environmental impact category where the impact of TV2 is significantly higher as compared to both TV1 and TV3, namely CML EP. This is due to the fact that nitrogen is used in the 3M QDEF manufacturing process, all of which is assumed to be emitted to air. Having said that, the normalisation exercise shows that the impact of CML EP compared to the other CML impact categories is negligible, even in the "comparable" normalised values.
- Given the above conclusions, there is a higher tendency for the environmental impact of TV2 to be lower than TV1 (as compared to TV3 vs. TV1). When taking into account the uncertainty determination, which provides a range in which the environmental impacts are likely to be found (see section 5.4), there are a number of impact categories, including global warming, a topic that is high on the European agenda, for which there is no overlap in environmental impact of TV2 and TV1. This can also be verified by comparing TV1's minimum value in the uncertainty tables, with TV2's maximum value in these tables. Therefore, as a result of the energy benefits in TV2's use phase as compared to TV1, there appears to be a positive effect on the environmental impact for the following categories:
  - For CML: ADPf, AP, GWPin, GWPex
  - For PEF: Acid, CC_ex, CC_in, IR, OD, RDW

7.1.2 Environmental impact of the LCD TVs by life cycle stage

From the analysis of the different LCD TVs by life cycle stage, it is apparent that for the majority of environmental impacts, the most contributing life cycle stages are Manufacturing and Use, with a mitigating factor in the impact because of EoL.

For those midpoints where there is a significant difference between TV1 and TV2 (see above), it is important to note that these differences can be attributed to the fact that the use phase is the most impactful life cycle stage on the overall environmental impact for that midpoint. Given the uncertainty calculations, no other significant differences can be found in the analysis.

Therefore it can be concluded that the real benefits of the environmental differentiation of TV2 compared to TV1 can be directly related to TV2's energy efficiency benefits.

7.1.3 Impact of QDs on 3M QDEF and TV2

QDs are an important element in the production of 3M QDEF. However, for a large amount of environmental impact categories, the impact of QD manufacturing has a contribution to 3M QDEF of less than 10%. When transferring this information into the life cycle of TV2, the overall contribution of QDs is far below 1%.

For those midpoints where QDs contribute significantly to the 3M QDEF manufacturing stage, these impacts can be mostly attributed to materials used in the QD production process, such as washing agents, but not the actual RMs. Therefore it can be concluded that as such, cadmium compounds , being the RMs for QDs, have a negligible contribution to the overall environmental impact of TV2.

7.1.4 Impact of 3M QDEF on the environmental impact of TV2

When comparing the impact of 3M QDEF with the overall environmental impact of TV2, there are only 4 impact categories for which the 3M QDEF contributes more than 5% to the overall environmental impact of TV2. These midpoints are:

- For CML: EP (62%)
- For PEF: ETF (8%), EPM (6%) and HT_c (23%)

Normalisation of the environmental impact of TV2 shows that apart from HT_c (8%), the other impact categories are negligible when considering the total life cycle, with a contribution not exceeding 1%. For HT_c, it is important to understand that more than 80% of the impact is related to the manufacturing phase, which means that any risk related to exposure should be mitigated by good environmental, health and safety processes in the manufacturing facilities.

7.1.5 Impact of variables on the environmental impact of LCD TVs

As results of an LCA study may vary significantly in changing conditions, a number of different scenarios are evaluated to assess the robustness of the study, and the relevance and reliability of the results. The scenarios included in this study are:

- The impact of colour gamut: 89% NTSC and 72% NTSC vs. base scenario of 100% NTSC
- The impact of luminance: 100 cd/m² vs. base scenario of 311 cd/m²
- The impact of the electricity grid: a number of country specific grid mixes vs. base scenario of EU-27 grid mix
- The impact of EoL treatment: incineration and landfill vs. base scenario of WEEE treatment
- The impact of a TV's life span: 5 years and 10 years vs. base scenario of 7 years
- The impact of the size of the TV: 48" vs. base scenario of 65"
- The avoided burden approach for foreground systems, i.e. taking credits for recycling operations and incineration with energy recuperation and therefore transferring the environmental impact of these operations to a life cycle outside of the boundaries of the system under analysis vs. a cut-off approach
- The zero impact assumption for QDEF in TV3

The conclusion coming out of the assessment of the variables is that in general, there are (significant) changes in all environmental impacts when the scenarios change. However, the impact on the LCIA typically changes in a similar way, in the same order of magnitude for all LCD TVs. Therefore, the conclusions drawn for the comparison of the LCD TVs can be expected to remain the same.

Specifically for the scenario of the size of the TV, it must be noted that only information on the different weights for TV2 are available. Therefore, the assessment was only done for TV2. The conclusion is that the smaller version of the TV has an environmental impact that is around two thirds of the environmental impact of the larger version of TV2, for all midpoints. However, the impact on by life cycle change, as well as the normalised distribution of the impact categories is almost identical for both versions of the TV2. Therefore, it can be concluded that the size of a TV has a significant impact on its overall environmental impact, but that these changes in impact are likely to be the same regardless of the type of TV, and that the conclusions drawn on the base scenario apply to all TV sizes compared in the same way as described above.

