Policies
to Promote
Sustainable
Consumption
Patterns

EUPOPP Work Package 4

Deliverable 4.3:

Effects of SC instruments on Sustainability, including the International Dimension

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Overview

The EU FP7 collaborative research project “European Policies to Promote Sustainable Consumption Patterns (EUPOPP)” is carried out by several research partners throughout Europe, co-ordinated by Oeko-Institut.

Within the EUPOPP workflow, Deliverable 4.3 (D4.3) provides results from the Work Package (WP) 4 tasks with regard to the **scenario results**, and the scenario analysis concerning the **international dimension**.

It builds on the outcomes of other WP4 tasks which are reported in Deliverables D 4.1 (Overall Approach of Material Flow Analysis and its Application to the Need Areas Food and Housing, and Hypotheses on the Impacts of SC Instruments) and D 4.2 (BAU and SC Scenario Assumptions and the MFA Database)[1].

Deliverable 4.3 is structured as follows:

After the introduction, Section 0 gives the results of the **BAU scenario** which are used as a reference (“baseline”) to be compared with the SC scenarios.

Section 2 presents the results of the **SC scenarios**, disaggregated for the food and housing sub-scenarios, and the total impacts. In Sections 0, the sustainability impacts of the **SC scenarios are compared** to the BAU scenario results.

Section 4 analyzes the results of the SC scenarios with regard to the **international dimension**, i.e. the results are disaggregated with respect to the shares occurring within the EU 27, and the “outside” impacts.

In an excurse (Section 5), the employment impacts of the scenarios are presented and discussed with regard to their indicative nature.

Section 6 briefly discusses **qualitative** sustainability impacts which are derived from the changes in “intensity” of relevant drivers. The section especially focuses on land-use related biodiversity impacts, and briefly discusses social implications.

The final Section 7 summarizes data **uncertainties and sensitivities** of the results, and derives some conclusions for **further work**.

The paper ends with a list of references, and abbreviations and acronyms, and the Annex gives some disaggregated data.

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[1] The deliverables are available for download at the EUPOPP website, see http://www.eupopp.net/documents.htm.

Introduction

This paper represents the results of the scenario work and the material flow analysis (MFA) for food and housing within Work Package 4 of the EUPOPP project.

The business-as-usual (BAU) scenario represents the **benchmark to compare** alternative future developments in which sustainable consumption (SC) instruments are assumed to be implemented (so-called SC scenarios)[1].

The results of the BAU and the SC scenarios are described in this paper, while the approach to quantifying the impacts of SC instruments using material flow analysis is presented in another deliverable[2].

The need area of **food** contains a variety of products, which are consumed within the EU 27. Each country, each region has specialties, favourites, habits or other food specific characteristics. As it was not possible to model all these features in detail, the system boundaries limit the need area to typical figures data on the Member State level and EU averages so that the model world of the scenario analysis is also based on this level of aggregation.

The need area of **housing** is focussing on buildings within the private (residential) sector, respective heating systems, and household appliances. The main outcomes of SC instruments are changes in the final end-energy demand from which then further indicators (GHG and air emissions etc.) were derived, again using the EU 27 average figures. As the EUPOPP work on the MFA database allows disaggregation to each EU Member State with regard to electricity and heat, impacts of instruments on the Member State level can be derived also.

It is beyond the scope of this paper to discuss impacts on the country level, but the data for this is made available to the public so that potential **follow-up** work could be carried out in that regard[3].

Thus, the results of the impact quantification are reported on the aggregated EU-27 level, and – see Section 4 – the international dimension. For the latter, also only “outside of the EU” impacts are reported here, but again the database allows also to further break down impacts to individual countries, and regions.

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[1] for details on the scenario definition and data background, see OEKO (2011b)

[2] for details on the MFA methodology used in EUPOPP see OEKO (2011b)

[3] The MFA database is freely available in the public domain software GEMIS (see www.gemis.de). Using this tool, interested parties can carry out their own (national) analyses of the EUPOPP results.

1 Results of the BAU Scenario

In WP4, the formulation of baseline scenario (business-as-usual = BAU) as reference for the comparison with “sustainable consumption” (SC) scenarios was a key issue.

The BAU scenario consists of the two sub-scenarios for the need areas “food” and “housing”, and is based on several other studies which delineate future dynamics of the EU energy system, and the agricultural sector[4].

The results of the sub-scenarios are reported separately in the following sub-sections 1.1 and 1.2, and the results for the total BAU scenario is given in sub-section 1.3.

1.1 Results of the BAU Sub-Scenario for Food

The BAU sub-scenario for food consumption assumes a continuation of the trends from 1990-2005, but with a slower pace per capita, and an overall convergence of consumption patterns between the EU regions.

Taking into account the population dynamics in the EU regions and the disaggregated trends for the per-capita consumption, the overall food consumption was determined.

The total EU 27 demand for the food product groups is shown in the following table[5].

Table 1 Development of Total EU Food Consumption, BAU Scenario

[million t]	**2010**	**2020**	**2030**
Fruit	40,4	43,6	44,3
Vegetables	21,1	22,3	20,9
Vegetable Oils	8,6	9,7	10,3
Cereals	19,2	19,1	19,9
Sugar	14,7	14,5	14,8
Beverages	49,0	46,5	46,7
Dairy	22,0	22,9	24,5
Meat	41,0	42,0	42,5
Fish	11,2	11,6	12,0
All Food	**454,2**	**464,8**	**471,7**
All Food + Beverages	**503,2**	**511,3**	**518,3**

Source: own computations based on EUPOPP Deliverable 4.2, see OEKO (2011b)

As can be seen, the overall consumption is slightly increasing, especially for cereals, dairy, fruit and fish, while vegetables and sugar remain more or less constant.

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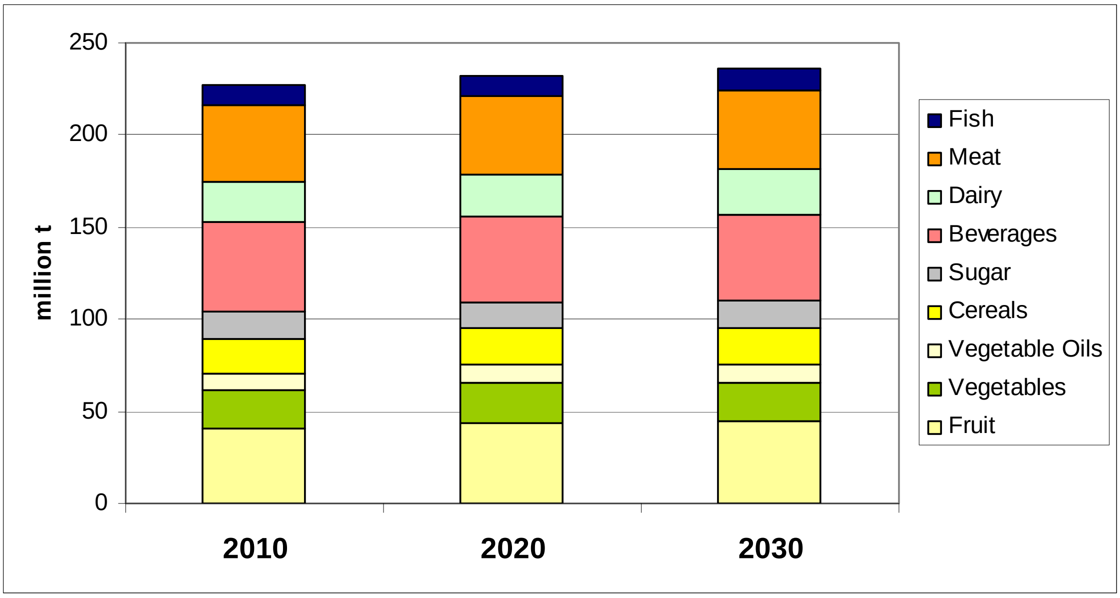
[4] In EUPOPP Deliverable 4.2, the future trends from 2005 onwards to 2030 are presented which define the BAU (reference) scenario, see OEKO (2011b).

[5] The disaggregated results for all food products are given in the Annex 1.

Meat is increasing also, but in this group beef demand levels off, while chicken increases further. The following figure shows the overall dynamics.

Figure 1 EU Food Consumption in the BAU Scenario



Source: own computations based on EUPOPP Deliverable 4.2, see OEKO (2011b)

From these demand dynamics, the quantified sustainability impacts were derived using the material-flow database established in the EUPOPP project for the EU-27 which was implemented in the GEMIS 4.7 database[6]. The following tables show the respective results.

Table 2 GHG Emissions from EU Food Consumption, BAU Scenario

[million t]	**CO_2eq**	**CO_2**	**CH_4**	**N_2O**
EU food-2010	1.619	227	7,3	4,1
EU food-2020	1.645	227	7,2	4,2
EU food-2030	1.674	220	7,1	4,3

Source: own calculation using GEMIS 4.7

The overall GHG emissions in terms of CO_2eq will increase slightly, while CO_2 and CH4 and CH_4 emissions decrease, and N_2O emissions show a small increase.

Note that these results are given for the **total life-cycles** including emissions from outside of the EU, and including the energy use for production, processing and distribution of the food, but **not** the energy use for cooling and cooking in the residential households, as those are reported under “housing” (see Section 2.1).

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[6] For details, see OEKO 2011b and the GEMIS 4.7 database available at www.gemis.de

Table 3 Air Pollutant Emissions from EU Food Consumption, BAU Scenario

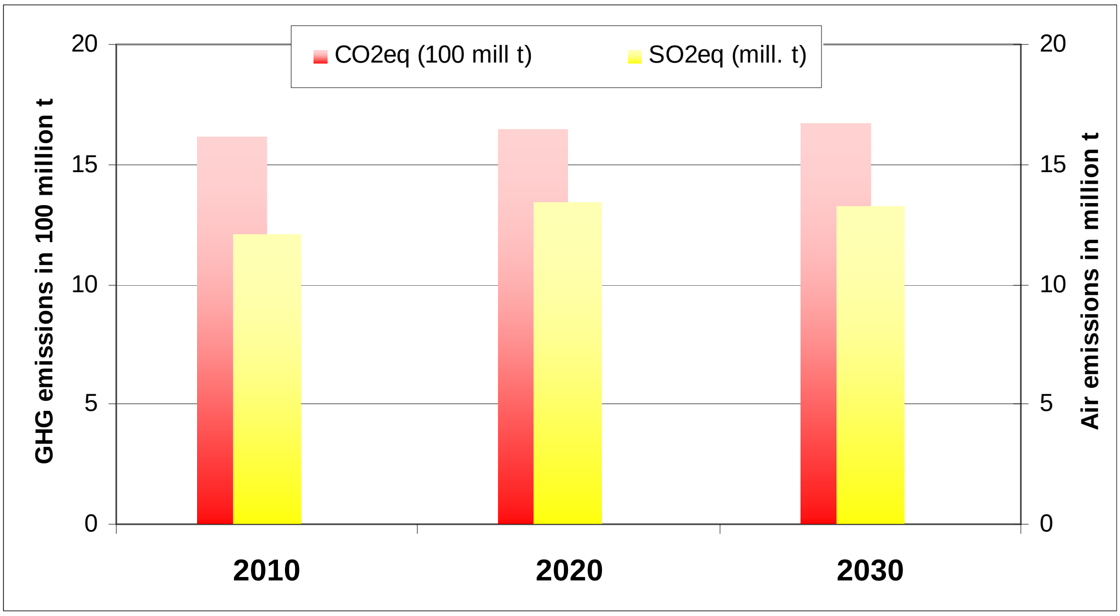
[million t]	SO_2eq	SO_2	NO_x	PM_{10}
EU food-2010	12,1	0,4	1,5	0,16
EU food-2020	13,4	0,3	1,4	0,17
EU food-2030	13,3	0,3	1,4	0,18

Source: own calculation using GEMIS 4.7

Similar to the GHG emissions, the air pollutant emissions from EU food consumption in the BAU scenario expressed as SO_2eq and PM_{10} will also increase slightly, while SO_2 and NO_x emissions will slightly decrease[7].

The overall trends in GHG and air emissions in the BAU sub-scenario for food are shown in the following figure.

Figure 2 GHG and Air Emissions from EU Food Consumption, BAU Scenario



Source: own calculation using GEMIS 4.7

The food dynamics – both from the consumption and the production side – will lead to a small increase of both GHG and air pollutant emissions until 2030.

The MFA computation also gives impacts for the resource use, expressed in cumulated primary energy use, cumulated raw material use, and land use.

The following tables give the respective results.

