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Report
Life cycle assessment of a 3M QDEF-film

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Content

Digital attachment

Annex 3

Abbreviations

LCA	Life cycle assessment
LCI	Life cycle inventory
ALCA	Attributional life cycle assessment
QDEF	Quantum Dot Enhancement Film
PET	Polyethylene terephthalate
MSWI	Municipal solid waste incineration

Legend Graphs

1	Climate change
2	Ozone depletion
3	Terrestrial acidification
4	Freshwater eutrophication
5	Marine eutrophication
6	Human toxicity
7	Photochemical oxidant formation
8	Particulate matter formation
9	Terrestrial ecotoxicity
10	Freshwater ecotoxicity
11	Marine ecotoxicity
12	Ionising radiation
13	Agricultural land occupation
14	Urban land occupation
15	Natural land transformation
16	Water depletion
17	Metal depletion
18	Fossil depletion

1 Introduction

Improving the technical and environmental performance of consumer electronics is becoming increasingly important. Energy labels are a commonly known tool which try to inform customers about the performance of products [1], [2]. However, by improving energy efficiency of such devices other environmental consequences might occur that reduce or even nullify the energetic benefits [3], [4]. So before conclusions about the environmental performance can be drawn, the entire life cycle has to be taken into account.

This report describes a life cycle assessment (LCA) of a Quantum Dot Enhancement Film (QDEF) produced by 3M. Such a film can be applied in LCD screens where it maximizes both the efficiency and color performance of a display. A drawback of this technology is that the film encompasses cadmium containing crystals within a matrix layer. Since the cadmium content is the main issue of concern in this study, the effect of cadmium is analyzed in detail in relation to the environmental impact of the entire film. To take into account potential benefits, the 3M QDEF film is compared with an alternative film. The latter is cadmium free but less performant.

The potential risk for cadmium exposure is when after the service life the devices are disposed of. Especially airborne emissions due to incineration can have a significant effect on human health [5], [6]. Therefore, multiple end-of-life scenarios are included to take into account the uncertainty related to future actions. The first two scenarios are in accordance with current practice, namely sanitary landfill and municipal waste incineration. As a highly conservative assumption, uncontrolled open air incineration has been included as well. This in not common practice in the European Union due to current waste treatment regulations, but since the related emissions have a significant effect on human health, it is included as a 'worst case' scenario [7].

The report starts with the description of the goal and scope and how the life cycle is modelled in section 2. This section includes the description of the different scenarios and the selected environmental indicators as well. The results are presented in section 3 and further discussed in section 4. The report ends with an overall conclusion.

2 Methods

2.1 Goal & scope

The general objective of the study is twofold: on the one hand analyzing the environmental profile of a 3M QDEF film with special attention for the cadmium flows, on the other hand comparing this film with a Cd-free film taking into account the difference in energetic performance.

Both films can be applied in an identical television without any other adaptions, so the analysis of the television itself is beyond the scope of this research. Also all other parameters are assumed to be identical and therefore are not taken into account e.g., transport to stores, distribution, etc. Since no data was available on the production process of the Cd-free film, it is assumed this film is burden free. Only the difference in technical performance and energy efficiency is taken into account.

The main goal of this study is to gain insight in the environmental profile of the two alternatives based on current practice. As a consequence this study is an attributional approach. An attributional LCA (ALCA) can be defined 'by its focus on describing the environmentally relevant flows within the chosen temporal window' [8]. This means current market mixes are applied so all suppliers will be linked to the markets, regardless their level of technology.

The functional unit in this assessment is a film applied in a 48'' LCD TV, in operation for 5 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 and a color gamut of 100% NTSC.

The two films will be applied in a 48" Samsung UN48JS9000 television [9].

2.2 System boundaries

A LCA is simulation of reality so the boundaries of the study have to be defined. Some boundaries are related to how the LCA model is structured, such as for example the choice for an attributional approach. These assumptions and boundaries are described in the next section. Other boundaries are listed below:

<u>Included</u>:
- Transport of raw materials and between the different 3M plants
- Packaging of final products (QDEF concentrate and QDEF film)
- Energy savings due to the implementation of the 3M QDEF film vs. non-Cd film

<u>Excluded:</u>
- Intermediate packaging (impact assumed to be negligible)
- Capital goods of 3M plants

2.3 Data collection and LCI modeling

For this study, data has been extracted from the Ecoinvent database 3.1 [10] and modelled with Simapro software version 8.0.5. As recommended, only one database was used to avoid double counting or missing impacts. When data was missing, a proxy was constructed within the Ecoinvent database instead of adding records from other databases. Multiple system models are available in Ecoinvent, one consequential and two attributional ones. For this study, the default attributional model has been applied instead of the 'recycled content' attributional model. The harmful effects of cadmium mainly occur during the waste treatment, so internal and external waste treatment has potentially a big influence. Therefore there was opted not to have a cut-off as it might provide misleading results and does not stimulate actions to optimize waste recovery and recycling. This implies no recycled content, but recycling and energy recuperation are taken into account. The latter is implemented by means of system expansion, so both the treatment as the benefits of replacing other products on the market are taken into account.

Also in the case of processes with multiple outputs system expansion has been applied. Especially in the case of internal processes, by-products leaving the system are often intermediate but substitutable products.

Identifying a ratio for allocation representing the relevant underlying causal relationship was considered to be too subjective.

To obtain realistic results, specific LCI data was collected for internal production processes for both 3M and Nanosys processes. Fig. 1 shows a simplified flowchart of the included processes covered with specific data. Raw materials delivered by external suppliers are modelled with generic data because suppliers can change over time.

The geographical delimitation differs depending the type of data. Specific data is modelled with site depended local data e.g., electricity mixes and transport scenarios, while generic data is assumed to be global. The latter assumption is supported by statistics covering the trading of chemicals on a global market [11], [12]. Transport scenarios, market mixes and packaging are modelled accordingly.

When a film has been installed, whether it is the 3M QDEF or Cd-free version, this results in a technical improvement and a reduced energy consumption. According to the functional unit, the performance should be identical, so only the energetic performance differs. For a 48'' LCD TV with a luminescence of 311 cd/m² and a color gamut of 100% NTSC, the power difference is 43,0W.

For the sake of clarity, process flows containing cadmium are displayed separately as much as possible. This is particularly the case for waste products containing cadmium.

Annex 1 contains a graphical representation of the modeling structure and assumptions.

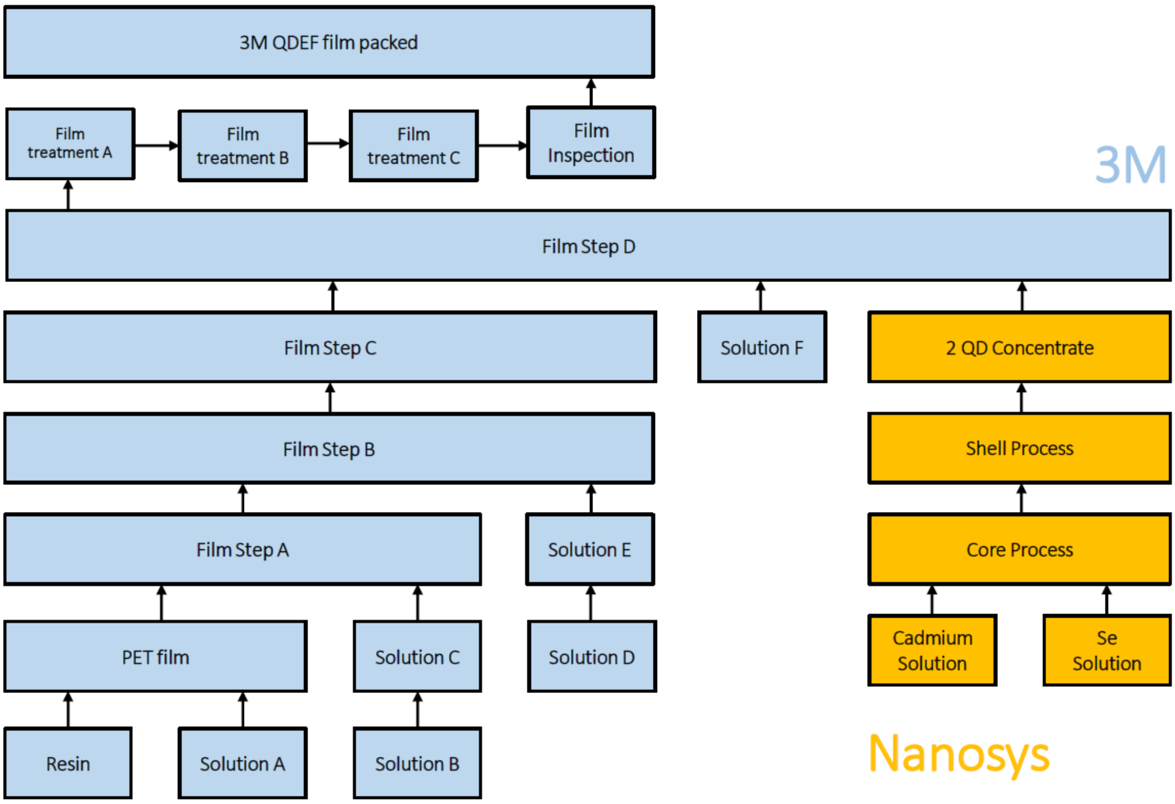

Fig. 1 Simplified flowchart of a 3M QDEF film

2.4 Scenarios and sensitivity analysis

In order to check if the results generated according to the LCI model described in the previous sections are robust, several scenarios are added as sensitivity analysis. These scenarios are spread over the different life cycle stages and mainly concern waste treatment, energy recuperation and energy mixes. In the next sections, the scenarios are described more in detail. For a graphical representation for the LCI model including the scenarios, see Annex 1.