7.2 Limitations

The following limitations must be taken into account when making statements regarding the system under analysis, or any of the calculations resulting from the model, including its assumptions:

- For the purpose of the study, data for the foreground systems could easily be gathered. Having said that, due to the wide array of LCD devices making use of QDEF, it is impossible to gather information covering all potential scenarios. Assumptions, as well as sector and market averages were gathered, and applied to the specific TV makes and models used in this assessment in order to model LCD TVs and the possible EoL scenarios as relevant for this study. As this information falls outside of the expertise of DMSD, thinkstep were commissioned to perform research in order to provide a model that approaches reality in the best possible way.
- For substances used in the supply chain for which no data sets were readily available, or no straightforward alternative modelling process could be identified (e.g. modelling the manufacturing process of the material), alternatives needed to be assumed for the purpose of the study. These alternatives were selected in order to approach the supply chain process as much as possible, as such mostly focusing on materials with similar environmental impacts, instead of the chemical hazards related to the substances required. As a result, the LCA results related to human health and toxicity may differ slightly from reality, and should be carefully assessed prior to using in comparative assertion.
- A number of chemicals, for which industry data sets were not readily available, were modelled based on assumptions related to chemical reaction processes. Due to the lack of specific knowledge and expertise related to these processes, the models may differ from reality, but due to the very low impact on the overall environmental impact of the TVs, these assumptions are regarded as sufficiently approaching reality.
- 3M conducted a series of tests to be able to compare improvements in energy efficiency of TV2 as compared to TV1 and TV3. The methodology used is described in a publicly available white paper [36], but due to the fact that these tests were carried out by 3M internally, care must be taken when using these results in further assessments and statements.

7.3 Recommendations

- Even though the DQR for the system under analysis is acceptable, primary data from all stages in the supply chain could further improve the study. Especially in the area of TV manufacturing and EoL treatment of devices, more detailed background information could be helpful to fully understand all aspects of the supply chain.
- Where appropriate and as possible, chemicals and processes should be modelled in accordance with reality. When using chemical reaction processes to model materials, these should reflect the actual manufacturing processes of the materials. These elements could further improve data quality of the study, and reduce uncertainty on the results.

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9 Data quality

The EU PEF guidance uses 6 data quality indicators to assess whether or not the data gathered for the system under analysis is of sufficient quality.

The six DQIs are:

- Technology;
- Geography;
- Time;
- Completeness;
- Methodology;
- Precision.

The five data quality ratings (DQRs) are:

- Very good: Quality rating 1 – the data meet the criterion to a very high degree, without need for improvement;
- Good: Quality rating 2 – the data meet the criterion to a high degree, with a little significant need for improvement;
- Fair: Quality rating 3 – the data meet the criterion to an acceptable degree, but merit improvement;
- Poor: Quality rating 4 – the data do not meet the criterion to a sufficient degree, but rather require improvement;
- Very poor: Quality rating 5 – the data do not meet the criterion, and substantial improvement is necessary. This score should also be given if the criterion was not assessed or if the quality could not be verified or is unknown.

In a later stage of the LCA study, the data quality assessment can be used to assess the uncertainty of the LCA results. The data quality rating for each data point is transposed to a standard deviation using a Pedigree Matrix. Those standard deviations are, in combination with the LCA results, used in Monte Carlo Analysis to determine the quantitative uncertainty on LCA results.

9.1 Rating

9.1.1 Technology

- Very good: Supplier data
- Good: Same manufacturing process, same chemical
- Fair: Same manufacturing process, different chemical OR Mix including the technology
- Poor: Different manufacturing process OR Mix including the technology for a Different chemical
- Very poor: Unknown technology (for the data set)

9.1.2 Geography

For scoring geographical data quality, GaBi documentation is used to assess the score.

- Very good: Smallest possible area within a country (e.g. US state or facility, EU country)
- Good: Average data set (US average, EU average,…)
- Fair: (Different country within the) Continent level data set
- Poor: Country outside the continent, or global data sets
- Very poor: Unknown geography

9.1.3 Time

For scoring temporal data quality, GaBi documentation is used to assess the score.

- Very good: Less than or equal to 3 years
- Good: Less than or equal to 6 years
- Fair: Less than or equal to 10 years
- Poor: Less than or equal to 20 years
- Very poor: More than 20 years

9.1.4 Completeness

For scoring completeness, GaBi DQRs can be used where available.

- Very good: >90% (as compared to ideal data)
- Good: 80-90% (as compared to ideal data)
- Fair: 70-80% (as compared to ideal data)
- Poor: 50-70% (as compared to ideal data)
- Very poor: <50% (as compared to ideal data)

9.1.5 Methodology

- Very good: Fully in line with PEF
- Good: Attributional LCA, with all 3 of the following: multi-functionality, EoL, system boundaries in line with PEF
- Fair: Attributional LCA, with 2 of the following: multi-functionality, EoL, system boundaries in line with PEF
- Poor: Attributional LCA, with 1 of the following: multi-functionality, EoL, system boundaries in line with PEF
- Very poor: Attributional LCA, without the following: multi-functionality, EoL, system boundaries in line with PEF

9.1.6 Precision

For scoring precision/uncertainty, GaBi DQRs can be used where available.