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[7] The increase of the SO_2eq is due to rising emissions of NH_3 which mainly stems from fertilizer applications in agriculture. The NH_3 emission data are not shown here but are available together with other air pollutants (such as CO, HCl, HF and NMVOC) in the GEMIS database.

Table 4 Cumulated Primary Energy Use from EU Food Consumption, BAU Scenario

[PJ]	total	non renewable	renewable
EU food-2010	3.617	3.467	150
EU food-2020	3.718	3.447	271
EU food-2030	3.661	3.370	290

Source: own calculation using GEMIS 4.7

The cumulated primary energy use will increase slightly, with a decrease in non-renewable and an increase in renewable energy sources used by the EU food system.

Table 5 Cumulated Raw Material Use from EU Food Consumption, BAU Scenario

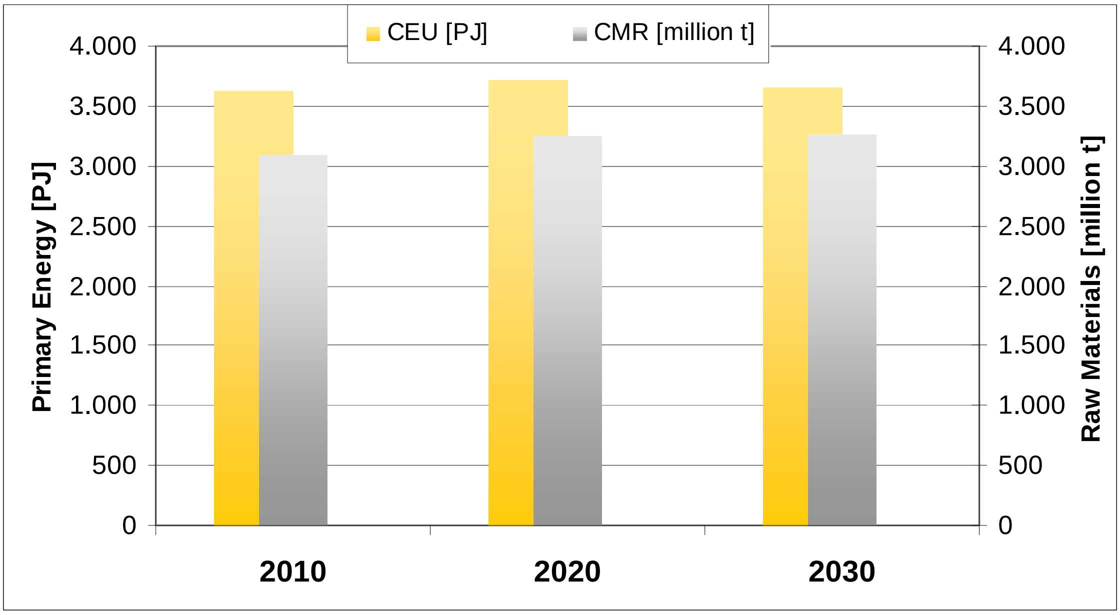
[million t]	total	non renewable	renewable
EU food-2010	3.088	116	2.972
EU food-2020	3.240	131	3.109
EU food-2030	3.264	139	3.125

Source: own calculation using GEMIS 4.7

The results for the raw material use show a higher increase, both for non-renewable and renewable raw materials.

The overall trends in resource use in the BAU sub-scenario for food are shown in the following figure.

Figure 3 Primary Energy and Raw Material Use from EU Food Consumption, BAU Scenario



Source: own calculation using GEMIS 4.7

This shows that BAU sub-scenario for food will have increasing resource use trends.

Table 6 Land Use and Costs from EU Food Consumption, BAU Scenario

	Land Use [million ha]	**Costs [billion €]**
EU food-2010	350	381
EU food-2020	370	446
EU food-2030	369	520

Source: own calculation using GEMIS 4.7

The land use associated with the EU food system, and the costs for delivering the food to the customers (at retail stores) will both rise, with the costs increasing far more prominently than the land use.

The overall sustainability of the BAU sub-scenario for food in the EU-27 will – in terms of quantified results – not be improved, as both consumption levels and production systems will cause rising emissions, resource use, and costs.

1.2 Results of the BAU Sub-Scenario for Housing

The need area “housing” comprises household **electricity** consumption due to the use of appliances, **heating** requirements due to building characteristics and household **energy** consumption for heating and hot water.

The BAU sub-scenario for housing is based on the PRIMES reference scenario for the EU 27 which was prepared for the European Commission[8]. The following table gives some of the key data of the sub-scenario.

Table 7 Key Data of the BAU Sub-Scenario for Housing

	2010	**2020**	**2030**
Number of households [million]	217	231	241
Households size [inhabitants/household]	2,30	2,22	2,16
Final Energy Demand [TWh]	**3596**	**3647**	**3441**
Heating and cooling (incl. cooking) [TWh]	3155	3100	2821
Electric appliances and lighting [TWh]	441	547	620
by fuel [TWh]			
Solids	86	72	54
Oil	606	491	396
Gas	1473	1367	1192
Electricity	815	963	1103
Heat	235	219	203
Other	380	535	493

Source: EC (2010), PRIMES Reference Scenario

The quantification of sustainability impacts goes beyond the PRIMES data, though: as for food, the **full life-cycles** of the electricity and heat provision is included in the MFA calculation, taking into account also the emissions from “upstream” life-cycles such as primary energy extraction, processing and transport from outside of the EU.

The following tables show the respective results of all quantified sustainability impacts.

Table 8 GHG Emissions from EU Housing, BAU Scenario

[million t]	**CO_2eq**	**CO_2**	**CH_4**	**N_2O**
el + heat 2010	1.088	1.012	2,7	0,03
el + heat 2020	969	901	2,4	0,03
el + heat 2030	867	809	2,0	0,02

Source: own calculation using GEMIS 4.7

The overall GHG emissions in terms of CO_2eq will decrease slightly, with CO_2, CH_4 and N_2O emissions all show a reduction: the total GHG emission, compared to 2010, will be reduced by 11% by 2020, and by 20% by 2030.

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[8] For details, see OEKO (2011b).

The air pollutant emissions of the BAU sub-scenario for housing are shown in the following table.

Table 9 Air Pollutant Emissions from EU Housing, BAU Scenario

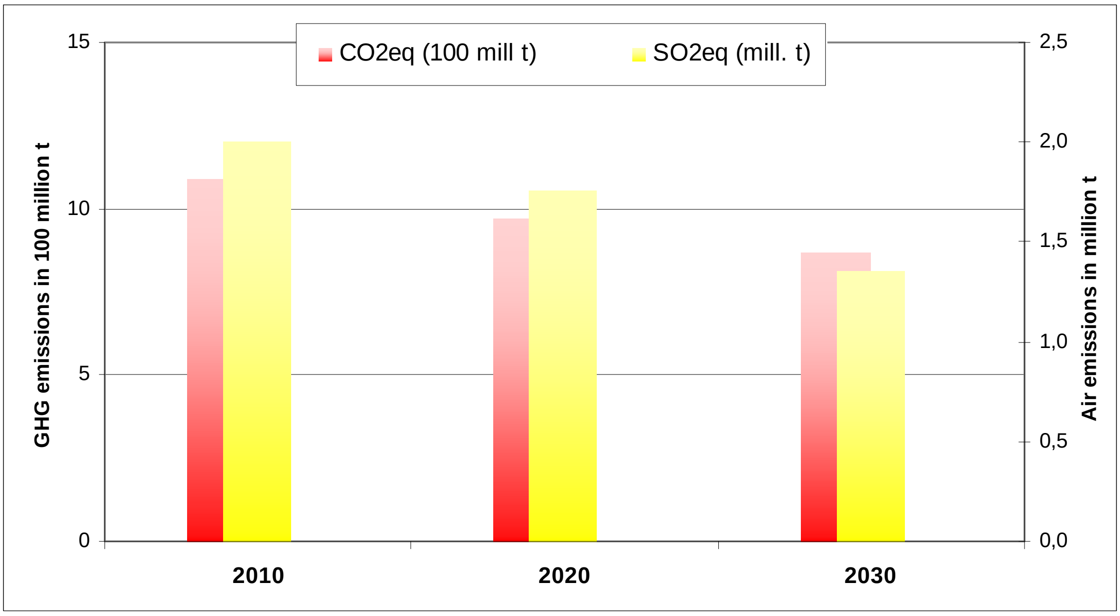
[million t]	SO_2eq	SO_2	NO_x	PM_{10}
el + heat 2010	2,0	1,1	1,2	0,17
el + heat 2020	1,8	0,8	1,3	0,16
el + heat 2030	1,4	0,6	1,1	0,14

Source: own calculation using GEMIS 4.7

All air pollutants from the residential energy use will show a significant decline, most prominently for SO_2eq which will be reduced by 12% by 2020, and 32% by 2030, compared to the 2010 levels.

The overall trends in GHG and air emissions in the BAU sub-scenario for housing are shown in the following figure.

Figure 4 GHG and Air Emissions from EU Housing, BAU Scenario



Source: own calculation using GEMIS 4.7

The MFA computation also gives impacts for the resource use, expressed in cumulated primary energy use, cumulated raw material use, and land use.

The following tables give the respective results.

Table 10 Cumulated Primary Energy Use from EU Housing, BAU Scenario

[PJ]	**total**	**non renewable**	**renewable**
el + heat 2010	21.188	17.976	3.211
el + heat 2020	22.054	16.580	5.474
el + heat 2030	21.131	15.481	5.651

Source: own calculation using GEMIS 4.7

The cumulated primary energy use will increase slightly until 2020, and then decrease slightly below the 2010 level by 2030. In parallel, a decreasing amount of non-renewable and an increasing amount of renewable energy sources will be used by the EU housing in the BAU scenario.

Table 11 Cumulated Raw Material Use from EU Housing, BAU Scenario

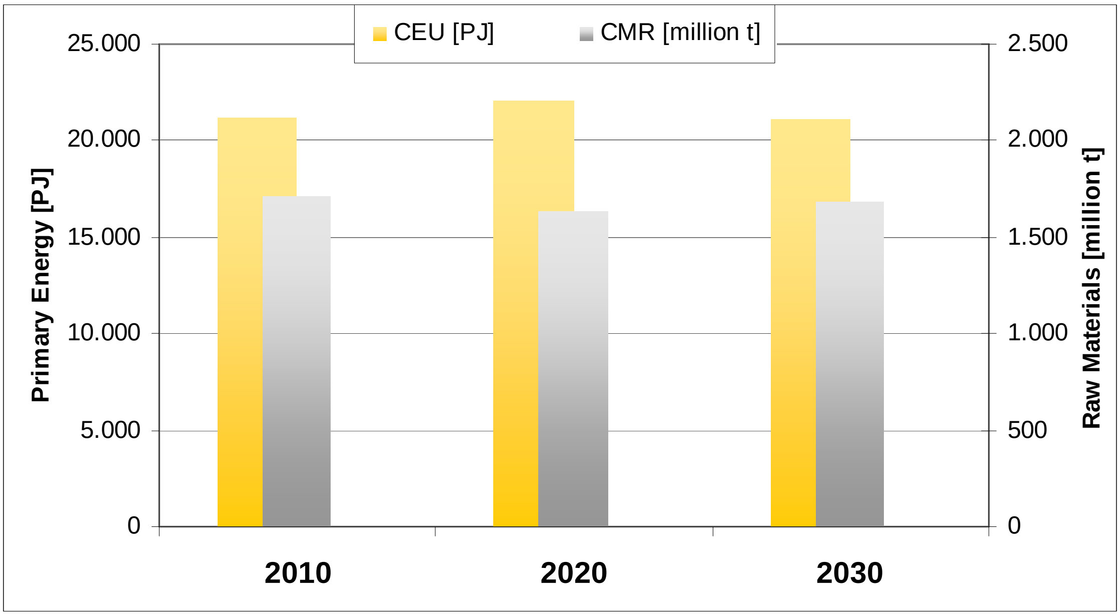
[million t]	**total**	**non renewable**	**renewable**
el + heat 2010	1.711	26	1.686
el + heat 2020	1.633	31	1.602
el + heat 2030	1.681	33	1.648

Source: own calculation using GEMIS 4.7

The results for the raw material use show a smaller decrease in the total, with a small increase for non-renewable and a decrease for renewable raw materials.

The overall trends in resource use in the BAU sub-scenario for housing are shown in the following figure.

Figure 5 Primary Energy and Raw Material Use from EU Housing, BAU Scenario



Source: own calculation using GEMIS 4.7

This shows that BAU sub-scenario for housing will have slightly declining resource use trends.