2.4.1 Production phase

In the general LCI model energy recuperation has been taken into account during the incineration waste. The exact amount of avoided heat or electricity can differ over time because of the waste composition, the demand for energy, etc. Therefore the alternative scenario for the production phase is to exclude the energy recuperation.

2.4.2 Use phase

In the use phase, only the energy savings of the 3M QDEF film vs. the non-Cd film are taken into account. Depending on the region, the environmental profile of the grid electricity mix can vary substantially. To take these variations into account, multiple market mixes for electricity are taken into account [13], [14]. The selected regions represent the most important areas of distribution.

Selected regions

- EU
- USA
- Bulgaria
- China
- France
- Germany
- UK
- Italy
- Poland
- Sweden

2.4.3 End-of-life phase

After the useful service life of the television, the device is disposed of. Since it is not easy to separate the film from the rest of the television, is assumed the film will not be recycled. Similar to electricity production, there are regional differences in waste treatment practice [7]. Therefore three extreme scenarios are taken into account: complete landfill, municipal solid waste incineration and uncontrolled open-air incineration.

To get a clear image of the influence of cadmium, the waste flows are modelled separately. 1 kg of QDEF film contains slightly less cadmium as requested in the exemption according to the model (0,35 g instead of 0,42 g Cd / kg film). There has been opted to work with the most conservative assumption, therefore it is assumed the cadmium content is 0,42 g of cadmium per kg of film.

1. <u>Landfill</u>

The landfill scenario has been modelled as sanitary landfill. It is split up in the landfill of PET and Cadmium. The record for Cadmium is derived from a regular record for sanitary landfill, but it is assumed the input is 100% of cadmium. Emissions are adapted and scaled accordingly

- o Waste polyethylene terephthalate {RoW}| treatment of waste polyethylene terephthalate, sanitary landfill
- o Waste CADMIUM {RoW}| treatment of waste CADMIUM, sanitary landfill

2. <u>Municipal solid waste incineration (MSWI)</u>

A similar approach is maintained for incineration. The incineration of the film is modelled as the municipal solid waste incineration of PET, with or without energy recuperation (see section 2.4.1). The data for

Cadmium incineration is derived from a regular record for incineration, but it is assumed the input is 100% cadmium. Emissions are adapted and scaled accordingly. Due to the small amounts, no energy recuperation is taken into account for cadmium incineration.

- Waste polyethylene terephthalate {RoW}| treatment of waste polyethylene terephthalate, municipal incineration
- Municipal solid waste, no E recup - CADMIUM {RoW}| treatment of, incineration

3. Uncontrolled open air incineration

As a conservative and 'worst case' scenario, the uncontrolled open air incineration of waste is included. This is not common practice in Europe, but it might occur in remote areas with insufficient waste services. In MSWI plants, flue gasses are purified, waste water treated and residual solid waste is disposed off to landfills. As a result, only a small fraction of the harmful substance are emitted to the environment. In the case of uncontrolled open air incineration, such treatment does not take place. The amount of emitted substances may increase by a few orders of magnitude compared to MSWI with a significant effect on the environment and human health [15].

In the case of PET incineration, the basic record is the one of municipal solid waste incineration. The flue gas purification process is excluded and the emissions are scaled accordingly, following the emission factors described in the Ecoinvent reports [16], [15]. This dataset has been complemented with specific data of measurements concerning open air incineration as described by Park et al. [17] and USEPA (1995) [18]. The same is true for cadmium, but again with a 100% cadmium input.

- Waste polyethylene terephthalate {RoW}| treatment of waste polyethylene terephthalate, open air incineration
- Incineration of cadmium: Solid waste - CADMIUM {RoW}| treatment of, open air incineration

2.5 Selection of environmental indicators

To analyze the environmental impacts of the system under study, there are several impact assessment methods available. There is opted to work with the ReCiPe method, developed by RIVM, CML, PRé Consultants, Radboud Universiteit Nijmegen and CE Delft. In ReCiPe you can choose to use midpoint indicators or endpoint indicators. Each method has been created for three different perspectives [19].

The two default variants are:

- ReCiPe Midpoint Hierarchist version (1.12) with global normalization values
- ReCiPe Endpoint Hierarchist version (1.12) with global normalization values

The first method is the default midpoint version of ReCiPe. For illustration purposes only, the Endpoint version has been included as well. Even though subjective value choices are involved during the calculation of a single score indicator, the results are more clear and easier to interpret.

Additionally, following impact assessment methods have been included for the purpose of sensitivity analysis:

- EPD midpoints (2015)
  - This method contains the best-known set of midpoint indicators.
- ReCiPe Endpoint Egalitarian version (1.12) with global normalization values
  - Similar to the previous method, but with a single score indicator

3 Results

3.1 Life cycle 3M QDEF film, excluding use phase

In this section the results are presented of the production of the 3M QDEF film including end-of-life. So in general, all material related processes are included. In the regular models energy recuperation is taken into account when waste is incinerated, both for the production as the end-of-life phase. Due to the varieties related to waste incineration practices (plant efficiency, waste composition, area of distribution …) the benefits related to energy recuperation may differ as well. Hence a sensitivity scenario is presented as well at which energy recuperation during waste incineration is not taken into account. Both the midpoint and endpoint results of the ReCiPe Hierarchist version are presented and discussed (see Fig. 2-Fig. 7 and Table 1).

Looking at the normalized midpoint indicators, the high level of marine, freshwater and human toxicity can be noticed immediately. Especially the non-Cd materials and processes contribute majorly to these categories (and to the other categories as well). Looking at these non Cd-materials more into detail, apparently the main constituent for the film, namely PET, and the electricity consumption during the barrier coating process are the dominant sources. The effect of the cadmium content however is barely noticeable.

The end-of-life has a relatively small but not negligible influence. Especially the uncontrolled open-air incineration has a disadvantageous effect. But similar to the production process, this is mainly caused by the PET film and not by the cadmium content.

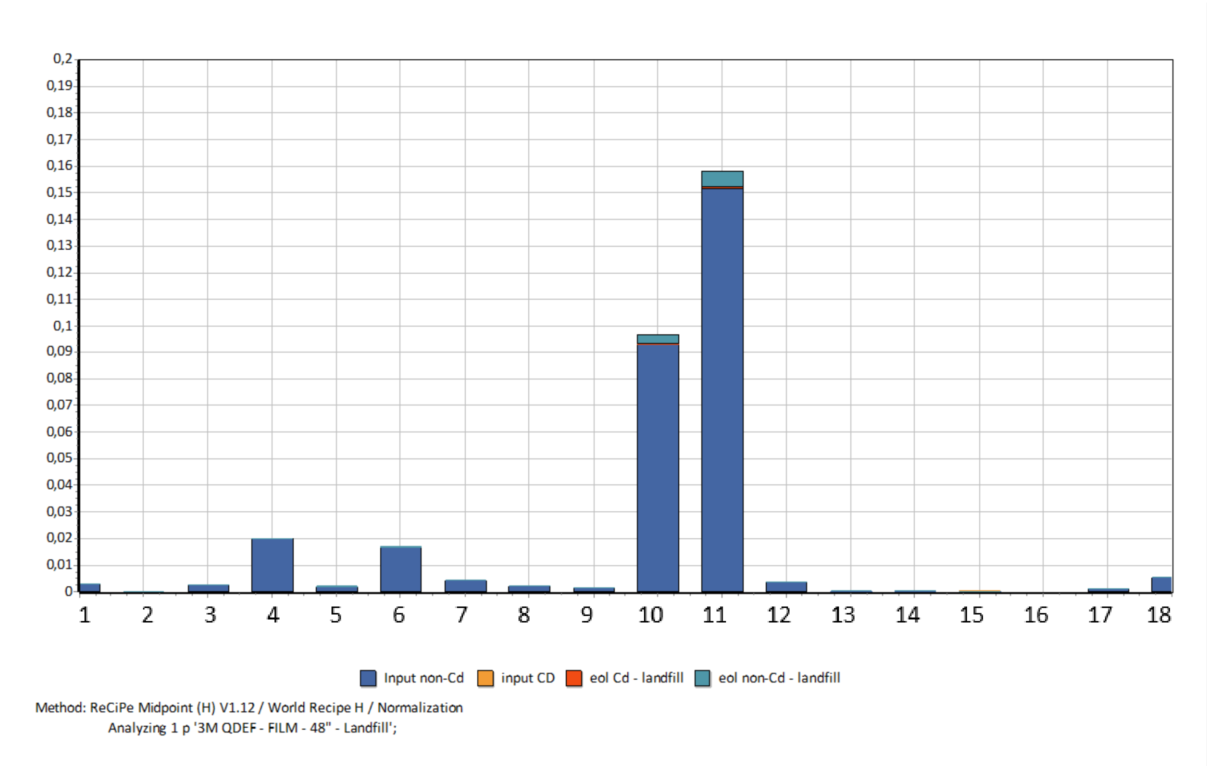

Fig. 2 Regular model, landfill (normalized ReCiPe midpoints - Hierarchist) – Legend presented on p. 2