- Very good: Uncertainty ≤10%
- Good: Uncertainty 10-20%
- Fair: Uncertainty 20-30%
- Poor: Uncertainty 30-50%
- Very poor: Uncertainty >50%

9.2 Default rating scores

9.2.1 Energy

All GaBi processes used as energy input in process steps (e.g electricity, thermal energy, etc)

- Time: Documentation GaBi
- Geography: Documentation GaBi
- Technology: 1) GaBi DQR if GaBi process matches the type of energy and if available
  2) GaBi documentation
  3) Poor
- Completeness: 1) GaBi DQR if GaBi process matches the type of energy and if available
  2) GaBi documentation
  3) Poor

- Methodology: 1) Good
  2) Poor for ecoinvent dataset
- Precision: 1) GaBi DQR if GaBi process matches the type of energy and if available
  2) GaBi documentation
  3) Poor

9.2.2 *Raw material components*

All GaBi processes used to represent a raw material or used as substance/ingredient in a raw material or materials used for final packaging of the product.

- Time: Documentation GaBi
- Geography: Documentation GaBi
- Technology: 1) GaBi DQR if GaBi process matches the chemical and if available
  2) GaBi documentation
  3) Poor
- Completeness: 1) GaBi DQR if GaBi process matches the chemical and if available
  2) GaBi documentation
  3) Poor
- Methodology: 1) Good
  2) Poor for ecoinvent dataset
- Uncertainty: 1) GaBi DQR if GaBi process matches the chemical and if available
  2)GaBi documentation
  3) Poor

9.2.3 *Other inputs*

All GaBi process used as ancillary input (e.g. water, cleaning chemical, etc.)

- Time: Documentation GaBi
- Geography: Documentation GaBi
- Technology: 1) GaBi DQR if GaBi process matches the ancillary input and if available
  2) GaBi documentation
  3) Poor
- Completeness: 1) GaBi DQR if GaBi process matches the ancillary input and if available
  2) GaBi documentation
  3) Poor
- Methodology: 1) Good
  2) Poor for ecoinvent dataset
- Uncertainty: 1) GaBi DQR if GaBi process matches the ancillary input and if available
  2)GaBi documentation
  3) Poor

9.2.4 *Process emissions*

Processing datasets based on specific (collected) data containing emission flows. To calculate the wt%, make the sum of all the emission's masses in the process and the sum of all emission's masses where the flow represents the same emission as given in the data. After divide the latter by the first to calculate the wt% of emissions model with the same emission flow.

- Time: Very good
- Geography: Very good
- Technology: Very good: >90 wt% of the emissions are the same
  Good: 80-90 wt% of the emissions are the same
  Fair: 70-80 wt% of the emissions are the same
  Poor: 50-70 wt% of the emissions are the same
  Very poor: <50 wt% of the emissions are the same

- Completeness: Very good: >90 wt% of the emissions are the same
  Good: 80-90 wt% of the emissions are the same
  Fair: 70-80 wt% of the emissions are the same
  Poor: 50-70 wt% of the emissions are the same
  Very poor: <50 wt% of the emissions are the same
- Methodology: Good
- Uncertainty: Very good

9.2.5 Packaging (GaBi dataset)

GaBi process used to model packaging (e.g. pallet, cardboard box, PP film, etc.)

- Time: Documentation GaBi
- Geography: Documentation GaBi
- Technology: 1) GaBi DQR if GaBi process matches the packaging type and if available
  2)GaBi documentation
  3) Poor
- Completeness: DQR GaBi or Good
- Methodology: 1) Good
  2) Poor for ecoinvent dataset
- Uncertainty: 1) GaBi DQR if GaBi process matches the packaging type and if available
  2) GaBi documentation
  3) Poor

9.2.6 Packaging (no GaBi dataset)

GaBi plans used to model packaging (e.g. steel drum, plastic pail, etc.)

- Time: 1) Documentation GaBi of process with lowest data quality in the plan
  2) Poor
- Geography: 1) Documentation GaBi of process with lowest data quality in the plan
  2) Poor
- Technology: 1) Overall evaluation of the GaBi documentation of the different plans
  2) Poor
- Completeness: 1) Overall evaluation of the GaBi documentation of the different plans
  2) Poor
- Methodology: 1) Good
  2) Poor for ecoinvent dataset
- Uncertainty: Poor

9.2.7 Waste

All GaBi processes used to model waste disposal

- Time: Documentation GaBi
- Geography: Documentation GaBi
- Technology: 1) GaBi DQR if GaBi process matches the waste process and if available
  2) GaBi documentation
  3) Poor
- Completeness: 1) GaBi DQR if GaBi process matches the waste process and if available
  2) GaBi documentation
  3) Poor
- Methodology: 1) Good
  2) Poor for ecoinvent dataset
- Uncertainty: 1) GaBi DQR if GaBi process matches the waste process and if available
  2) GaBi documentation
  3) Poor

9.2.8 Transportation (SIS)

All GaBi processes used to model specific transportation based on data coming from 3M's Ship It Smarter (SIS) system

- Time: Documentation GaBi
- Geography: Documentation GaBi
- Technology: 1) GaBi DQR if GaBi process matches the transport process and if available
  2) GaBi documentation
  3) Poor
- Completeness: 1) GaBi DQR if GaBi process matches the transport process and if available
  2) GaBi documentation
  3) Poor
- Methodology: 1) Good
  2) Poor for ecoinvent dataset
- Uncertainty: 1) GaBi DQR if GaBi process matches the transport process and if available
  2) GaBi documentation
  3) Poor

9.2.9 Transportation (not SIS)

All generic transportation plans used to model transportation based on other data than Ship It Smarter