Table 12 Land Use and Costs from EU Housing, BAU Scenario

	Land Use [million ha]	**Costs [billion €]**
el + heat 2010	0,23	373
el + heat 2020	0,32	447
el + heat 2030	0,48	465

Source: own calculation using GEMIS 4.7

The land use associated with the EU housing, and the costs for delivering the energy services in the households will both rise, with the land use increasing far more prominently than the costs. It should be noted, though, that the land use for housing is by a factor of 1000 **smaller** than the land use for food, while the costs are in the same order of magnitude

The overall sustainability of the BAU sub-scenario for housing in the EU-27 – in terms of quantified results – will be improved slightly, as both consumption levels and production systems will result in lower emissions, but resource use, and costs will still increase.

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1.3 Results of the BAU Scenario (Total)

The sum of the two sub-scenarios gives the total results of the BAU scenario developed in EUPOPP. As before, the respective result tables and figures are presented below.

Table 13 GHG Emissions from the BAU Scenario

[million t]	**CO_2eq**	**CO_2**	**CH_4**	**N_2O**
EU food + housing 2010	2707	1239	10,0	4,1
EU food + housing 2020	2614	1128	9,5	4,2
EU food + housing 2030	2541	1029	9,1	4

Source: own calculation using GEMIS 4.7

The overall GHG emissions in terms of CO_2eq as well as all individual GHG will decrease slightly, compare to 2010.

Note that these results are given for the **total life-cycles** including emissions from outside of the EU, and including the energy use for production, processing and distribution of the food, and the energy use for heating, cooling, cooking and lighting as well as other energy uses in the residential households.

Table 14 Air Pollutant Emissions from the BAU Scenario

[million t]	**SO_2eq**	**SO_2**	**NO_x**	**PM_{10}**
EU food + housing 2010	14,1	1,5	2,8	0,33
EU food + housing 2020	15,2	1,2	2,7	0,33
EU food + housing 2030	14,6	0,9	2,5	0,32

Source: own calculation using GEMIS 4.7

The air pollutant emissions from the BAU scenario expressed as SO_2eq will increase slightly, while SO_2 and NO_x emissions will slightly decrease[9].

The overall trends in GHG and air emissions in the BAU scenario are shown in the following figure.

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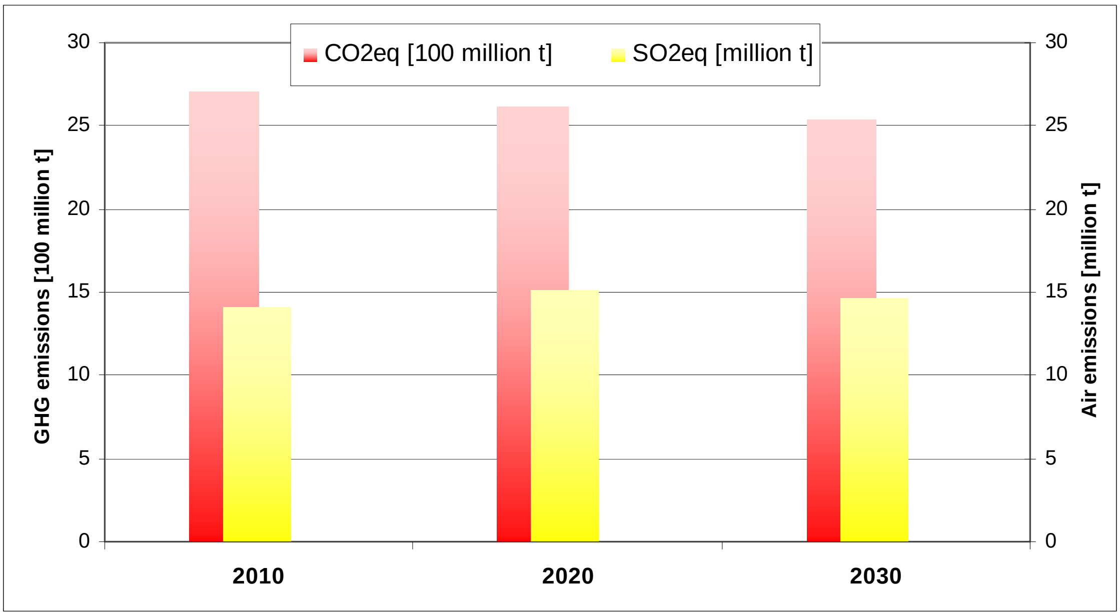
[9] The increase of the SO_2eq is due to rising emissions of NH_3 which mainly stems from fertilizer applications in agriculture. The NH_3 emission data are not shown here but are available together with other air pollutants (such as CO, HCl, HF and NMVOC) in the GEMIS database.

Figure 6 GHG and Air Emissions from the BAU Scenario



Source: own calculation using GEMIS 4.7

The MFA computation also gives impacts for the resource use, expressed in cumulated primary energy use, cumulated raw material use, and land use.

The following tables give the respective results.

Table 15 Cumulated Primary Energy Use from the BAU Scenario

[EJ]	**total**	**non renewable**	**renewable**
EU food + housing 2010	24,8	21,4	3,4
EU food + housing 2020	25,8	20,0	5,7
EU food + housing 2030	24,8	18,9	5,9

Source: own calculation using GEMIS 4.7

The cumulated primary energy use will increase slightly until 2020 and then return to the 2010 level, with a decrease in non-renewable and an increase in renewable energy sources.

Table 16 Cumulated Raw Material Use from the BAU Scenario

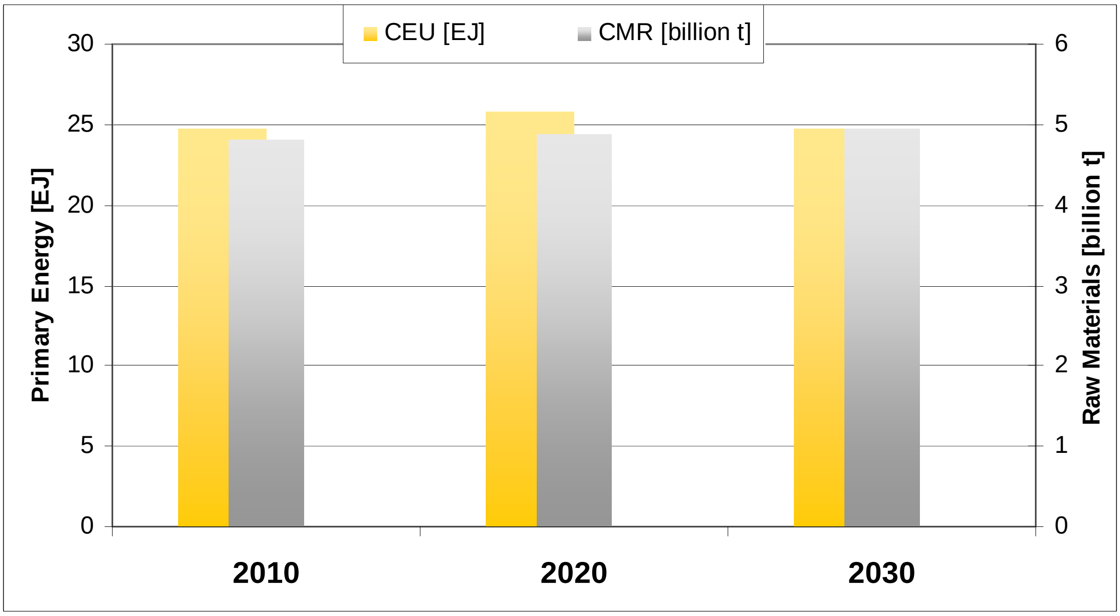
[million t]	**total**	**non renewable**	**renewable**
EU food + housing 2010	4799	141	4658
EU food + housing 2020	4873	162	4712
EU food + housing 2030	4945	172	4773

Source: own calculation using GEMIS 4.7

The results for the raw material use show a higher increase, both for non-renewable and renewable raw materials.

The overall trends in resource use in the BAU scenario are shown in the following figure.

Figure 7 Primary Energy and Raw Material Use from the BAU Scenario



Source: own calculation using GEMIS 4.7

This shows that BAU scenario will have slightly increasing resource use trends.

Table 17 Land Use and Costs from the BAU Scenario

	Land Use [million ha]	Costs [billion €]
EU food + housing 2010	351	754
EU food + housing 2020	370	893
EU food + housing 2030	369	984

Source: own calculation using GEMIS 4.7

The land use and costs associated with the BAU scenario will both rise, with the costs increasing far more prominently than the land use.

The overall sustainability of the BAU scenario for the EU-27 – in terms of quantified results – will not be improved, as both consumption levels and production systems will cause resource use, and costs. For GHG and air emissions, a small reduction compared to the 2010 levels will result, but clearly not enough to achieve the EU targets for climate protection.

2 Results of the SC Scenarios

In contrast to the BAU scenario, the Sustainable Consumption (SC) scenarios assume the implementation of SC instruments and policies in the need areas of food and housing **beyond BAU**, i.e. **more** instruments and more **“intense”** formulation and implementation of the instruments.

To model the impacts of the SC scenario, these instruments were be quantified in their effects and – to facilitate modelling – “bundled” into aggregate policy sets for the respective need areas. As described in OEKO (2011b), the SC scenarios consist of SC-1 and SC-2 which assume a different “ambition” in implementing the available SC instruments:

SC-1 assumed moderate-to-high ambitions, while SC-2 assumes very high sustainability ambitions in both need areas, making **full** use of all the SC instruments identified.

As before, the results from the MFA analysis of the SC scenarios are given in the following sub-sections.

2.1 Results of the SC Sub-Scenarios for Food

As for BAU, the quantified sustainability impacts of the SC scenarios for food were calculated using the life-cycle emissions factors of food provisioning to the retail sector[10]. The following tables give the respective results.

Table 18 GHG Emissions from EU Food Consumption, SC Scenarios

[million t]	**CO_2eq**	**CO_2**	**CH_4**	**N_2O**
EU food 2010	1.619	227	7,3	4,1
EU food 2020 SC-1	1.621	224	7,0	4,1
EU food 2030 SC-1	1.624	214	6,8	4,2
EU food 2020 SC-2	1.546	213	6,7	3,9
EU food 2030 SC-2	1.474	194	6,2	3,8

Source: own calculation using GEMIS 4.7

The overall GHG emissions in terms of CO_2eq and all individual GHG will remain more or less constant in SC-1, while they decrease significantly in SC-2.

Note that these results are given for the **total life-cycles** including emissions from outside of the EU, and including the energy use for production, processing and distribution of the food, but **not** the energy use for cooling and cooking in the residential households, as those are reported under “housing” (see Section 2.2).

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[10] To avoid double-counting with the effects of instruments in the need area housing, the in-house handling and preparation of food, e.g. cooling, cooking etc., is not included in the life-cycle. Also, the transport between households and retail is not considered, as this is outside of the scope of the need area as defined within EUPOPP.

Table 19 Air Pollutant Emissions from EU Food Consumption, SC Scenarios

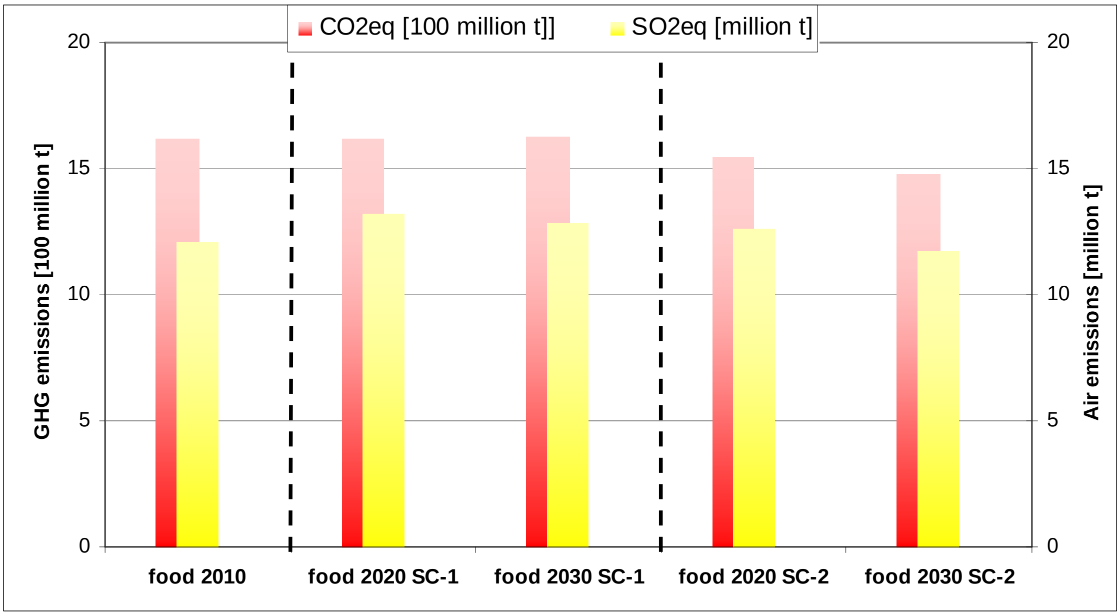
[million t]	SO_2eq	SO_2	NO_x	PM_{10}
EU food 2010	12,1	0,4	1,5	0,16
EU food 2020 SC-1	13,2	0,3	1,4	0,17
EU food 2030 SC-1	12,8	0,3	1,4	0,18
EU food 2020 SC-2	12,6	0,3	1,4	0,16
EU food 2030 SC-2	11,7	0,3	1,3	0,16

Source: own calculation using GEMIS 4.7

Similar to the GHG emissions, the air pollutant emissions from EU food consumption in the SC-1 scenario expressed as SO_2eq and PM_{10} will also increase slightly, while SO_2 and NO_x emissions will slightly decrease[11]. For the SC-2 scenario, the air emissions will be **reduced** by 2030.