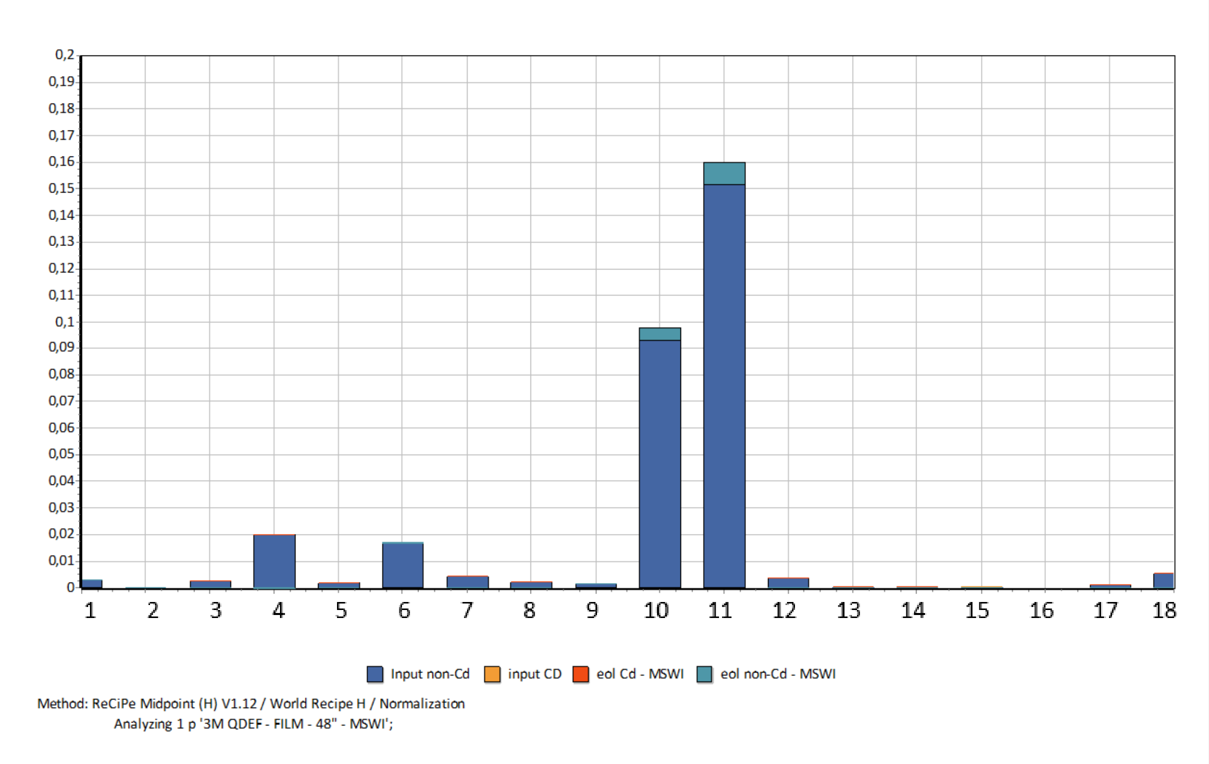

Fig. 3 Regular model, MSWI (normalized ReCiPe midpoints - Hierarchist) – Legend presented on p. 2

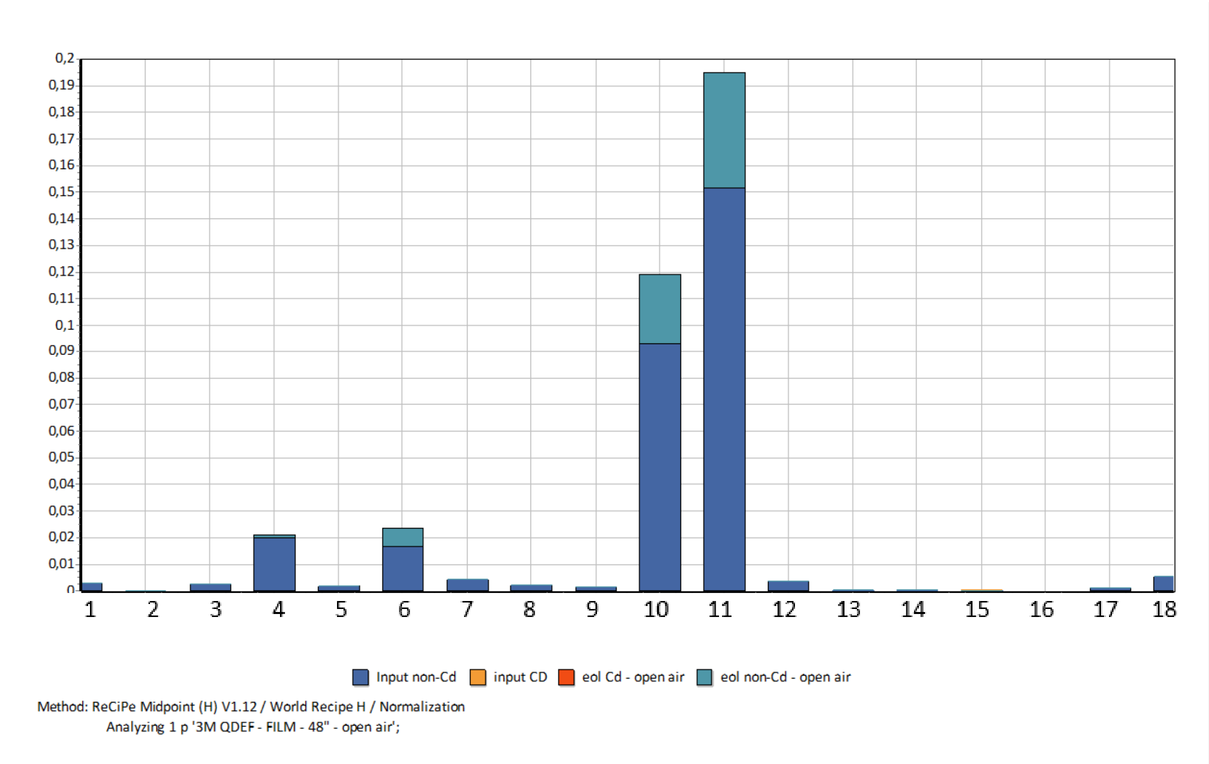

Fig. 4 Regular model, open air incineration (normalized ReCiPe midpoints - Hierarchist) – Legend presented on p. 2