- Time: Documentation GaBi of process with lowest data quality in the plan
- Geography: Documentation GaBi of process with lowest data quality in the plan
- Technology: GaBi DQR of process with lowest data quality in the plan
- Completeness: GaBi DQR of process with lowest data quality in the plan
- Methodology: 1) Good
  2) Poor for ecoinvent dataset
- Uncertainty: GaBi DQR of process with lowest data quality in the plan

Annex A Critical review

Critical Review Statement

chapter 6, ISO 14044:2006

ISO/TS 14071:2014

Organization:	**3M BELGIUM BVBA**		
Address:	**Hermeslaan 7, 1831 DIEGEM (BELGIUM)**		
Standards:	**ISO 14040, ISO 14044, ISO/TS 14071**		
Organization Representative:	Mr. K. Peerens	**Audit Dates:**	from 11st December 2015 to 31st December 2015
Technical Reviewer	Angelo Ferlini	**Other Members of the Audit Team:**	Roberta Bertani
Lead Auditor	Ambra Morelli		Paolo Simon Ostan

1. INTRODUCTION

SCOPE OF THE CRITICAL REVIEW

The Critical Review process was conducted in order to ensure that:

1. the scope and the type of critical review have been defined during the definition of the LCA scope (§ 4.2.3.8 ISO 14044);
2. the methods used to carry out the LCA are consistent with the ISO 14044 standard and are scientifically and technically valid;
3. the data used are appropriate and reasonable in relation to the goal of the study;
4. the interpretations reflect the limitations identified and the goal of the study;
5. the study report is transparent and consistent.

The review was performed according to paragraph 6.3 of ISO 14044.
The Panel has verified the conformity of the main LCA Report (Confidential and third-party LCA report (Non Confidential, publicly available) to the requirements stated in the ISO 14040 and ISO 14044.

NORMATIVE REFERENCES

- ISO 14040:2006, Environmental Management – Life Cycle Assessment – Principle and framework
- ISO 14044:2006, Environmental Management – Life Cycle Assessment –Requirements and guideline
- ISO/TS 14071:2014, Environmental Management – Life Cycle Assessment – Critical Review process and review competencies: Additional requirements and guidelines to ISO 14044:2006

Specific requirements for comparative LCA report, publicly available

Requirements for third-party report are stated in § 5.1 and § 5.2 ISO 14044.
As stated in § 5.2 of ISO 14044, when results of the LCA have to be communicated to any third party (i.e. interested party other than the commissioner or the practitioner of the study) a third-party report shall be prepared. The third-party report can be based on study documentation that contains confidential information that may not be included in the third-party report.
For LCA studies supporting comparative assertions intended to be disclosed to the public also the requirements listed in § 5.3 shall also be considered in addition to those identified in 5.1 and 5.2.

INFORMATION ON LCA REPORT

LCA Report [3M Confidential version]
"PROJECT PANDIA, LCA0014
Comparative Life Cycle Assessment of LED-enabled LCD TVs over their entire life cycle, comparing the effect of the integration of cadmium based and non-cadmium based light enhancement films", Version 1, effective date 31 December 2015

Third Party Report [Non Confidential version]
"PROJECT PANDIA, LCA0014
Comparative Life Cycle Assessment of LED-enabled LCD TVs over their entire life cycle, comparing the effect of the integration of cadmium based and non-cadmium based light enhancement films", Version 1 – Non Confidential Version for public consultation, effective date 31 December 2015

The commissioner of the Critical Review: **3M BELGIUM BVBA**

The commissioner of the LCA Study: **3M Display Material and System Division (DMSD)**

LCA practitioners: Katerina Softa (LCA Engineer), Jonas Depelchin (Advance LCA Engineer) in 3M West Europe's Sustainability Center of Expertise's LCA Department.

Author of the LCA Study: Katerina Softa
Reviewer of the LCA Study: Jonas Depelchin
Approver of the LCA Study: Kristof Peerens

INFORMATION ON PANEL REVIEW

SGS Italia SpA was selected by 3M Belgium BVBA (hereafter referred to as 3M) as external independent expert to execute a Critical Review according to ISO 14040, ISO 14044 requirements for a comparative LCA. A SGS technical reviewer was nominated as chairperson of the panel review. Based on the goal and the scope of the study the members of the panel where selected to provide all the necessary competences and knowledge to cover all the following topics:

- ISO 14040 and ISO 14044
- LCA methodology
- Critical Review practice
- The scientific discipline relevant to the important impact categories of the study
- Environmental, technical and other relevant performance aspects of the product systems assessed
- The language of the study

The practitioner and the commissioner of the study did not propose other candidates to serve as independent expert or interested parties.

Review Panel:

- ANGELO FERLINI: Technical Reviewer and Chair (SGS Italy SpA)
- AMBRA MORELLI: EPD and Weeelabex Lead Auditor, WEEE and Environmental Specialist (SGS Italy SpA)
- PAOLO SIMON OSTAN : LCA Specialist and PCR Moderator (Technical Expert)
- ROBERTA BERTANI: Professor of Chemistry for Technologies Science and Technology of Materials, at the Department of Industrial Engineering , (University of Padova)

Review process:

- The review was performed based on ISO 14044, 6.3
- The review was performed at the end of the study
- The review included an assessment of the LCI model
- The review included an analysis of the individual data set.