The overall trends in GHG and air emissions in the SC sub-scenarios for food are shown in the following figure.

Figure 8 GHG and Air Emissions from EU Food Consumption, SC Scenarios



Source: own calculation using GEMIS 4.7

The food dynamics – both from the consumption and the production side – will lead to a very small increase of both GHG and air pollutant emissions until 2030 for SC-1, while in SC-2 **net reductions** can be achieved, compared to the 2010 level.

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[11] The increase of the SO_2eq is due to rising emissions of NH_3 which mainly stems from fertilizer applications in agriculture. The NH_3 emission data are not shown here but are available together with other air pollutants (such as CO, HCl, HF and NMVOC) in the GEMIS database.

The MFA computation also gives impacts for the resource use, expressed in cumulated primary energy use, cumulated raw material use, and land use.

The following tables give the respective results.

Table 20 Cumulated Primary Energy Use from EU Food Consumption, SC Scenarios

[PJ]	**total**	**non renewable**	**renewable**
EU food 2010	3.617	3.467	150
EU food 2020 SC-1	3.666	3.399	267
EU food 2030 SC-1	3.559	3.277	282
EU food 2020 SC-2	3.499	3.244	254
EU food 2030 SC-2	3.233	2.977	256

Source: own calculation using GEMIS 4.7

The cumulated primary energy use will decrease in all SC scenarios, with a decrease in non-renewable and an increase in renewable energy sources used by the EU food system.

Table 21 Cumulated Raw Material Use from EU Food Consumption, BAU Scenario

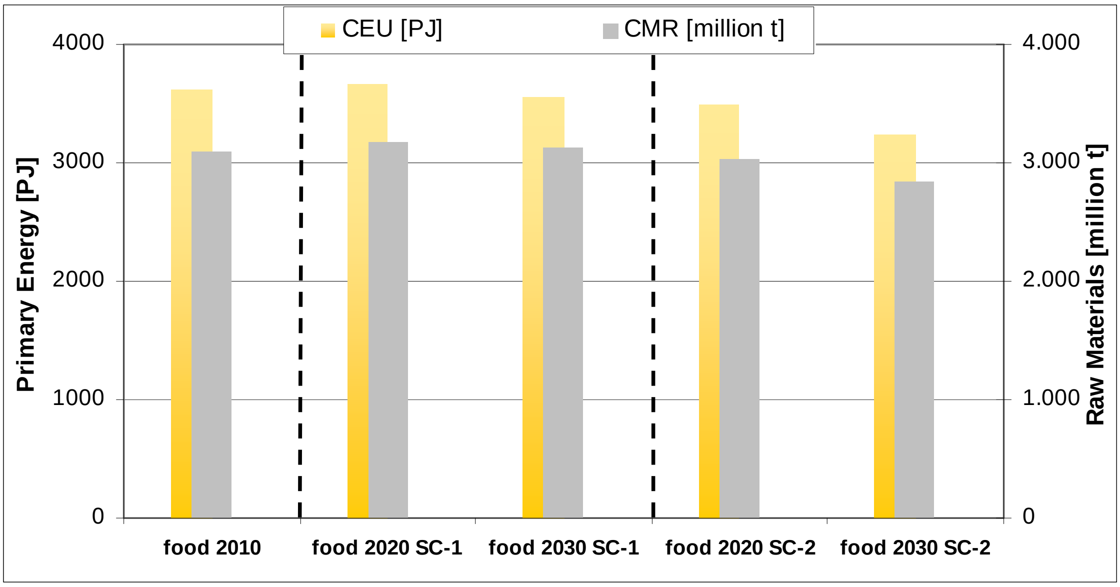
[million t]	**total**	**non renewable**	**renewable**
EU food 2010	3.088	116	2.934
EU food 2020 SC-1	3.175	128	3.010
EU food 2030 SC-1	3.134	133	2.961
EU food 2020 SC-2	3.027	122	2.870
EU food 2030 SC-2	2.841	121	2.683

Source: own calculation using GEMIS 4.7

The results for the raw material use show an increase for SC-1, both for non-renewable and renewable raw materials, while SC-2 will result in a reduction of total and renewable raw materials and a small increase for non-renewable raw materials.

The overall trends in resource use in the SC sub-scenarios for food are shown in the following figure.

Figure 9 Primary Energy and Raw Material Use from EU Food Consumption, SC Scenarios



Source: own calculation using GEMIS 4.7

This shows that SC sub-scenarios for food will have slightly increasing (SC-1) or decreasing (SC-2) resource use trends.

Table 22 Land Use and Costs from EU Food Consumption, SC Scenarios

	Land Use [million ha]	**Costs [billion €]**
EU food-2010	350	381
EU food-2020 SC-1	368	443
EU food-2030 SC-2	365	513
EU food-2020 SC-2	347	443
EU food-2030 SC-2	323	510

Source: own calculation using GEMIS 4.7

The land use associated with the EU food system, and the costs for delivering the food to the customers (at retail stores) will both rise in SC-1, while SC-2 achieves a **reduction** of land use, and the costs increase slightly less than in SC-1.

2.2 Results of the SC Sub-Scenarios for Housing

As for food, the quantified sustainability impacts of the SC scenarios for housing were calculated, the following tables give the respective results.

Table 23 GHG Emissions from EU Housing, SC Scenarios

[million t]	**CO_2eq**	**CO_2**	**CH_4**	**N_2O**
EU housing 2010	1.087	1.010	2,73	0,03
EU housing 2020 SC-1	845	785	2,06	0,03
EU housing 2030 SC-1	662	616	1,55	0,02
EU housing 2020 SC-2	841	782	2,06	0,03
EU housing 2030 SC-2	629	586	1,47	0,02

Source: own calculation using GEMIS 4.7

The overall GHG emissions in terms of CO_2eq and all individual GHG will significantly decrease in all SC scenarios.

Note that these results are given for the **total life-cycles** including emissions from outside of the EU, and including the energy use for heating, cooling, cooking, lighting etc. in the residential households.

Table 24 Air Pollutant Emissions from EU Housing, SC Scenarios

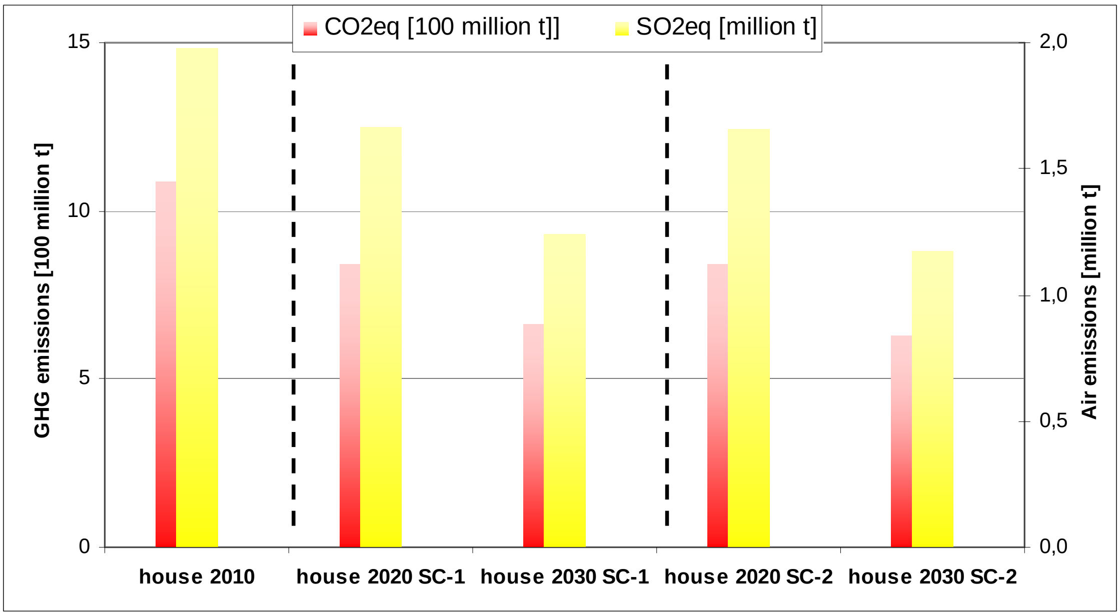
[million t]	**SO_2eq**	**SO_2**	**NO_x**	**PM_{10}**
EU housing 2010	2,0	1,1	1,2	0,17
EU housing 2020 SC-1	1,7	0,8	1,2	0,17
EU housing 2030 SC-1	1,2	0,5	1,0	0,15
EU housing 2020 SC-2	1,7	0,8	1,2	0,17
EU housing 2030 SC-2	1,2	0,5	1,0	0,14

Source: own calculation using GEMIS 4.7

Similar to the GHG emissions, the air pollutant emissions from EU housing in all SC scenarios will also decrease.

The overall trends in GHG and air emissions in the SC sub-scenarios for housing are shown in the following figure.

Figure 10 GHG and Air Emissions from EU Housing, SC Scenarios



Source: own calculation using GEMIS 4.7

The housing dynamics – both from the consumption and the production side – will lead to significant decreases of both GHG and air pollutant emissions until 2030 for both SC scenarios, compared to the 2010 level.

The MFA computation also gives impacts for the resource use, expressed in cumulated primary energy use, cumulated raw material use, and land use.

The following tables give the respective results.

Table 25 Cumulated Primary Energy Use from EU Housing, SC Scenarios

[PJ]	Total	non renewable	renewable
EU housing 2010	21.193	17.976	3.217
EU housing 2020 SC-1	20.894	14.417	6.478
EU housing 2030 SC-1	18.905	11.717	7.188
EU housing 2020 SC-2	20.801	14.351	6.450
EU housing 2030 SC-2	17.994	11.169	6.825

Source: own calculation using GEMIS 4.7

The cumulated primary energy use will decrease in all SC scenarios, with a decrease in non-renewable and an increase in renewable energy sources used for EU housing.

Table 26 Cumulated Raw Material Use from EU Housing, SC Scenarios

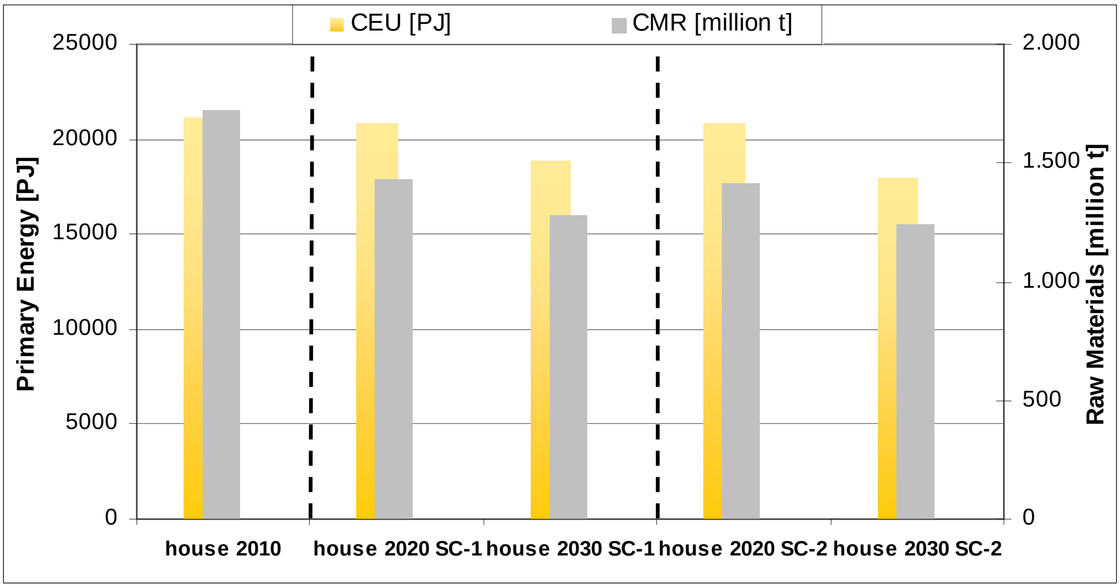
[million t]	total	non renewable	renewable
EU housing 2010	1.724	26	1.699
EU housing 2020 SC-1	1.428	28	1.400
EU housing 2030 SC-1	1.282	29	1.252
EU housing 2020 SC-2	1.414	28	1.385
EU housing 2030 SC-2	1.244	28	1.216

Source: own calculation using GEMIS 4.7

The results for the raw material use show a decrease for all SC scenarios, both for total and renewable raw materials, with small increases for non-renewable raw materials.