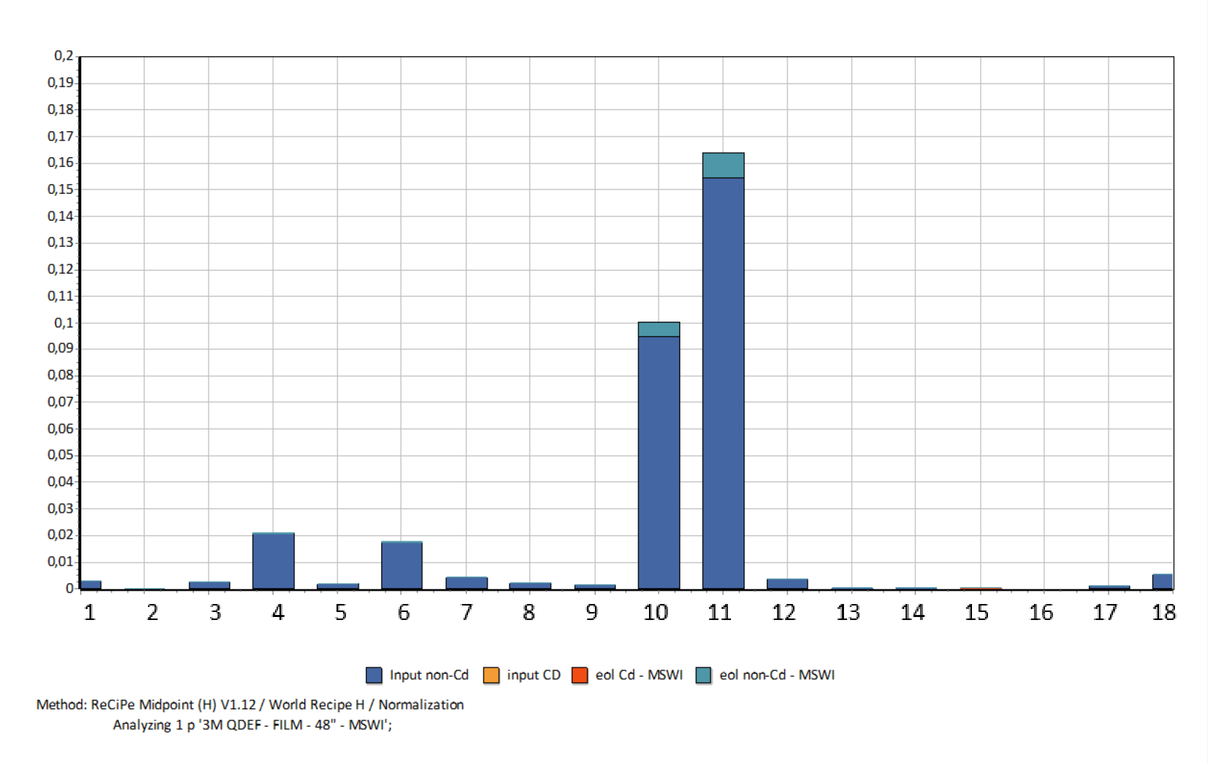

Fig. 5 Sensitivity 1, no E-recup, MSWI (normalized ReCiPe midpoints - Hierarchist) – Legend presented on p. 2

When energy recuperation during the waste incineration (both MSWI as incineration of production waste) is not taken into account, the impact in all categories raises. However, the effect is relatively small.

Analyzing the same scenarios but based on their single score, similar conclusions can be drawn. As displayed in Fig. 6, the non-cd material content is the dominant fraction. In Table 1 the single score of the different life cycle phases are displayed for the scenarios. In can be noticed that MSWI with energy recuperation even has a negative impact due to the high heating value of PET.

The sensitivity analysis where energy recuperation is excluded results in an increase of 6% of the total impact. In spite of the small effect in this study, the relevance of energy recuperation is an issue which cannot be overlooked on a larger scale.

For the purpose of illustration, the total impacts of the different scenarios are displayed in Fig. 7.

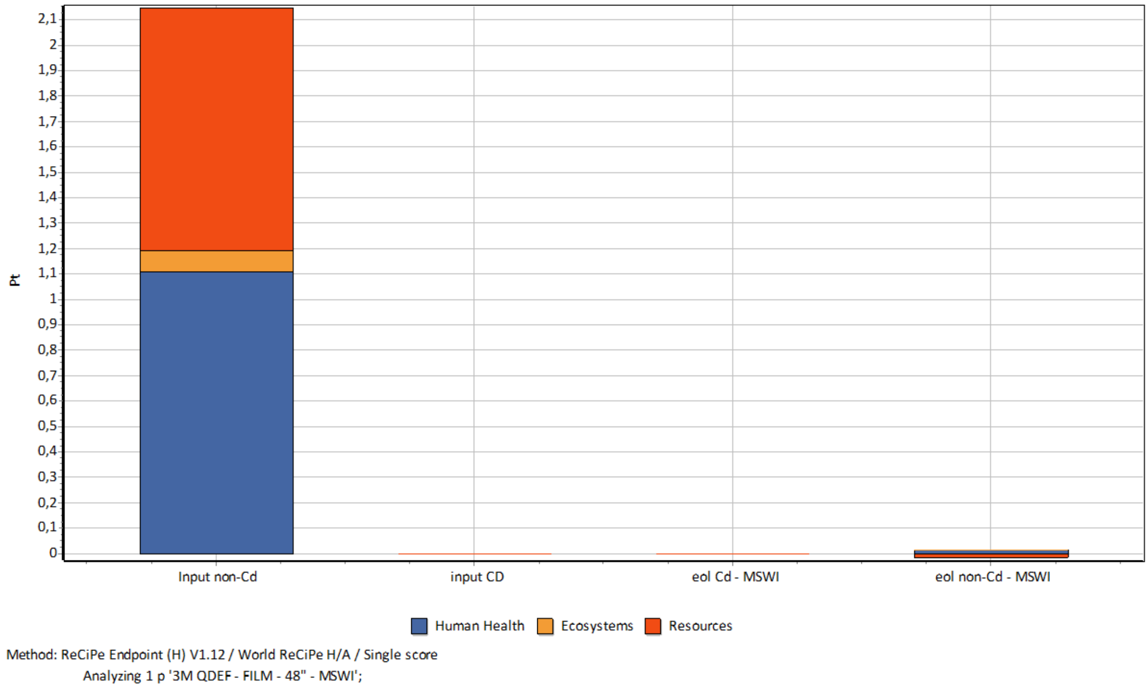

Fig. 6 Regular model, MSWI (ReCiPe endpoint Hierarchist) – Legend presented on p. 2

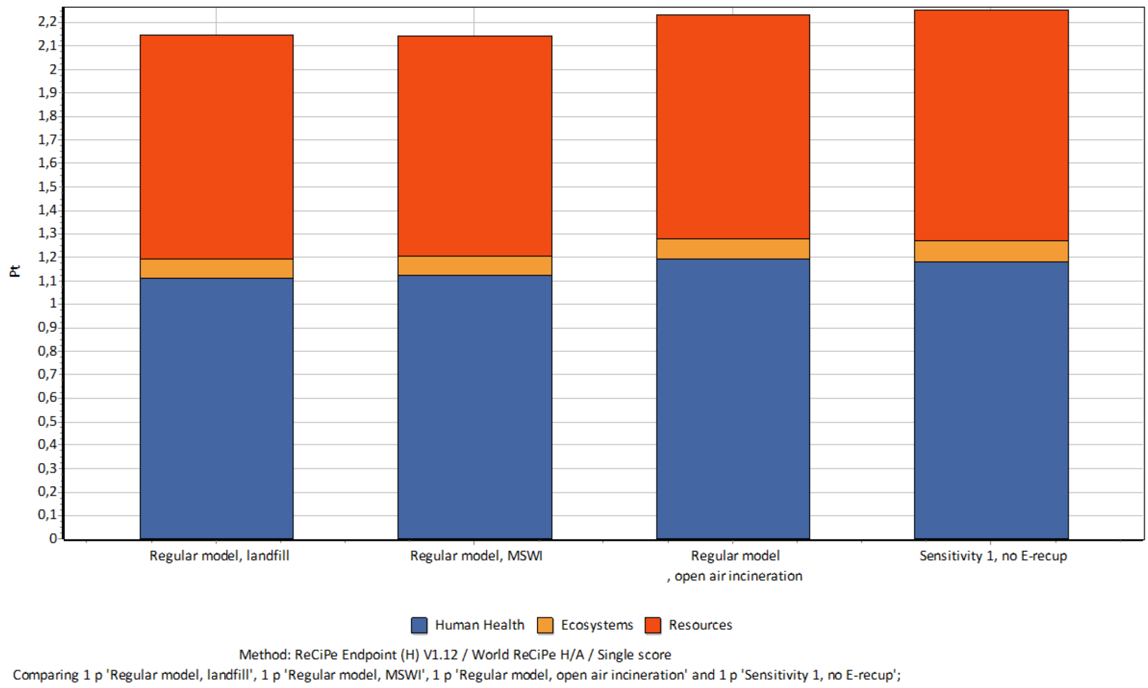

Fig. 7 Total impact of the four scenarios (ReCiPe endpoint Hierarchist) – Legend presented on p. 2

Description	Production (*Pt*)		Use (*Pt*)	End-of-life (*Pt*)		Total (*Pt*)
	Non-Cd	Cd		Non-Cd	Cd	
Regular model, landfill	2,15E+00	2,56E-08	-	3,32E-03	3,77E-04	2,15E+00
Regular model, MSWI	2,15E+00	2,56E-08	-	-1,79E-03	5,75E-05	2,14E+00
Regular model, open air inc.	2,15E+00	2,56E-08	-	8,84E-02	2,91E-04	2,23E+00
Sensitivity 1: no E-recup. , MSWI	2,22E+00	2,56E-08	-	3,70E-02	5,75E-05	2,25E+00

Table 1 Total impact of the four scenarios (ReCiPe endpoint Hierarchist)

3.2 Life cycle 3M QDEF film, including comparison use phase with non-Cd film

In this section, the avoided electricity consumption is included as well. Since the non-Cd film is assumed to be burden free and the use phase only considers the net difference between the two films, the results of this section represent in fact a comparison of the two films.