CRITICAL REVIEW PROCESS

The Critical Review process is a technique for verifying that the LCA study was conducted according to the methodology and principles contained in the ISO 14044 regulations, allowing the Organization to strengthen the credibility of the conducted LCA study.

The Critical Review process *"ensures that the classification, characterization, normalization, grouping and weighting elements are sufficient and are documented in such a way that enables the life cycle interpretation phase of the LCA to be carried out"*

As indicated in paragraph §7.1 of ISO 14040 *"a critical review can neither verify nor validate the goals chosen for an LCA* by the study commissioner, *nor the ways in which the LCA results are used ".*

The scope of the Critical Review process is to enable the intended audience of the LCA study to understand the complexity and reliability/limits of the study itself.

The review process has been coordinated between 3M Belgium BVBA , that conducted the LCA for 3M Display Material and System Division (DMSD), and the chair of the review panel.

The main stages of the Critical Review process are listed below:

- The agreement between the parties was signed on November 2015
- The panel was selected and confirmed on 11st November 2015
- 3M provided the draft of the final LCA report on 11st December 2015
- The Critical Review panel evaluate the draft of the final report and provide comments of general, technical and editorial nature by 21st December 2015 listed in the critical review report template.
- Several meetings via phone conferences between the review panel and 3M were held from 11st December and 24th December 2015.
- The second draft of the report was delivered to the panel on 27th December 2015.
- A final set of comments have been address and agreed with 3M in 29th December 2015,
- The third draft of the report was delivered to the panel on 30th December 2015.
- All the main comments on the LCA reports are described and reported in this critical review statement.

2. CRITICAL REVIEW REPORT

GENERAL

Document presented for the Critical Review:
"PROJECT PANDIA, LCA0014 Comparative Life Cycle Assessment of LED-enabled LCD TVs over their entire life cycle, comparing the effect of the integration of cadmium based and non-cadmium based light enhancement films".
Version 1, effective date 31 December 2015 - 3M Confidential version

The commissioner of the Critical Review: **3M BELGIUM BVBA**

The commissioner of the LCA Study: **3M Display Material and System Division (DMSD)**

LCA practitioners: Katerina Softa (LCA Engineer), Jonas Depelchin (Advance LCA Engineer) in 3M West Europe's Sustainability Center of Expertise's LCA Department.

The project was coordinated by Kristof Peerens, Product EHS&R and Sustainability Specialist, 3M West Europe.

The Critical Review process was developed through a first phase of preliminary documents analysis of the LCA study, and a second phase of discussion with the practitioners of the LCA study in which the methodological and technical aspects have been more deeply analysed.

Following the first stage of documents review the Panel composed and forwarded to the committee a preliminary Critical Review Report in which were highlighted potential significant issues found in the LCA study which required deeper investigation.

The following analysis performed by the panel, conducted with the direct participation of people who contributed to the completion of the LCA study, reviewed the appropriateness of the methodologies used for data collection and the computation models used, in accordance with what was already identified in the preliminary documents review.

The panel review met with the following people responsible for data management and completion of the LCA study:

- Kristof Peerens (3M Sustainability Services - Product EHS&R and Sustainability Specialist)
- Katerina Softa (3M Sustainability Services - LCA Practitioner/author)
- Jonas Depelchin (3M Sustainability Services – Project coordinator and LCA Internal Reviewer)

About the review of the data sets a sampling approach has been applied.
The Panel Review has not conducted a systematic check of the original data sources for all the data used in the study but they have been examined with a sampling technique

The data that have been considered during the sampling activity were selected by each member of the panel based on their competence and specific experiences. All the main data regarding, as example chemicals, energy consumption, emissions and waste were checked.

The set of data that were not fully checked by the Panel were the confidential data used in the model provide by the external party (Thinkstep) related to production of the LCD TVs and related EoL treatments.

GOAL AND SCOPE OF THE STUDY

The goal, scope, objectives and the intended application of the study are clearly reported in the study; the intended audience and limitations of the analysis have also been included.

The LCA report shows, in detail, in the chapter 2 "Goal of the study" and chapter 3 "Scope of the study": the description of the functional unit, the system boundaries, the cut-off criteria, the allocation methods, the types and data sources, the data quality requirements, the general assumptions and the description of the Critical Review process.

During the Critical Review process the Panel requested to:

- Specify, in § 2.1, the exact type of device considered within the study
- Add the description of the product, with specific reference to LCD TVs use in the models
- Clarify the approach for the determination of the functional unit and the supporting documents references (as PCR or scientific publications)
- Detail the material content of the parameterise LCD TV.
- Clarify at this level where the products and main components (QDEF) are produced

The additional information required have been added in the final LCA report in § 2 and § 3, detail on LCD TVs are available in §4.7.3.

- Clarify the methods that was expected for the external communication of the LCA study (included type of documentation and reporting).

The final LCA report defines in the §2.1 the availability of a Non Confidential Report (Third-party report) for the external communication. The Non Confidential Report has been drafted and sent to Panel Reviewers.

<u>System Boundaries and Exclusions</u>

The system boundaries were clearly stated, by considering a cradle-to-grave approach which covers all the life cycle stages from the acquisition of raw materials, production and packaging, distribution and use up to including the EoL treatment of the product; overall this approach is considered consistent with the objective of the study.