The overall trends in resource use in the SC sub-scenarios for housing are shown in the following figure.

Figure 11 Primary Energy and Raw Material Use from EU Housing, SC Scenarios



Source: own calculation using GEMIS 4.7

This shows that SC sub-scenarios for housing will imply **decreasing** resource use.

Table 27 Land Use and Costs from EU Housing, SC Scenarios

	Land Use [million ha]	Costs [billion €]
EU housing 2010	2,3	373
EU housing 2020 SC-1	3,1	436
EU housing 2030 SC-1	4,8	432
EU housing 2020 SC-2	3,1	435
EU housing 2030 SC-2	4,5	410

Source: own calculation using GEMIS 4.7

The land use associated with the EU housing, and the costs for delivering the energy services to the residential customers will both rise in the SC scenarios, while SC-2 achieves a lower costs increase less than SC-1.

2.3 Results of the SC Scenarios (Total)

The sum of the two SC sub-scenarios gives the total results of the SC scenarios developed in EUPOPP. As before, the respective result tables and figures are presented below.

Table 28 GHG Emissions in the SC Scenarios

[million t]	CO_2eq	CO_2	CH_4	N_2O
EU food+housing 2010	2706	1238	10,0	4,1
EU food+housing 2020 SC-1	2466	1009	9,1	4,1
EU food+housing 2030 SC-1	2285	830	8,4	4,2
EU food+housing 2020 SC-2	2387	995	8,8	3,9
EU food+housing 2030 SC-2	2103	780	7,6	3,8

Source: own calculation using GEMIS 4.7

The overall GHG emissions in terms of CO_2eq and all individual GHG will significantly decrease in all SC scenarios.

Note that these results are given for the **total life-cycles** including emissions from outside of the EU, and including the energy use for heating, cooling, cooking, lighting etc. in the residential households.

Table 29 Air Pollutant Emissions in the SC Scenarios

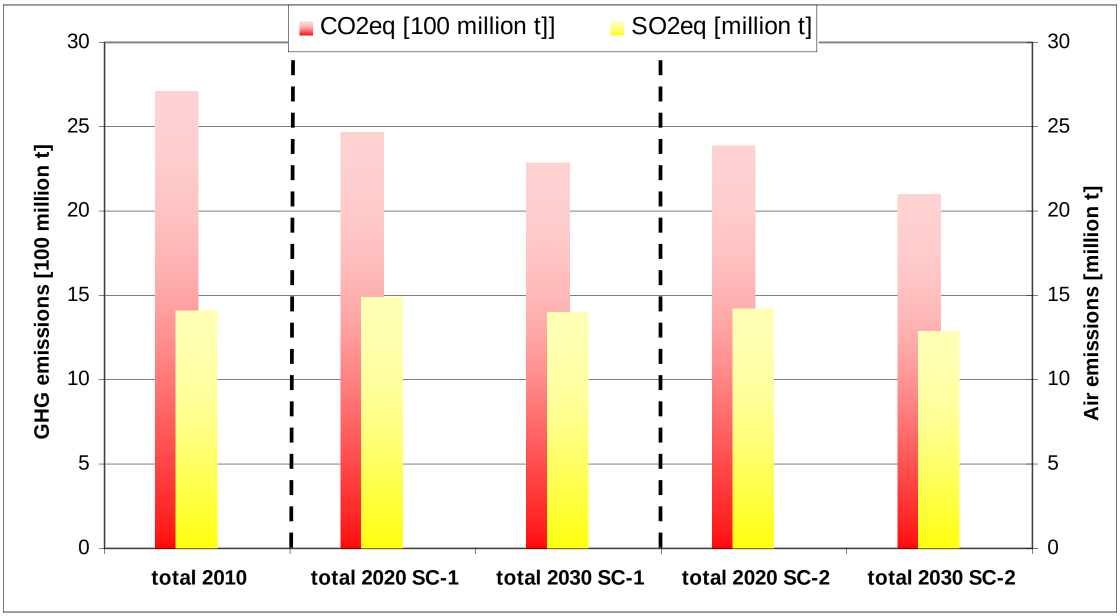
[million t]	SO_2eq	SO_2	NO_x	PM_{10}
EU food+housing 2010	14,1	1,5	2,8	0,33
EU food+housing 2020 SC-1	14,8	1,1	2,6	0,34
EU food+housing 2030 SC-1	14,1	0,8	2,4	0,32
EU food+housing 2020 SC-2	14,3	1,1	2,5	0,33
EU food+housing 2030 SC-2	12,9	0,8	2,2	0,30

Source: own calculation using GEMIS 4.7

Similar to the GHG emissions, the air pollutant emissions in the SC scenarios will also decrease.

The overall trends in GHG and air emissions in the SC scenarios are shown in the following figure.

Figure 12 GHG and Air Emissions in the SC Scenarios



Source: own calculation using GEMIS 4.7

The food and housing dynamics – both from the consumption and the production side – will lead to decreases of both GHG and air pollutant emissions until 2030 for both SC scenarios, compared to the 2010 level.

The MFA computation also gives impacts for the resource use, expressed in cumulated primary energy use, cumulated raw material use, and land use.

The following tables give the respective results.

Table 30 Cumulated Primary Energy Use in the SC Scenarios

[EJ]	total	non renewable	renewable
EU food+housing 2010	24,8	21,4	3,4
EU food+housing 2020 SC-1	24,6	17,8	6,7
EU food+housing 2030 SC-1	22,5	15,0	7,5
EU food+housing 2020 SC-2	24,3	17,6	6,7
EU food+housing 2030 SC-2	21,2	14,1	7,1

Source: own calculation using GEMIS 4.7

The cumulated primary energy use will decrease in all SC scenarios, with a decrease in non-renewable and an increase in renewable energy sources used.

Table 31 Cumulated Raw Material Use in the SC Scenarios

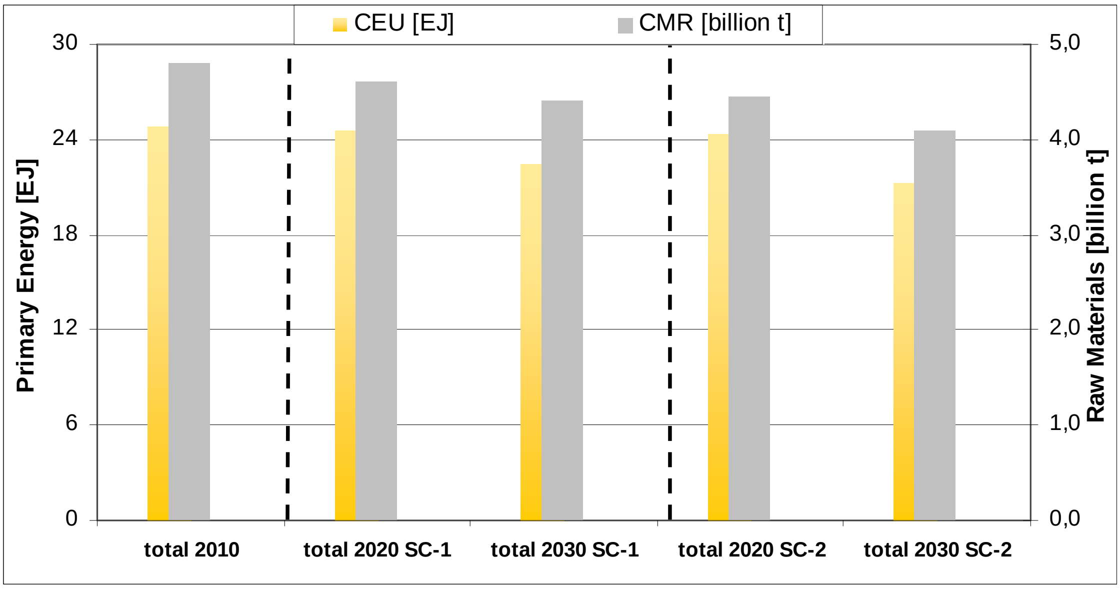
[billion t]	total	non renewable	renewable
EU food+housing 2010	4,8	0,1	4,7
EU food+housing 2020 SC-1	4,6	0,2	4,5
EU food+housing 2030 SC-1	4,4	0,2	4,2
EU food+housing 2020 SC-2	4,4	0,2	4,3
EU food+housing 2030 SC-2	4,1	0,1	3,9

Source: own calculation using GEMIS 4.7

The results for raw material use show a decrease for all SC scenarios in all materials.

The overall trends in resource use in the SC scenarios are shown in the following figure.

Figure 13 Primary Energy and Raw Material Use in the SC Scenarios



Source: own calculation using GEMIS 4.7

This shows that SC scenarios will imply a significant **decrease** in resource use, with SC-2 more prominently than SC-1.

Table 32 Land Use and Costs in the SC Scenarios

	Land Use [million ha]	Costs [billion €]
EU food+housing 2010	351	754
EU food+housing 2020 SC-1	368	880
EU food+housing 2030 SC-1	366	944
EU food+housing 2020 SC-2	347	857
EU food+housing 2030 SC-2	323	874

Source: own calculation using GEMIS 4.7

The land use associated with the SC-1 scenario and the costs for delivering the energy services to the residential customers will both rise, while SC-2 achieves a reduction in land use and lower costs, compared to the 2010 level.

The overall sustainability of the SC scenarios for the EU-27 – in terms of quantified results – will be improved, as changes in both consumption levels and consumption pattern will reduce resource use, and costs. For GHG and air emissions, significant reductions compared to the 2010 levels will result which will help achieving the EU targets for climate protection.

3 Sustainability Impacts: SC Scenarios Compared to BAU

One of the key questions in EUPOPP is how do SC instruments perform in terms of sustainability? To answer this, the methodology is to compare the quantified impacts of a baseline (BAU scenario) with the ones from the SC scenarios.

As before, this comparison is first made between the sub-scenarios for food (sub-section 3.1) and housing (sub-section 3.2), and then for the total scenarios (sub-section 3.3).

3.1 BAU vs. SC in the Sub-Scenarios for Food

In the following table, the results of the BAU sub-scenario for food are compared with the respective SC scenarios both in absolute terms, and as relative changes between the SC sub-scenarios for food, and BAU sub-scenario for food. The data are given for the year 2030 when the assumed SC instrument bundles are fully implemented.