Fig. 8 shows the result of the regular scenario with MSWI for the waste treatment. For the avoided 1380 MJ, the average European electricity mix has been applied. It is clear that the positive effect of the avoided emissions surpasses the contribution of the production and disposal by a great extent. Especially for the categories at which the film production has the highest normalized environmental impact i.e., the toxicity indicators, the gains are the highest.

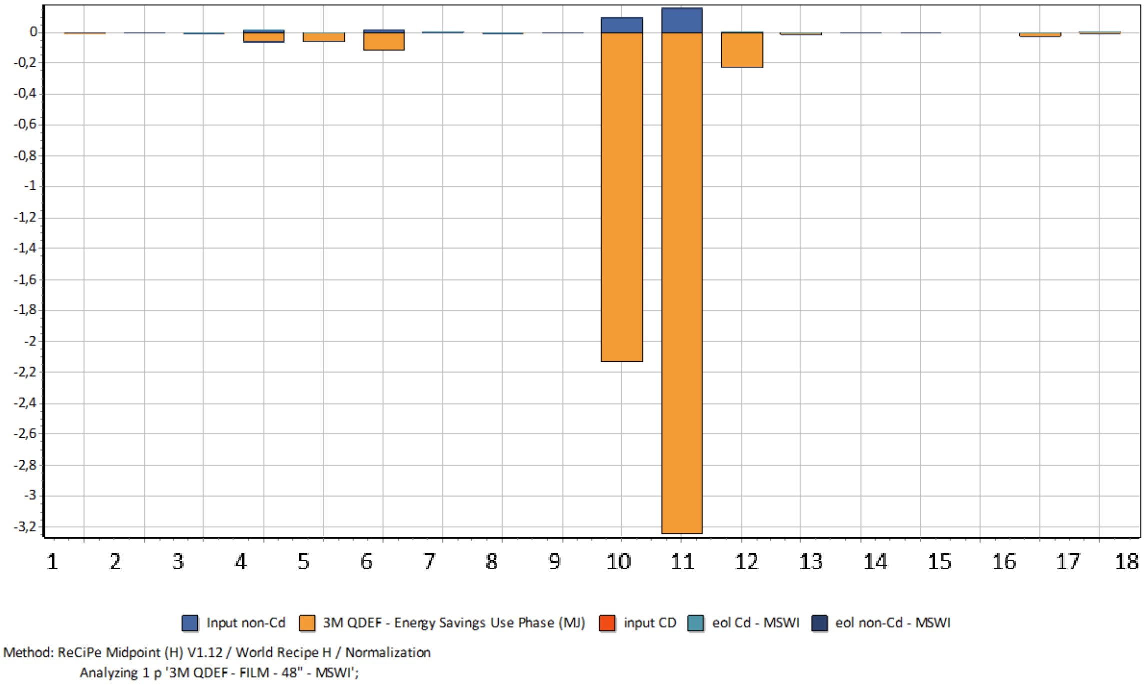

Fig. 8 Regular model, MSWI, including energy savings SE-mix (ReCiPe midpoint Hierarchist) – Legend presented on p. 2

The avoided electricity results in a lower environmental impact for all impact categories over the entire life cycle. However, there are large regional differences in the practice of electricity production, with corresponding variations in environmental impact. In Fig. 9 the impact of the avoided electricity is shown for the 10 most common areas of distribution of the finished televisions. As can be seen, the results differ substantially. However, for all mixes besides the Swedish one, the benefits of the savings surpass the film related impacts for all indicators. In the case of the Swedish mix, for one impact category the avoided impact is smaller than the film impact, namely for photochemical oxidant formation.

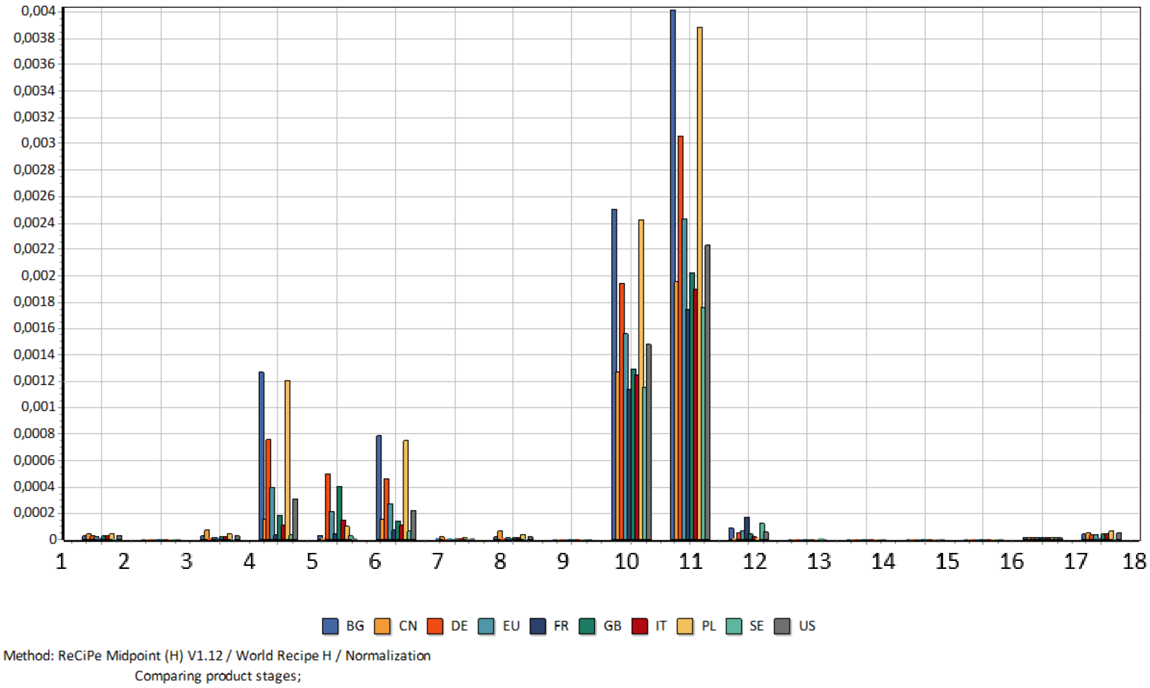

Fig. 9 Comparing Energy savings by regional electricity mix (ReCiPe midpoint Hierarchist) – Legend presented on p. 2

For de single scores, the previous conclusions become even clearer. Even in the case of the Swedish mix, with the lowest impact thus the smallest benefits, the savings are almost four times higher than the burdens.

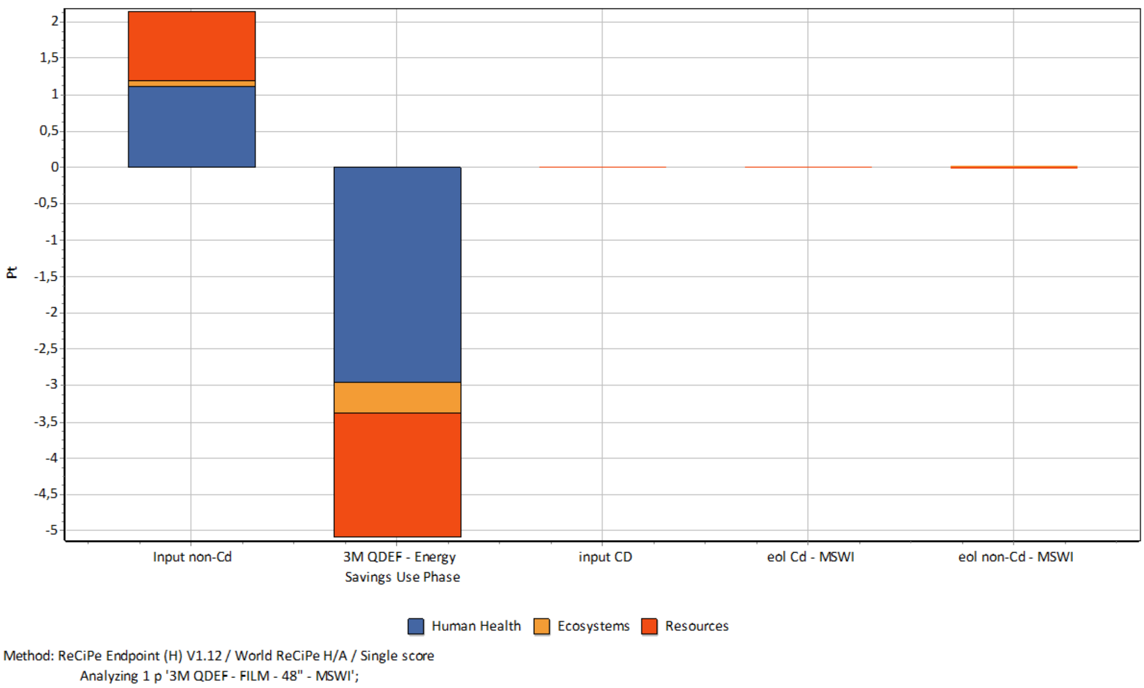

Fig. 10 Regular model, MSWI, including energy savings SE-mix (ReCiPe endpoint Hierarchist)