During the Critical Review process, the Panel requested to:

- Evaluate the equivalence between the system compared and declare difference between the systems (as required at §4.2.3.7 of ISO 14044, in case of comparative LCA)
- Clarify the statement reported at the paragraph 3.4 of the final LCA report: "the most important material production and average manufacturing processes have been considered". This phrase could be misunderstood.

The additional information required has been added in the final LCA report in § 3,4

- Add the allocation used for the production of QDEF and LCD TVs

The additional information required has been added in the final LCA report in §3.6.2 and 3.6.3

- Add the Cut off criteria for LCD TVs if applied

The additional information required has been added in the final LCA report in §3.7.

- The data quality assessment has been performed with the PEF methodology approach. The PEF approach and the "Data quality rating system" should be clearly described in the 3.10 paragraph and link to the chapter 5.3 should be added.

The additional information required on foreground data has been added in the final LCA report in §3.10. The quality assessment was performed for QD, 3M QDEF and LCA TVs. Information on the data quality assessments is available in § 5.3 for QD, 3M QDEF and LCA TVs.

During the Critical Review process, the Panel requested to adopt, in the LCA study, a single allocation approach for the waste flows generated during the life cycle. In fact two different approaches were used: "polluter pays principle" (attributional LCA) since the recycling process has been excluded from the system boundaries and the "system expansion" approach (consequential LCA) since the credits (avoided burden) from the production of electricity and heat of waste-to-energy treatments has been included.

In the final LCA report all references to the polluter pays principle have been removed but the use of two different allocation approaches for the waste flows has still adopt in the LCA study. 3M conducted a sensitivity analysis (paragraph 6.3.2) on the effect of avoided burden as compared to overall polluter pays approach and, for the large majority of indicators, the impact can be considered negligible.
The panel review, considering the irrelevant impact of the choice made for the allocation of waste flows, decided that the LCA model can be considered reliable.

Comment: It is recommended to use a single allocation approach for the waste flows in case of revision of the LCA study.

SELECTION OF THE ENVIRONMENTAL INDICATORS

The Panel deems the choice of the characterization methods in line with objectives and scope of the LCA study. The results of the LCA study are transparent and not misleading for the intended users.

The Organization has chosen the CML 2001 method with the most recently published characterisation factors (April 2013).

- Abiotic depletion potential, elements (ADPe)
- Abiotic depletion potential, fossil (ADPf)
- Acidification potential (AP)
- Eutrophication potential (EP)
- Freshwater aquatic ecotoxicity potential (FAETP)
- Global warming potential (GWPin)
- Global warming potential, excluding biogenic carbon (GWPex)
- Human toxicity potential (HTP)
- Marine aquatic ecotoxicity potential (MAETP)
- Ozone layer depletion potential (ODP)
- Photochemical ozone creation potential (POCP)
- Terrestric ecotoxicity potential (TETP)

Product Environmental Footprint (PEF) method has also been selected , this methodology combines a number of midpoints from different methodologies, all of which have been included in the report.

- Acidification (Acid)
- Climate change, excluding biogenic carbon (CC_ex)
- Climate change, including biogenic carbon (CC_in)
- Ecotoxicity freshwater (ETF)
- Eutrophication freshwater (EPF)
- Eutrophication marine (EPM)
- Eutrophication terrestrial (EPT)
- Human toxicity, cancer effects (HT_c)
- Human toxicity, non-cancer effects (HT_nc)
- Ionising radiation, human health (IR)
- Ozone depletion (OD)
- Particulate matter/Respiratory inorganics (PM/RI)
- Photochemical ozone formation, human heath (POF)
- Resource depletion, water (RDW)
- Resource depletion, mineral, fossils and renewables (RDMFR)

During the Critical Review process the Panel, due to the presence of a selected USEtox indicators and related comments, asked to select and evaluate the alternative substances (used as substitutes of substances not found in GaBi database) not only on the basis of their environmental impact but also by similar hazardous statements. The Panel also suggests to investigate the impacts generated by using this alternative approach.

The first draft of the LCA report included also:
USEtox: this impact assessment method is a scientific consensus model endorsed by the UNEP/SETAC Life Cycle Initiative for characterizing human and ecotoxicological impacts of chemicals. The midpoint categories recommended and included in the report are:

- o Ecotoxicity (Ecotox)
- o Human toxicity, cancer (Htox_c)
- o Human toxicity, non-cancer (Htox_nc)

In the final LCA Report the following statement has been added as a limitation (§7.2) chapter:

- For substances used in the supply chain for which no data sets were readily available, or no straightforward alternative modelling process could be identified (e.g. modelling the manufacturing process of the material), alternatives needed to be assumed for the purpose of the study. These alternatives were selected in order to approach the supply chain process as much as possible, as such mostly focusing on materials with similar environmental impacts, instead of the chemical hazards related to the substances required. As a result, the LCA results related to human health and toxicity may differ slightly from reality, and should be carefully assessed prior to using in comparative assertion.

In accordance with this declaration the selected USEtox indicators and related comments have been eliminated from the final LCA Report.