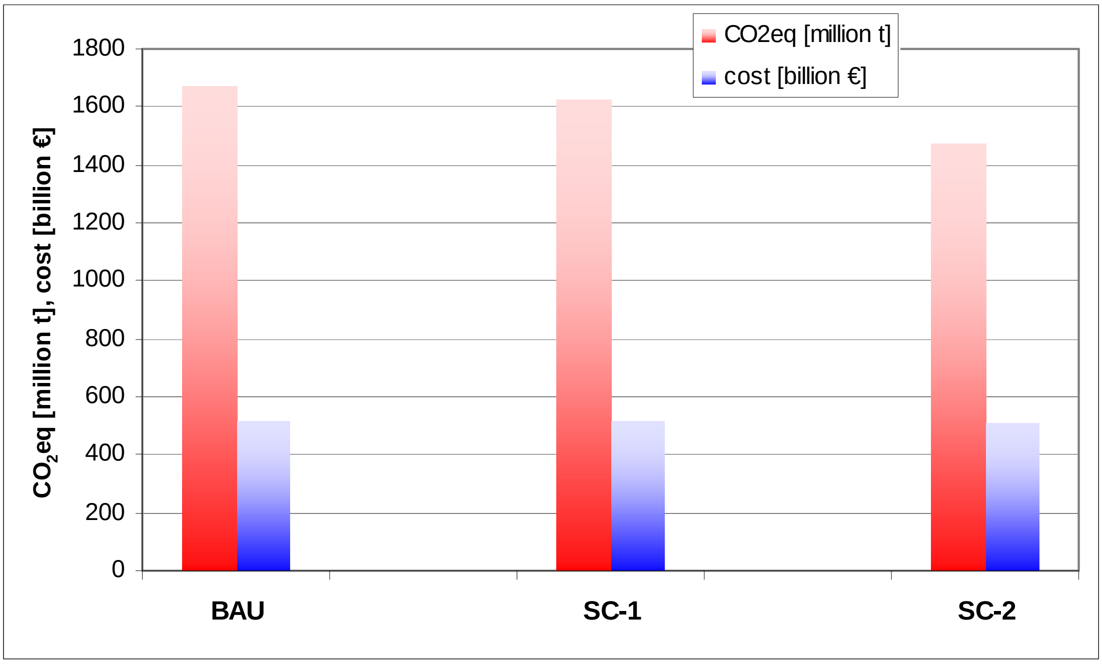
Table 33 Comparison of Selected Results of the Food Sub-Scenarios, Year 2030

	unit	BAU	SC-1	SC-2	SC-1 vs. BAU	SC-2 vs. BAU	SC-1 vs. BAU	SC-2 vs. BAU
GHG emisssions								
CO_2eq	million t	1674	1624	1474	-50	-200	-3%	-12%
CO_2	million t	220	214	194	-6	-25	-3%	-12%
air emissions								
SO_2eq	million t	13,3	12,8	11,7	-0,5	-1,6	-3%	-12%
PM_{10}	million t	0,18	0,18	0,16	0,0	0,0	-2%	-11%
primary energy								
non-renewable	EJ	3,4	3,3	3,0	0	0	-3%	-12%
renewable	EJ	0,3	0,3	0,3	0	0	-3%	-12%
raw materials								
non-renewable	million t	139	133	121	-6	-18	-4%	-13%
renewable	million t	3125	2961	2683	-164	-442	-5%	-14%
other indicators								
Land Use	billion m^2	3686	3654	3230	-33	-456	-1%	-12%
Cost	billion €	520	513	510	-7	-10	-1%	-2%

Source: own computation

This comparison shows that typically, SC-1 achieves 1 to 5% reductions over the BAU values, while SC-2 allows 11-14% reduction with the exception of costs which are only 2% less than in BAU. SC-2 is, depending on the indicator, two to three times more effective in reducing sustainability impacts than SC-1.

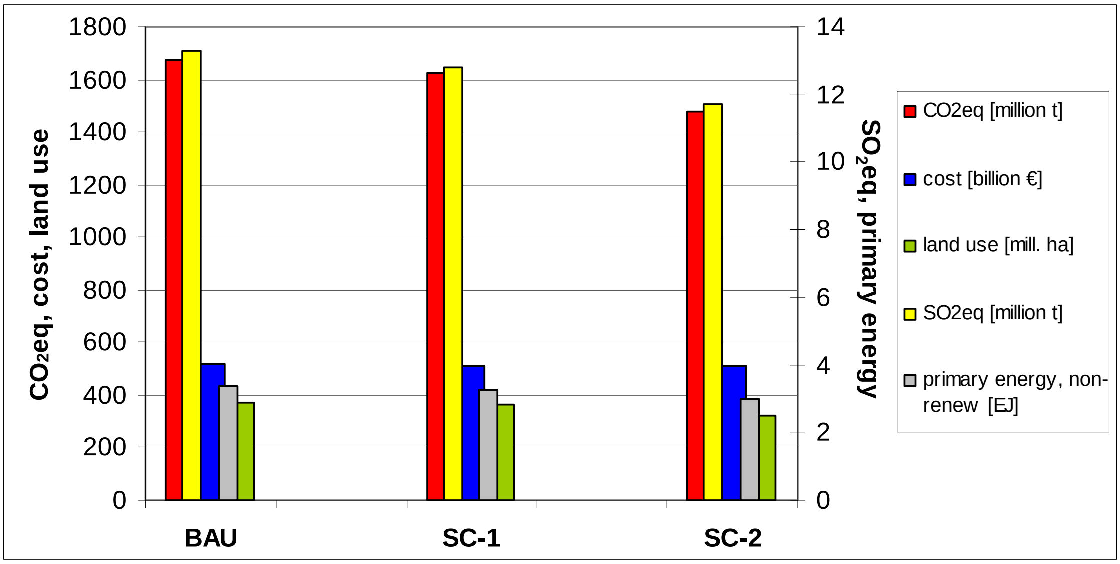
Figure 14 GHG Emissions and Costs of the Food Sub-Scenarios, Year 2030



Source: own computation

The figure above shows the comparison of the GHG emissions and costs between the SC sub-scenarios for food and the BAU sub-scenario for food. The total costs do not differ much, while GHG emissions can be reduced substantially: SC-1 achieves approx. 3% reduction, and SC-2 12%, compared to BAU. The following figure gives the full range of results. The SC sub-scenarios for food reduce all indicators.

Figure 15 Comparison of Selected Results of the Food Sub-Scenarios, Year 2030



Source: own computation

To allow for a better understanding of the results, the following table translates the data presented previously into per-capita data (based on total EU-27 population).

Table 34 Comparison of Selected per-Capita Results of the Food Sub-Scenarios, Year 2030

GHG emisssions	**BAU**	**SC-1**	**SC-2**	**Unit**
CO_2eq	3,2	3,1	2,8	t/cap
CO_2	0,4	0,4	0,4	t/cap
air emissions				
SO_2eq	25,5	24,6	22,5	kg/cap
PM_{10}	0,3	0,3	0,3	kg/cap
primary energy				
non-renewable	6,5	6,3	5,7	TJ/cap
renewable	0,6	0,5	0,5	TJ/cap
raw materials				
non-renewable	0,3	0,3	0,2	t/cap
renewable	6,0	5,7	5,2	t/cap
other indicators				
Land Use	0,71	0,70	0,62	ha/cap
Cost	999	986	980	€/cap

Source: own computation

It is an interesting result that the per-capita land use for food is about 7000 m^2 in BAU, and about 6000 m^2 in SC-2. Compared with the average size of the direct housing footprint of a single-family house with 2.5 inhabitants (approx. 60 m^2/cap), this is 100 times more land use.

The primary energy use for food is 6.5 TJ/cap in BAU and 5.7 TJ/cap in SC-2, and the typical heating demand of an existing single-family house in Central Europe is approx. 60 TJ per year. Thus, the primary energy for food is about 1/10 of the heating demand.

3.2 BAU vs. SC in the Sub-Scenarios for Housing

In the following table, the results of the BAU sub-scenario for housing are compared with the respective SC scenarios both in absolute terms, and as relative changes between the SC sub-scenarios for housing, and BAU sub-scenario for housing. The data are given for the year 2030 when the assumed SC instrument bundles are fully implemented.

Table 35 Comparison of Selected Results of the Housing Sub-Scenarios, Year 2030

	unit	**BAU**	**SC-1**	**SC-2**	**SC-1 vs. BAU**	**SC-2 vs. BAU**	**SC-1 vs. BAU**	**SC-2 vs. BAU**
GHG emisssions								
CO_2eq	million t	867	662	629	-206	-238	-24%	-27%
CO_2	million t	809	616	586	-193	-224	-24%	-28%
air emissions								
SO_2eq	million t	1,4	1,2	1,2	-0,1	-0,2	-8%	-13%
PM_{10}	million t	0,14	0,15	0,14	0,0	0,0	8%	2%
primary energy								
non-renewable	EJ	15,5	11,7	11,2	-4	-4	-24%	-28%
renewable	EJ	5,7	7,2	6,8	2	1	27%	21%
raw materials								
non-renewable	million t	33	29	28	-4	-5	-11%	-15%
renewable	million t	1648	1252	1216	-396	-432	-24%	-26%
other indicators								
Land Use	billion m^2	5	5	5	0	0	-1%	-7%
Cost	billion €	465	432	410	-33	-55	-7%	-12%

Source: own computation

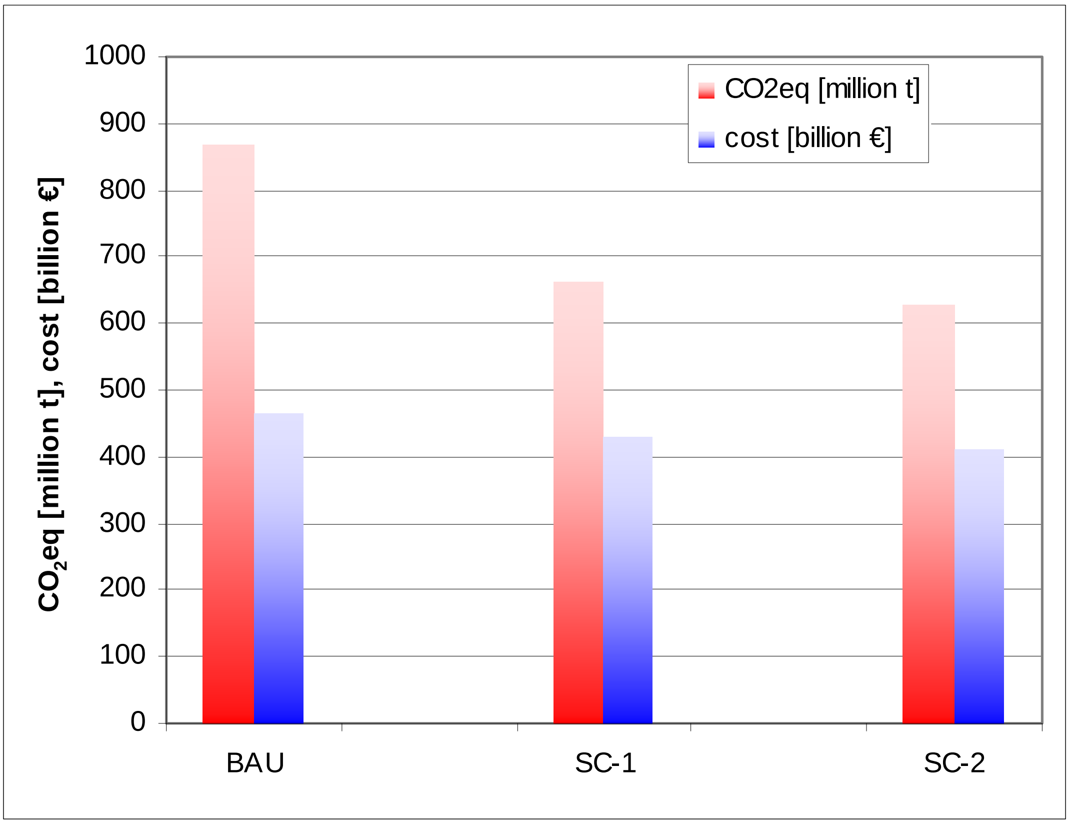
The comparison shows that in contrast to the food sub-scenarios, the reduction levels achieved by SC-and SC-2 are closer:

SC-1 achieves 8 to 24% reductions over the BAU values, while SC-2 allows 13-28% reduction with the exception of land use and costs which are only 7 and 12% less than in BAU, respectively. Both SC-1 and SC-2 cannot achieve reductions of PM_{10} emissions, though – this is due to the increased use of solid biomass (pellets) for direct heating.

Also, the SC sub-scenarios for housing increase the use of renewable energies significantly over BAU, with SC-2 achieving less than SC-1 due to reduced heating demands.

The following figure compares the GHG emissions and costs between the SC sub-scenarios for housing and the BAU sub-scenario for housing. The total costs are reduced by 7 and 12% for SC-1 and SC-2, respectively, and the GHG emissions are reduced by 24 and 27%, compared to BAU.