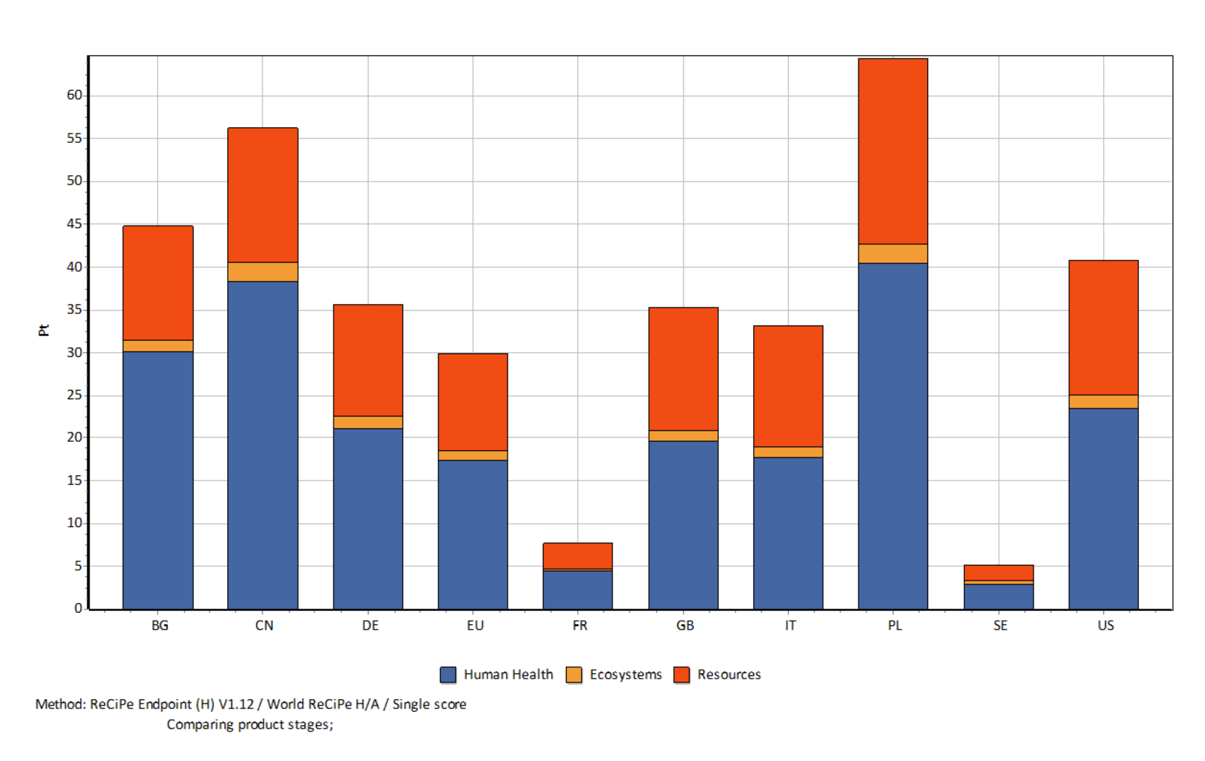

Fig. 11 Comparing Energy savings by regional electricity mix (ReCiPe endpoint Hierarchist)

3.3 Sensitivity methods impact assessment

3.3.1 ReCiPe Endpoint Egaliterian version

To verify the robustness of the conclusions, also the results of the single scores of the ReCiPe Egalitarian versions will be discussed. Similar to the previous sections, first the impact of the material flows is analyzed. In contrast to the Hierarchist version, the unfavorable effect of open-air incineration becomes much more pronounced (see Fig. 12 and Table 2). The latter makes sense since the Egalitarian version focusses on the long-term impacts increasing the relative proportion of toxic effects.

Description	Production (*Pt*)		Use (*Pt*)	End-of-life (*Pt*)		Total (*Pt*)
	Non-Cd	Cd		Non-Cd	Cd	
Regular model, landfill	5,19E+00	7,44E-08	-	5,58E-02	9,63E-04	5,25E+00
Regular model, MSWI	5,19E+00	7,44E-08	-	7,40E-02	1,15E-04	5,27E+00
Regular model, open air inc.	5,19E+00	7,44E-08	-	2,15E+00	7,43E-04	7,35E+00
Sensitivity 1: no E-recup. , MSWI	5,39E+00	7,44E-08	-	1,53E-01	1,15E-04	5,54E+00

Table 2 Total impact of the four scenarios (ReCiPe endpoint Egalitarian)

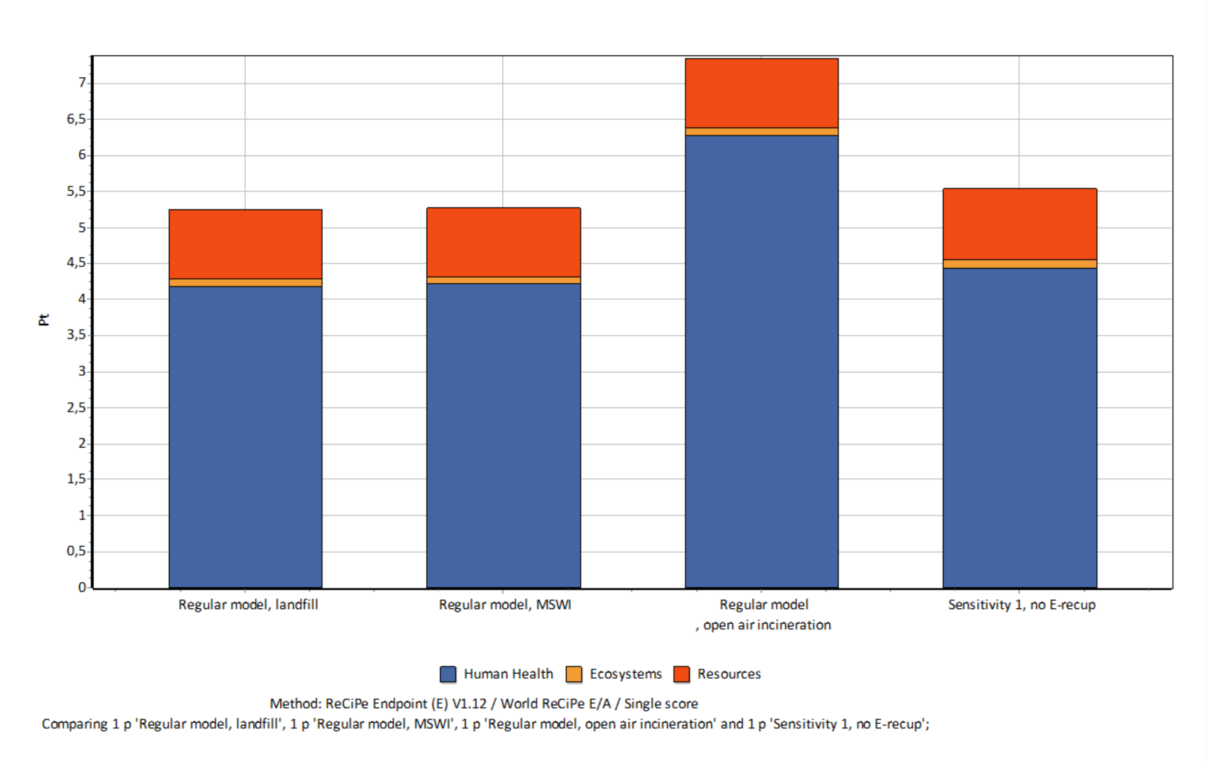

Fig. 12 Total impact of the four scenarios (ReCiPe endpoint Egalitarian)

When the avoided electricity is included, the results are very similar to the Hierarchist version. For both the life cycle impact and the different market mixes the conclusions remain valid (see Fig. 13 and Fig. 14)