INVENTORY ANALYSIS

Regarding the inventory analysis of the LCD TVs and the related end of life processes Thinkstep AG were commissioned by 3M to create a manufacturing model of a LCD TV and an EoL model.
During the Critical Review process, the Panel provided the following comments about the inventory analysis of the LCD TVs and the related end of life processes:

- as in the use phase a series of different LCD TVs models have been considered for the estimations of energy consumptions, also for the manufacturing of the LCD TVs (e.g. materials composition) the same approach should be used (or, at least, a validation based on official bibliography data should be performed);
- detailed information about the model used for the LCD TVs manufacturing (e.g. raw materials, production processes, transports, etc.) is not available in the LCA report;
- detailed information about the treatments of the waste generated during the LCD TVs manufacturing is not available;
- a clear description of the EoL scenario is not available in the LCA report, e.g. the percentage of the waste materials divided into the different types of treatments;
- since the LCD TV production and the related EoL scenario are important phases in the LCA study the documentation used by Thinkstep should be clearly reported in the LCA bibliography

More detailed information regarding the LCI model of the manufacturing of the LCD TVs and the related EoL has been provided by 3M. Several information required in the comments have been added in the final LCA report at paragraphs 4.7.3, 4.9 and in the bibliography. Despite this the information and the LCI data reported in the final LCA report are still lacking due to the fact that Thinkstep models are based on confidential datasets. The panel review has however verified that the main methodological requirements of the LCA reference standards used for the LCD TVs model and the related EoL model have been met. In fact, the datasets can be considered in the same way as GaBi database processes and a reasonable level of reliability is ensured. The use of those data from Thinkstep has been included *by 3M as a limitation of the study in the interpretation chapter of the LCA study by sharing this decision with the Panel review.*

Comment: It is recommended to include, in case of revision of the LCA study, more detailed information regarding the inventory analysis of the LCD TVs and the related end of life processes.

During the Critical Review process, the Panel also provided the following remarks regarding the inventory used in the LCA study:

- ✓ Are not available details about the composition (% materials) of the 3 different types of LCD TVs use in the study

The additional information required has been added in the final LCA repor. Table with composition details added to section 3.3. Further down the report, weight information as well as make and model of the TVs used for modelling are provided in section 4.7.3.

- ✓ Clarify that QDEF and QD productions are upstream processes, indeed the core (as shown in Figure 3) is the manufacturing of the LCD TV.

The additional information required has been added in the final LCA report.

- ✓ Should be reported information on QDEF production sites (di*vided between the various manufacturing plants)*

The additional information required has been added in the final LCA report.

- ✓ Is not available information on transport of all raw materials to China manufacturing site. The paragraph should clarify the division between the transport involved in the different phases (especially for the LCD manufacturing scenario)

The additional information required has been added in the final LCA report (§4.5.5).

- ✓ *To increase the transparency of the LCA Report it is suggested to insert information on all type of waste divided by the different phases of the LCA (e.g: QDEF, LCD Manufacturing, EoL of LCD)*

The additional information required hasn't been added in the final LCA report

Comment: It is recommended, in case of a revision of the LCA study, to increase the transparency of the Report adding this data.

- ✓ Some synthesis reactions used in the model not always follow punctually the synthesis reactions proposed by literature (e.g antimony triacetate, cobalt acetate, isophtaloil chloride, sartomer, Tri-n-octylphosphine, diphenylphosphine, dimethylaminopyridine(DMAP), diethyl zinc)

An analysis on the contribution of chemicals involved in the synthesis reactions has been sent to the Panel. The analysis shows that, apart from eutrophication midpoints, the impact of all these chemicals combined does not exceed 1% and that, after normalisation, the contribution is even far below 0.05%.

The final LCA Report includes this consideration in the limitations §7.2 and recommendations §7.3.

Checked the analysis done on the contribution of chemicals involved in the synthesis reactions in the overall impacts, the Panel agrees with the approach set out in the study with special reference to statements available in the limitations and in the recommendations chapters.

Comment: It is recommended, in case of revision of the LCA study, to deeply investigate the part of the synthesis reactions.

- ✓ Is not available information about the "general manufacturing process" of the QDEF. To increase the transparency of the report and understanding of the QD and QDEF production phase, a descriptions of this information should be reported.

The additional information required has been added in the final LCA report: high level process flows inserted to the appropriate sections in 4.7.1 and 4.7.2.

- ✓ the packaging "*Mylar* " is composed by ethylene glycol and terephthalic acid (PET) and not in PE

Based on supplier information, different options are available for Mylar bags. Assessment carried out, comparing different options, shows that 3M's assumption (also available in reference [14]) is most conservative [19].

- ✓ Is not available a clear description of the use scenario and the energy mix used (European/Regional). Is not available information on energy consumption of the 3 LCD TVs. This information are essential because of the contribution on the final results. Used data and the tests done (QDEF) have to be reported in the study.
- ✓ The tests to determine the% of energy savings by the TV2 (with QDEF) compared to TV1 (without) and TV3 (alternative) are made internally by 3M. This may not guarantee the impartiality. In the public report it should be state as an important limitation.

Details added to "use" section of the report (4.8), and partly removed from the "scenario analysis" section (e.g. EU grid mix)

The additional information required has been added in the final LCA report in particular has been inserted the "internal testing results" into the limitations chapter.

- ✓ The CAS of the Selenium (78-50-2) is not correct. In general is good practice to insert always the CAS number of the substances.

In the final LCA Report CAS numbers have been added for all materials that are substances. The limitations chapter has been update.

In the final LCA report CAS number of Selenium has been corrected to 7782-49-2 in text and figure.