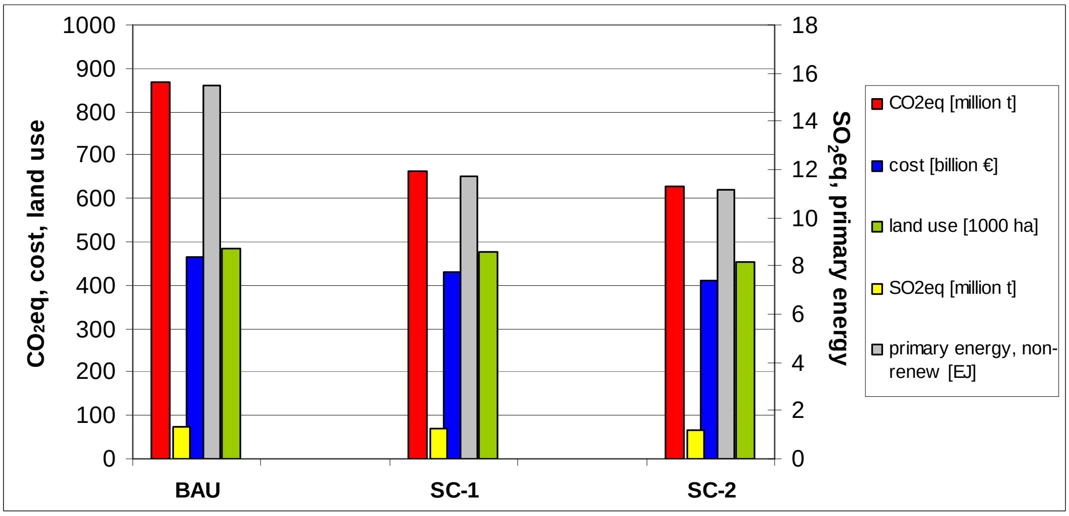
Figure 16 GHG Emissions and Costs of the Housing Sub-Scenarios, Year 2030



Source: own computation

The following figure gives the full range of results. The SC sub-scenarios for housing reduce all indicators except PM_{10}.

Figure 17 Comparison of Selected Results of the Housing Sub-Scenarios, Year 2030



Source: own computation

To allow for a better understanding of the results, the following table translates the data presented previously into per-capita data (based on total EU-27 population).

Table 36 Comparison of Selected per-Capita Results of the Housing Sub-Scenarios, Year 2030

GHG emisssions	**BAU**	**SC-1**	**SC-2**	**unit**
CO_2eq	1,7	1,3	1,2	t/cap
CO_2	1,6	1,2	1,1	t/cap
air emissions				
SO_2eq	2,6	2,4	2,3	kg/cap
PM_{10}	0,3	0,3	0,3	kg/cap
primary energy				
non-renewable	29,8	22,5	21,5	TJ/cap
renewable	10,9	13,8	13,1	TJ/cap
raw materials				
non-renewable	0,1	0,1	0,1	t/cap
renewable	3,2	2,4	2,3	t/cap
other indicators				
Land Use	0,00	0,00	0,00	ha/cap
Cost	894	830	789	€/cap

Source: own computation

This comparison shows that the per-capita GHG emissions for housing are less than 50% of those for food (see Table 34), and the air pollutant emissions are about 10% of those for food.

The per-capita primary energy use for housing is about 6 times higher for housing than for food, while the raw material use is in the same magnitude, as are the costs.

The land use for housing – excluding the direct footprint of the buildings – is about 9 m^2/cap in all scenarios, which is approx. 1/1000 of the value for food.

3.3 BAU vs. SC in the total Scenarios

Similar to the previous comparison of the BAU and SC sub-scenarios, the following table shows the comparison of the total BAU and SC scenarios.

Table 37 Comparison of Selected Results of the Total Scenarios, Year 2030

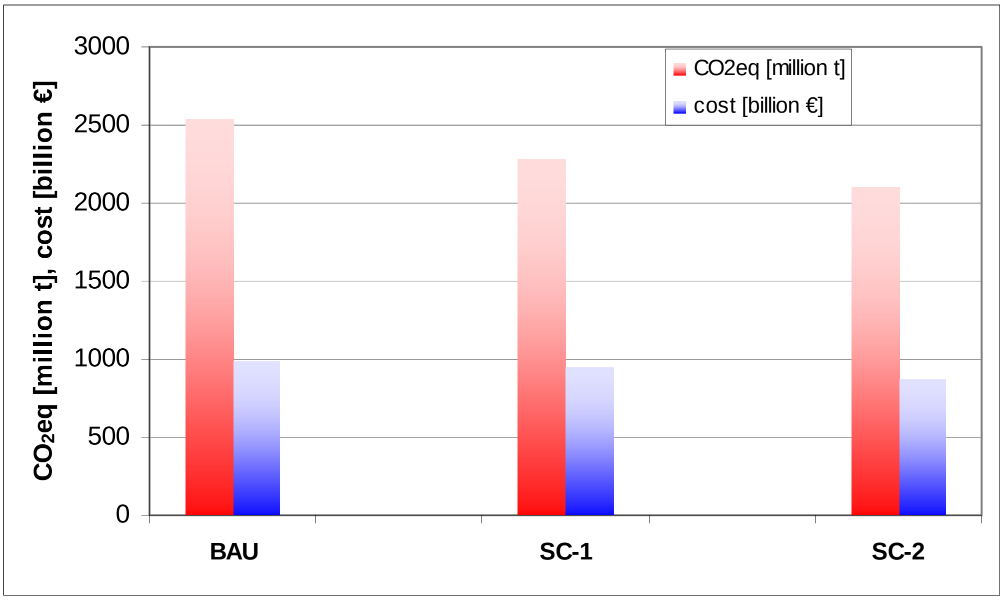
	unit	**BAU**	**SC-1**	**SC-2**	**SC-1 vs. BAU**	**SC-2 vs. BAU**	**SC-1 vs. BAU**	**SC-2 vs. BAU**
GHG emisssions								
CO_2eq	million t	2541	2285	2103	-256	-438	-10%	-17%
CO_2	million t	1029	830	780	-199	-249	-19%	-24%
air emissions								
SO_2eq	million t	14,6	14,1	12,9	-0,6	-1,7	-4%	-12%
PM_{10}	million t	0,32	0,32	0,30	0,0	0,0	2%	-5%
primary energy								
non-renewable	EJ	18,9	15,0	15,0	-4	-4	-20%	-20%
renewable	EJ	5,9	7,5	7,5	2	2	26%	26%
raw materials								
non-renewable	million t	172	162	149	-10	-23	-6%	-13%
renewable	million t	4773	4254	3936	-519	-837	-11%	-18%
other indicators								
Land Use	billion m^2	3691	3658	3235	-33	-457	-1%	-12%
Cost	billion €	984	944	874	-40	-111	-4%	-11%

Source: own computation

In comparison to BAU, the SC scenarios reduce the sustainability impacts for all indicators except for renewables where they achieve a 26% increase over BAU.

The following graph shows a comparison of the GHG emissions and costs. The SC scenarios achieve a 10 to 17% reduction over BAU by 2030, and a 1 to 12% cost reduction in parallel.

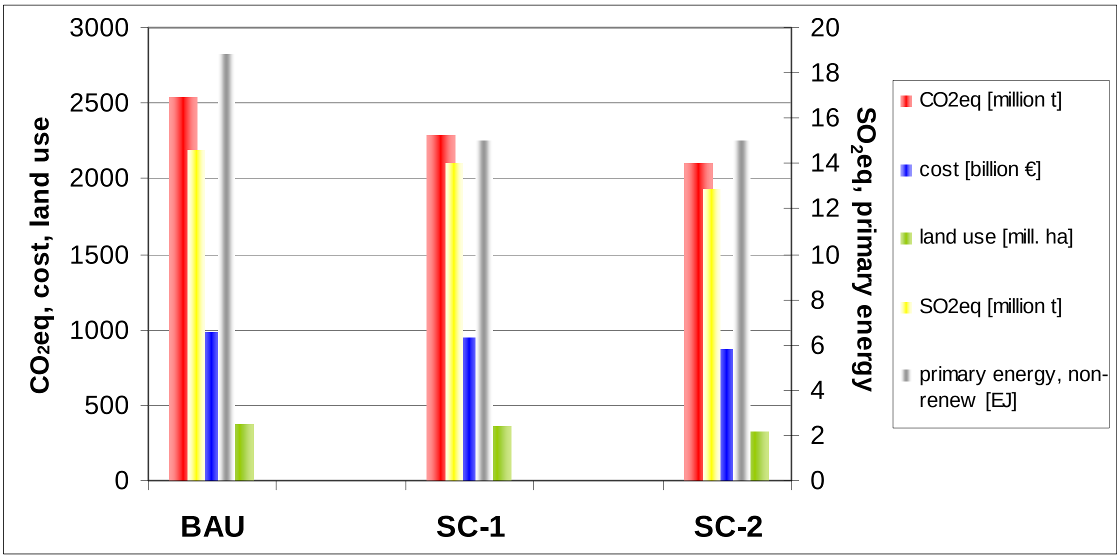
Figure 18 GHG Emissions and Costs of the Total Scenarios, Year 2030



Source: own computation

The following figure gives the full range of results. The SC scenarios reduce all sustainability indicators, i.e. they are **robust** in achieving higher sustainability.

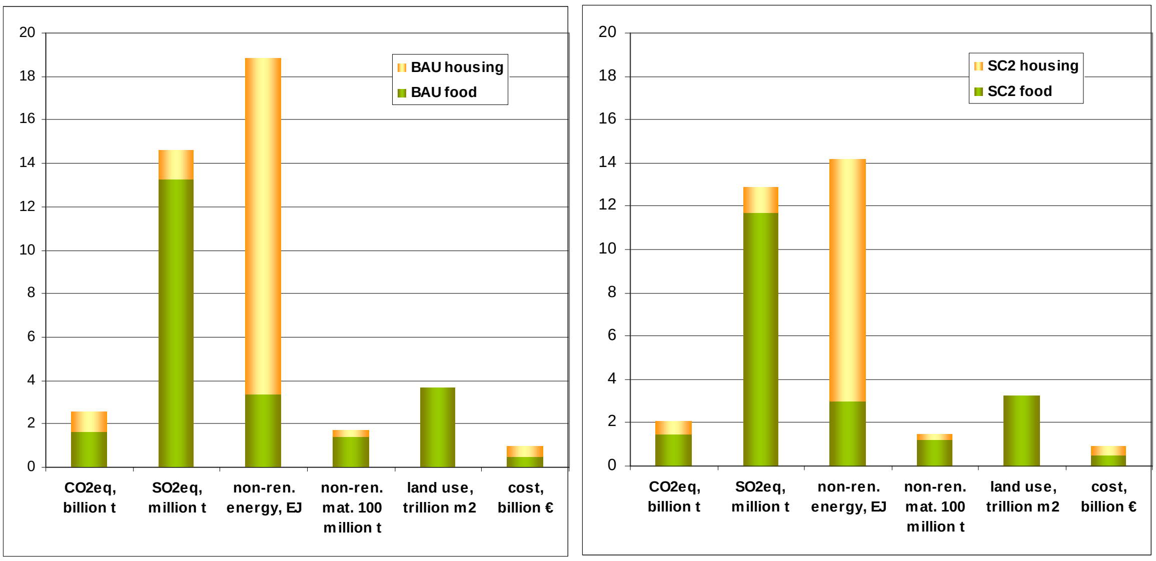
Figure 19 Comparison of Selected Results of the Total Scenarios, Year 2030



Source: own computation

It is interesting to break down the total results into the contributions of the need areas food and housing. This is shown in the following figure.

Figure 20 Comparison of the Contributions of the Sub-Scenarios for Food and Housing in the BAU and SC-2 Scenarios for Selected Results, Year 2030



Source: own computation

In the left section of Figure 20, the BAU results are shown, while the right section shows the SC-2 results. The GHG, air pollutant, non-renewable raw material and cost reductions in SC-2 come from both food and housing, while the reduction of non-renewable primary energy comes mainly from housing, and the land use reduction from food. The following table shows the per-capita comparison.

Table 38 Comparison of Selected per-Capita Results of the Total Scenarios, Year 2030

GHG emisssions	**BAU**	**SC-1**	**SC-2**	**unit**
CO_2eq	4,9	4,4	4,0	t/cap
CO_2	2,0	1,6	1,5	t/cap
air emissions				
SO_2eq	28,1	27,0	24,8	kg/cap
PM_{10}	0,6	0,6	0,6	kg/cap
primary energy				
non-renewable	36,3	28,8	28,8	TJ/cap
renewable	11,4	14,4	14,4	TJ/cap
raw materials				
non-renewable	0,3	0,3	0,3	t/cap
renewable	9,2	8,2	7,6	t/cap
other indicators				
Land Use	0,71	0,70	0,62	ha/cap
Cost	1893	1816	1680	€/cap

Source: own computation

4 The International Dimension of SC Instrument Impacts

A further research question in EUPOPP was how the sustainability impacts of the SC scenarios compare regarding the **international dimension**, i.e. to what extent reductions of EU sustainability impacts are possibly compensated by increases of impacts **outside** of the EU, especially in developing countries.

To answer this question, the scenario results were disaggregated with respect to the shares occurring **within** the EU 27, and the "outside" impacts.