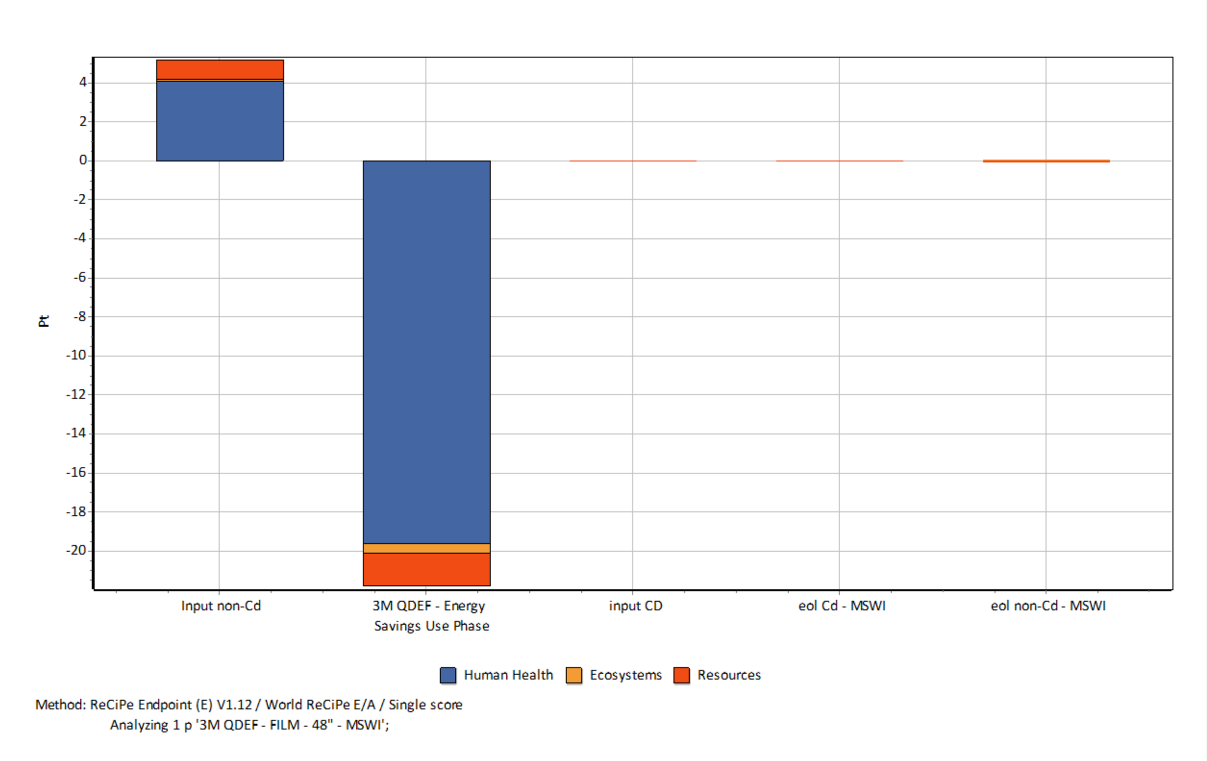

Fig. 13 Regular model, MSWI, including energy savings SE-mix (ReCiPe endpoint Egalitarian)

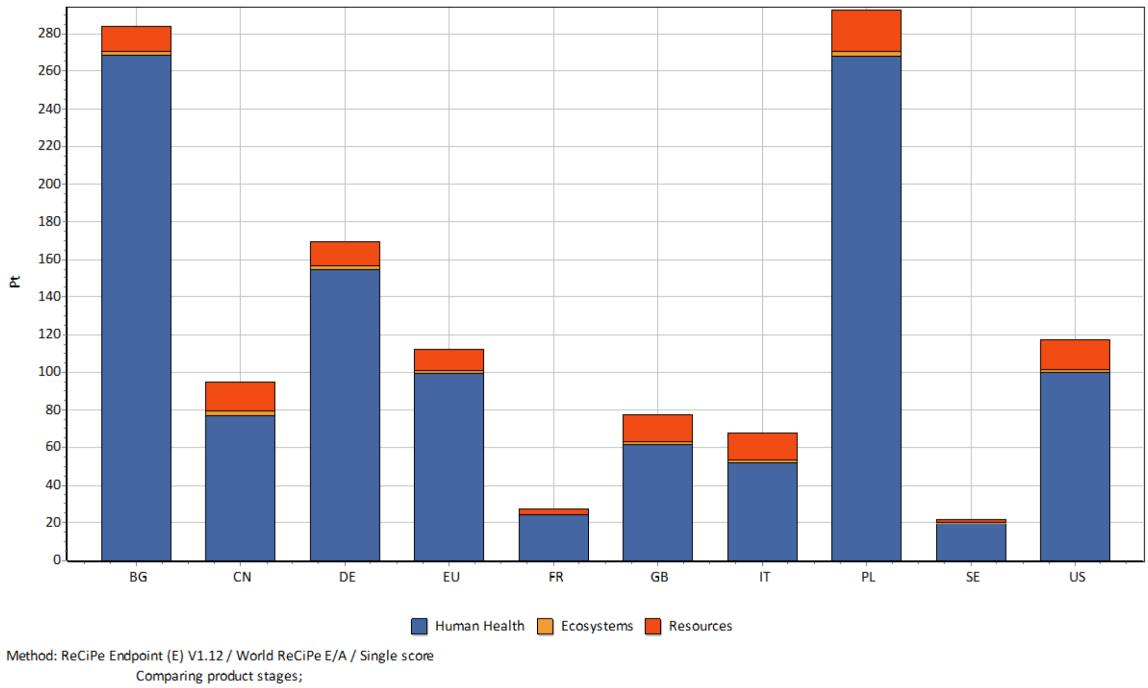

Fig. 14 Comparing Energy savings by regional electricity mix (ReCiPe endpoint Egalitarian)

3.3.2 EPD

The EPD midpoint categories show strong similarities with other midpoint impact categories of the ReCiPe Hierarchist version. Since the results according to the EPD indicators are analogue, they will not be discussed in detail. For the purposes of completeness, the results are displayed in Annex

4 Discussion and limitations

The results presented in the previous section indicate a clear potential for environmental savings due to the avoided electricity consumption when a 3M QDEF film is applied. To verify the robustness of the results, multiple scenarios have been added as sensitivity analysis, which all lead to a similar outcome. Some of these scenarios such as uncontrolled open air incineration are not current practice (or even legal) but they represent a ‘worst case’ scenario. A similar approach is applied in the energy scenarios, where there is mainly focused on the Swedish electricity mix. This is the mix with the lowest environmental impact, so consequentially, the benefits of avoided electricity consumption are the smallest. The results point out that the contribution of cadmium to the total material related environmental impact is very small. When the energy savings are taken into account as well, the influence of cadmium is negligible over the entire life cycle for all included scenarios.

The three most important aspects (and areas for improvement as well) are the impacts of the PET film production, the treatment of the non-Cd components after the useful service life and the applied energy mix during the use phase.

However, it is difficult to compare the results with other studies due to the focus on the film production only and not the entire television production, which is a limitation of this study. Other studies also indicate a lower energy use of the device, but since the functional unit used in those studies is different from the current one, comparison with the results they present should be carried out with care [3]. Such studies do reveal other ways for optimizing the environmental and energetic performance of televisions. So besides the implementation of films like the 3M QDEF film, a holistic design approach would probably be more beneficial.

A second limitation of this study is that no data was available on the non-Cd film. To assume this film is burden-free is not realistic, but a worst-case assumption. Especially when the performance of such films improves, a detailed LCA of production process should be carried out.

5 Conclusion

This study analyzed the environmental profile of the cadmium containing 3M QDEF film and compared this with a non-Cd film. For the 3M QDEF film, a detailed LCA was carried out, while the non-Cd film is assumed to be burden free. The final conclusion of this study is that in current situation, the benefits of the saved energy surpass the burdens of the film production for the 3M QDEF film, compared to the non-Cd film. A second conclusion is that within the 3M QDEF film, cadmium as such comes with a negligible environmental impact, compared to the non-Cd components in the process, even when conservative scenarios have been applied.