RESULTS AND INTERPRETATION

The results are correctly presented per functional unit, they are clear and exhaustively reported in the LCA report.

The interpretation phase, in line with the requirements of the ISO 14044, reflects the fact that the LCIA results are based on a relative approach, that they indicate potential environmental effects, and that they do not predict actual impacts on category endpoints, the exceeding of thresholds or safety margins or risks.

During the Critical Review process, the Panel also provided the following remarks regarding the results and interpretation:

- ✓ Since the study have a significant number of hypothesis and limitations (including those in the interpretation chapter), the phrase "it can be stated with certainty" should be reviewed.

In the final LCA report the conclusion has been reviewed.

- ✓ By checking the "Graphical representation of environmental impacts" (chapter 6.1) it is possible to see that if the uncertainly range is considered in the result interpretation, the statement "are a number of environmental impact categories where the impact of TV2 is significantly lower as compared to TVs" is not properly correct. In fact, for the CML ADPf, for example, the lower value of the uncertainly range for TV1 and the higher value of uncertainty range of TV2 are practically the same. This consideration are valid also for other impact categories in which you declare a lower impact for the TV2. It is then important to describe in the report which is the approach that you applied for the comparison of the results and the associated uncertainties.

In the final LCA report the conclusion has been reviewed and additional information on the approach applied for the comparison of result has been added.

- ✓ Since the USETox indicators (Ecotoxicity, Human toxicity) are included in the LCA results, it is recommended to evaluate the substances not only for "similar production process" but also considering similar function and hazard statements (eg H3XX).

In the final LCA report the selected USEtox indicators have been eliminated and any assertion has been made or included using these indicators.

- ✓ The dimension of the whole device may influence the final impact, it is recommended to investigate on this alternative scenario.

The final LCA report includes information and introduces a Scenario tested. The results have been added in a new paragraph (6.2.7) as well as in the conclusions (7.1).

- ✓ Chapter 7.2 the statement "Assumptions, as well as sector and market averages were used to model LCD TVs and the possible EoL scenarios. Could be misunderstood. It is necessary to clarify that the average is applicable only to the use phase of LCD TVs and not for manufacturing process considered in the model.

The additional information required has been added in the final LCA report and the limitations chapter has been reviewed.

THIRD PARTY- REPORT

During the Critical Review process, the Panel also provided the following remarks regarding the Third Party- Report:

- ✓ In the NON Confidential Report FrontPage - is necessary to add a statement that the report is the NON Confidential Report Version.

The FrontPage of the final Third Party Report has been modified: Non – confidential version, for public consultation.

- ✓ The non-confidential LCA report have to include the following statement in compliance with 5.3, letter E, point 8:
  " LCIA results are relative expressions and do not predict impacts on category endpoints, the exceeding of thresholds, safety margins or risks"

The final Third Party Report has been modified (§ 5.1).

- ✓ Since the disclaimer you reported in the point 2.3 of the not-confidential LCA report is a very important point, it should be included also in the conclusion of the report (chapter 7) to allow the reader to correctly interpret the conclusion.

The final Third Party Report has been modified (§ 7).

- ✓ The paragraph 5.2 of the ISO 14044, point d) Life cycle inventory analysis, report that the public available report have to include "qualitative and quantitative description of unit processes". The LCA report, in particular the not-confidential version has a very brief description of the processes in fact most of the processes for the TVs are included in the thinkstep study which is not public available.

All the unit processes regarding the TV production have been checked during the Critical Review process and they can be considered adequate. Most of those unit processes are based on confidential data and information could be not inserted in the third party report.

Comment: It is recommended to include, in case of revision of LCA study, more detail information regarding the inventory analysis.

3. CONCLUSION

The Panel Review evaluates that the LCA study is compliant with the methodology and principles contained in the ISO 14044 regulations. The LCA report is sufficiently transparent in the description of the analysis carried out, of the main contributions to the considered impacts and of the results and relative uncertainty factors.

A point of strength are the sensitivity analysis conducted on the major points of uncertainty.

The globally selected data were evaluated to be generally reliable.

The calculation software chosen (GaBi Software®), the assumptions and the methodological choices (e.g. system boundaries, allocations, etc.) are appropriate with respect to the stated objectives.

The main limitations concerns:

- Use of LCD TVs models, developed by external party (Thinkstep AG) not based on sector representative data.
- Use of alternative substances to substiture substances for which no data sets were readily available or no straightforward alternative modelling process could be identified.
- Chemicals models based on assumptions related to chemical reaction processes that may differ from reality.
- Tests on energy efficiency have been carried out by 3M internally and they may not guarantee impartiality.

The Panel Review encourages the use of data and information ever more detailed and relevant for the organizations / processes involved in the life cycle of the products.

The Panel Review evaluates that the Third-Party Report is compliant with the applicable requirements of ISO 14044.

Disclaimer

This review statement in only valid for the LCA reports (main report and third party repot) received on 30 December 2015.

SGS Italia SPA and the Panel Review are not responsible of any partial content extracted from the LCA study (3M confidential or Non confidential reports) and use for misleading communication purpose.
It is pointed out that the environmental claims and the requirements for the environmental communication are regulated by ISO 14021 and ISO 14063 under the responsibility of the commissioner.

Milano, 31/12/2015

Technical Reviewer: ANGELO FERLINI

Authorized by: PAOLA SANTARELLI

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