6 References

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Annex 1

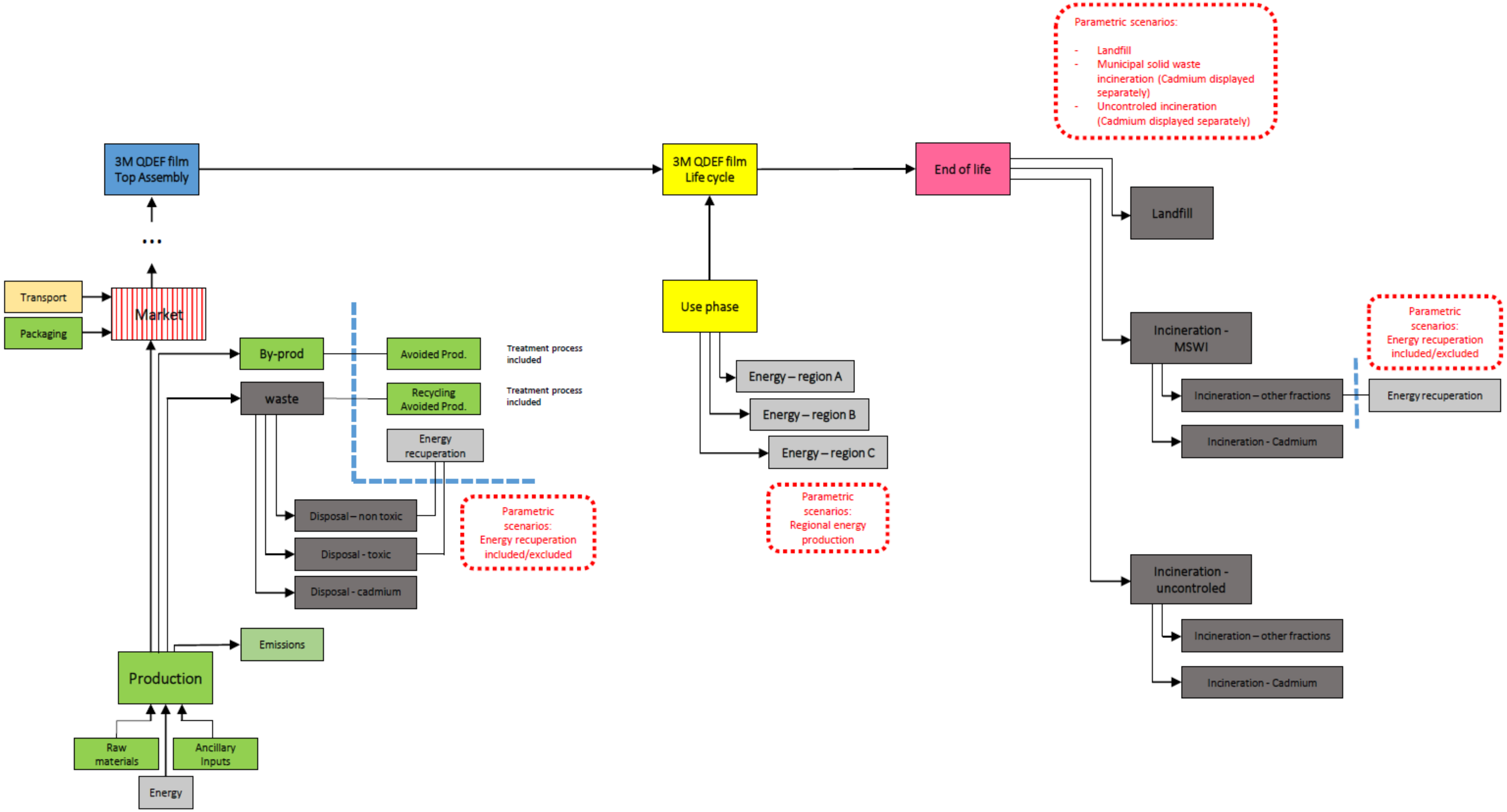

Fig. 15 - Modelling structure and parametric scenarios

Annex 2

Impact category	Unit	Input non-Cd	input CD	eol Cd - landfill	eol non-Cd - landfill	Total
Acidification (fate not incl.)	kg SO2 eq	1,21E-01	1,52E-09	1,38E-08	4,07E-05	1,21E-01
Eutrophication	kg PO4--- eq	3,03E-02	5,06E-10	3,04E-09	1,55E-03	3,19E-02
Global warming (GWP100a)	kg CO2 eq	1,88E+01	2,33E-07	1,74E-06	2,83E-02	1,89E+01
Photochemical oxidation	kg C2H4 eq	1,21E-01	6,39E-11	5,61E-10	5,91E-06	1,21E-01
Ozone layer depletion (ODP) (optional)	kg CFC-11 eq	1,61E-06	1,70E-14	4,21E-13	1,00E-09	1,61E-06
Abiotic depletion (optional)	kg Sb eq	4,65E-05	8,62E-13	2,19E-12	5,21E-09	4,65E-05

Annex - Table 1. Regular model, landfill (EPD midpoints)

Impact category	Unit	Input non-Cd	input CD	eol Cd - MSWI	eol non-Cd - MSWI	Total
Acidification (fate not incl.)	kg SO2 eq	1,21E-01	1,52E-09	3,51E-08	-1,43E-03	1,19E-01
Eutrophication	kg PO4--- eq	3,03E-02	5,06E-10	3,22E-08	-4,02E-04	2,99E-02
Global warming (GWP100a)	kg CO2 eq	1,88E+01	2,33E-07	6,58E-06	3,70E-01	1,92E+01
Photochemical oxidation	kg C2H4 eq	1,21E-01	6,39E-11	2,01E-09	-8,17E-05	1,21E-01
Ozone layer depletion (ODP) (optional)	kg CFC-11 eq	1,61E-06	1,70E-14	1,08E-12	-4,58E-08	1,56E-06
Abiotic depletion (optional)	kg Sb eq	4,65E-05	8,62E-13	8,46E-11	-1,39E-07	4,63E-05

Annex - Table 2. Regular model, MSWI (EPD midpoints)

Impact category	Unit	Input non-Cd	input CD	eol Cd - open air	eol non-Cd - open air	Total
Acidification (fate not incl.)	kg SO2 eq	1,21E-01	1,52E-09	1,20E-09	3,63E-04	1,21E-01
Eutrophication	kg PO4--- eq	3,03E-02	5,06E-10	2,49E-10	1,93E-03	3,23E-02
Global warming (GWP100a)	kg CO2 eq	1,88E+01	2,33E-07	1,61E-07	8,19E-01	1,97E+01
Photochemical oxidation	kg C2H4 eq	1,21E-01	6,39E-11	6,47E-11	1,09E-05	1,21E-01
Ozone layer depletion (ODP) (optional)	kg CFC-11 eq	1,61E-06	1,70E-14	5,84E-14	4,38E-09	1,61E-06
Abiotic depletion (optional)	kg Sb eq	4,65E-05	8,62E-13	2,51E-13	3,71E-08	4,65E-05

Annex - Table 3. Regular model, open air incineration (EPD midpoints)

Impact category	Unit	Input non-Cd	input CD	eol Cd - MSWI	eol non-Cd - MSWI	Total
Acidification (fate not incl.)	kg SO2 eq	1,24E-01	1,52E-09	3,51E-08	1,44E-04	1,24E-01
Eutrophication	kg PO4--- eq	3,15E-02	5,06E-10	3,22E-08	8,51E-05	3,16E-02
Global warming (GWP100a)	kg CO2 eq	1,95E+01	2,33E-07	6,58E-06	7,37E-01	2,03E+01
Photochemical oxidation	kg C2H4 eq	1,21E-01	6,39E-11	2,01E-09	2,23E-06	1,21E-01
Ozone layer depletion (ODP) (optional)	kg CFC-11 eq	1,63E-06	1,70E-14	1,08E-12	6,44E-10	1,63E-06
Abiotic depletion (optional)	kg Sb eq	4,67E-05	8,62E-13	8,46E-11	1,09E-08	4,67E-05

Annex - Table 4. Regular model, MSWI, no Energy recupertion (EPD midpoints)

Impact category	Unit	BG	CN	DE	EU	FR	GB	IT	PL	SE	US
Acidification (fate not incl.)	kg SO2 eq	1,95E-01	1,95E-01	1,95E-01	1,95E-01	1,95E-01	1,95E-01	1,95E-01	1,95E-01	1,95E-01	1,95E-01
Eutrophication	kg PO4--- eq	2,65E-01	2,65E-01	2,65E-01	2,65E-01	2,65E-01	2,65E-01	2,65E-01	2,65E-01	2,65E-01	2,65E-01
Global warming (GWP100a)	kg CO2 eq	3,40E+01	3,40E+01	3,40E+01	3,40E+01	3,40E+01	3,40E+01	3,40E+01	3,40E+01	3,40E+01	3,40E+01
Photochemical oxidation	kg C2H4 eq	1,10E-02	1,10E-02	1,10E-02	1,10E-02	1,10E-02	1,10E-02	1,10E-02	1,10E-02	1,10E-02	1,10E-02
Ozone layer depletion (ODP) (optional)	kg CFC-11 eq	3,06E-05	3,06E-05	3,06E-05	3,06E-05	3,06E-05	3,06E-05	3,06E-05	3,06E-05	3,06E-05	3,06E-05
Abiotic depletion (optional)	kg Sb eq	3,78E-04	3,78E-04	3,78E-04	3,78E-04	3,78E-04	3,78E-04	3,78E-04	3,78E-04	3,78E-04	3,78E-04

Annex - Table 5. Avoided electricity production (EPD midpoints)