For this, the MFA calculation identified all contributions to sustainability impacts from processes and activities situated in the EU-27, and from all other locations. To facilitate the comparison, the following tables give the results only for the total BAU and SC scenarios[12].

Table 39 Disaggregation of the GHG Emissions of the BAU Scenario (total)

	GHG emissions, in million t			
in EU-27 only	**CO_2eq**	**CO_2**	**CH_4**	**N_2O**
Food + housing 2010	2577	1147	8,6	4,08
Food + housing 2020	2490	1041	8,2	4,17
Food + housing 2030	2419	942	7,9	4,29
outside of EU-27	**CO_2eq**	**CO_2**	**CH_4**	**N_2O**
Food + housing 2010	130	93	1,4	0,01
Food + housing 2020	125	87	1,3	0,01
Food + housing 2030	122	87	1,2	0,01
domestic share in EU-27	**CO_2eq**	**CO_2**	**CH_4**	**N_2O**
Food + housing 2010	95%	93%	86%	99,7%
Food + housing 2020	95%	92%	86%	99,7%
Food + housing 2030	95%	92%	87%	99,7%

Source: own computation

These results show that the GHG emissions in the BAU scenario origin predominantly from domestic sources, especially for N_2O. For CH_4, the external share is about 15%, while for CO_2 and CO_2eq, approx. 95% are resulting from emitters within the EU-27.

A detailed analysis of the emission patterns using the GEMIS model features identified that the key reason for the comparatively high share of "external" CH_4 is the methane emissions of the Russian gas system which delivers a rising share of the EU natural gas supply.

The following table gives the results for the SC scenarios.

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[12] The respective analysis for the sub-scenarios is available in the GEMIS 4.7 model.

Table 40 Disaggregation of the GHG Emissions of the SC Scenarios (total)

	GHG emissions, in million t			
in EU-27 only	**CO_2eq**	**CO_2**	**CH_4**	**N_2O**
Food+housing 2010	2581	1151	8,6	4,08
Food+housing 2020 SC-1	2352	928	7,9	4,11
Food+housing 2030 SC-1	2180	754	7,3	4,17
Food+housing 2020 SC-2	2275	917	7,6	3,92
Food+housing 2030 SC-2	2005	709	6,7	3,78
outside of EU-27	**CO_2eq**	**CO_2**	**CH_4**	**N_2O**
Food+housing 2010	125	87	1,4	0,01
Food+housing 2020 SC-1	114	80	1,2	0,01
Food+housing 2030 SC-1	106	76	1,0	0,01
Food+housing 2020 SC-2	112	79	1,2	0,01
Food+housing 2030 SC-2	98	71	0,9	0,01
domestic share in EU-27	**CO_2eq**	**CO_2**	**CH_4**	**N_2O**
Food+housing 2010	95%	93%	86%	99,8%
Food+housing 2020 SC-1	95%	92%	87%	99,7%
Food+housing 2030 SC-1	95%	91%	88%	99,7%
Food+housing 2020 SC-2	95%	92%	86%	99,7%
Food+housing 2030 SC-2	95%	91%	88%	99,7%

Source: own computation

The emission pattern is nearly the same as for the BAU scenario, i.e. the dominant contributors to the GHG emissions are of EU-27 origin. The “external” share of CH_4 is slightly higher than in BAU, but it must be noted that the **absolute** values of external CH_4 emissions is **lower** than in BAU.

The following table shows the results for the air pollutants from BAU.

Table 41 Disaggregation of Air Pollutant Emissions of the BAU Scenario (total)

	air emissions, million t			
in EU-27 only	**SO_2eq**	**SO_2**	**NO_x**	**PM_{10}**
Food + housing 2010	13,3	1,1	2,2	0,27
Food + housing 2020	14,4	0,9	2,1	0,27
Food + housing 2030	13,9	0,6	1,9	0,24
outside of EU-27	**SO_2eq**	**SO_2**	**NO_x**	**PM_{10}**
Food + housing 2010	0,8	0,4	0,6	0,06
Food + housing 2020	0,7	0,3	0,6	0,06
Food + housing 2030	0,7	0,3	0,6	0,08
domestic share in EU-27	**SO_2eq**	**SO_2**	**NO_x**	**PM_{10}**
Food + housing 2010	95%	75%	80%	82%
Food + housing 2020	95%	74%	79%	81%
Food + housing 2030	95%	65%	77%	75%

Source: own computation

The EU share of SO_2eq is similar to the CO_2eq, i.e. 95% of the emissions are of European origin. With regard to SO_2, NO_X and PM_{10}, though, the external shares are higher, and **increase over time**.

This result is mainly caused by the rising import shares of fossil energy, especially oil (from OPEC and Russia) and natural gas (Russia).

The following table shows the results for the air pollutants from the SC scenarios.

Table 42 Disaggregation of Air Pollutant Emissions of the SC Scenarios (total)

	air emissions, million t			
in EU-27 only	**SO_2eq**	**SO_2**	**NO_x**	**PM_{10}**
Food+housing 2010	13,4	1,1	2,2	0,27
Food+housing 2020 SC-1	14,2	0,8	2,1	0,28
Food+housing 2030 SC-1	13,4	0,6	1,9	0,25
Food+housing 2020 SC-2	13,6	0,8	2,0	0,27
Food+housing 2030 SC-2	12,2	0,5	1,7	0,23
outside of EU-27	**SO_2eq**	**SO_2**	**NO_x**	**PM_{10}**
Food+housing 2010	0,7	0,3	0,5	0,06
Food+housing 2020 SC-1	0,7	0,3	0,5	0,06
Food+housing 2030 SC-1	0,7	0,3	0,5	0,08
Food+housing 2020 SC-2	0,7	0,3	0,5	0,06
Food+housing 2030 SC-2	0,6	0,3	0,5	0,07
domestic share in EU-27	**SO_2eq**	**SO_2**	**NO_x**	**PM_{10}**
Food+housing 2010	95%	77%	80%	82%
Food+housing 2020 SC-1	95%	74%	80%	82%
Food+housing 2030 SC-1	95%	66%	78%	76%
Food+housing 2020 SC-2	95%	74%	80%	82%
Food+housing 2030 SC-2	95%	66%	78%	76%

Source: own computation

Again, the pattern is quite similar to the BAU case, but the SC scenarios have typically a 1%-point **higher domestic** share of SO_2, NO_X and PM_{10}, and the absolute values of the air pollutant emissions both within and outside of the EU are lower than in BAU.

Thus, the SC scenarios do not "export" impacts – on the contrary, they **reduce** the external burden caused by EU demands. This effect is mainly due to the higher efficiency of the buildings, and the higher share of domestic renewables supplying heat services.

This can be verified by comparing the results for the cumulated primary energy use of the BAU and SC scenarios which is shown in the following tables.

Table 43 Disaggregation of the Cumulated Energy Use of the BAU Scenario (total)

	Cumulated primary energy use, EJ		
in EU-27 only	**total**	**non renewable**	**renewable**
Food + housing 2010	14,0	10,7	3,3
Food + housing 2020	15,4	9,8	5,7
Food + housing 2030	14,3	8,4	5,9
outside of EU-27	**total**	**non renewable**	**renewable**
Food + housing 2010	10,8	10,8	0,0
Food + housing 2020	10,3	10,3	0,1
Food + housing 2030	10,5	10,5	0,1
domestic share in EU-27	**total**	**non renewable**	**renewable**
Food + housing 2010	56%	50%	99%
Food + housing 2020	60%	49%	99%
Food + housing 2030	58%	44%	99%

Source: own computation

The BAU scenario requires 42% of the total primary energy use to come from **outside** of the EU-27 by 2030, i.e. the domestic share will be 58% of the non-renewable primary energy use, the domestic shares will decrease to 44%, i.e. 56% will come from external sources by 2030. The SC scenarios, in contrast, will achieve a domestic share of 63% of all primary energy, and 45% of non-renewable energy (see table below).

Table 44 Disaggregation of the Cumulated Energy Use of the SC Scenarios (total)

	Cumulated primary energy use, EJ		
in EU-27 only	**total**	**non renewable**	**renewable**
Food+housing 2010	14,1	10,7	3,3
Food+housing 2020 SC-1	15,4	8,7	6,7
Food+housing 2030 SC-1	14,2	6,8	7,4
Food+housing 2020 SC-2	15,3	8,6	6,7
Food+housing 2030 SC-2	13,4	6,3	7,0
outside of EU-27	**total**	**non renewable**	**renewable**
Food+housing 2010	10,8	10,7	0,0
Food+housing 2020 SC-1	9,1	9,1	0,1
Food+housing 2030 SC-1	8,3	8,2	0,1
Food+housing 2020 SC-2	9,0	9,0	0,0
Food+housing 2030 SC-2	7,9	7,8	0,1
domestic share in EU-27	**total**	**non renewable**	**renewable**
Food+housing 2010	57%	50%	99%
Food+housing 2020 SC-1	63%	49%	99%
Food+housing 2030 SC-1	63%	45%	99%
Food+housing 2020 SC-2	63%	49%	99%
Food+housing 2030 SC-2	63%	45%	99%

Source: own computation

The domestic share of primary energy in the SC scenarios is significantly higher than in BAU, i.e. the external impacts will be reduced accordingly.

A similar development can be seen for the raw material use (see tables below). Again, the SC scenarios achieve a higher domestic share for the total and the renewable raw materials by 2030.

Table 45 Disaggregation of the Raw Material Use of the BAU Scenario (total)

	Cumulated raw material use, million t		
in EU-27 only	**total**	**non renewable**	**renewable**
Food + housing 2010	2388	117	2271
Food + housing 2020	2489	135	2354
Food + housing 2030	2488	144	2344
outside of EU-27	**total**	**non renewable**	**renewable**
Food + housing 2010	2411	24	2387
Food + housing 2020	2385	27	2358
Food + housing 2030	2457	28	2429
domestic share in EU-27	**total**	**non renewable**	**renewable**
Food + housing 2010	50%	83%	49%
Food + housing 2020	51%	83%	50%
Food + housing 2030	50%	84%	49%

Source: own computation

Table 46 Disaggregation of the Raw Material Use of the SC Scenarios (total)

	Cumulated raw material use, million t		
in EU-27 only	**total**	**non renewable**	**renewable**
Food+housing 2010	2390	117	2273
Food+housing 2020 SC-1	2422	130	2292
Food+housing 2030 SC-1	2355	134	2221
Food+housing 2020 SC-2	2312	125	2188
Food+housing 2030 SC-2	2140	123	2017
outside of EU-27	**total**	**non renewable**	**renewable**
Food+housing 2010	2422	24	2398
Food+housing 2020 SC-1	2181	27	2154
Food+housing 2030 SC-1	2060	28	2033
Food+housing 2020 SC-2	2128	26	2102
Food+housing 2030 SC-2	1945	26	1919
domestic share in EU-27	**total**	**non renewable**	**renewable**
Food+housing 2010	50%	83%	49%
Food+housing 2020 SC-1	53%	83%	52%
Food+housing 2030 SC-1	53%	83%	52%
Food+housing 2020 SC-2	52%	83%	51%
Food+housing 2030 SC-2	52%	83%	51%

Source: own computation

A key issue of the international dimension is land use. The following table shows the respective breakdown for the BAU scenario.

Table 47 Disaggregation of the Land Use of the BAU Scenario (total)

	Land use billion m²			domestic share of EU-27
	total	**in EU-27 only**	**outside of EU-27**	
food + housing 2010	3507	3489	18	99,5%
food + housing 2020	3700	3678	22	99,4%
food + housing 2030	3691	3666	26	99,3%

Source: own computation

In BAU, the land use is predominantly domestic, but the share of external land use is rising slightly over time, mainly due to rising imports of food[13]. The respective results for the SC scenarios are given in the following table.

Table 48 Disaggregation of the Land Use of the SC Scenarios (total)

	Land use billion m²			domestic share of EU-27
	total	**in EU-27 only**	**outside of EU-27**	
food+housing 2010	3507	3489	18	99,5%
food+housing 2020 SC-1	3683	3661	22	99,4%
food+housing 2030 SC-1	3658	3633	26	99,3%
food+housing 2020 SC-2	3469	3448	21	99,4%
food+housing 2030 SC-2	3235	3212	23	99,3%

Source: own computation

The SC scenarios achieve the same patterns as BAU, but the absolute amount of land used outside of the EU-27 is about 10% lower.

This indicates that the overall "pressure" on land outside of the EU from domestic demands will be reduced. This result is mainly due to the changes in food consumption patterns (level and diets) which favour less land-intense products (less meat).

The following figure summarizes the domestic shares of the sustainability indicators for all scenarios for the year 2030.

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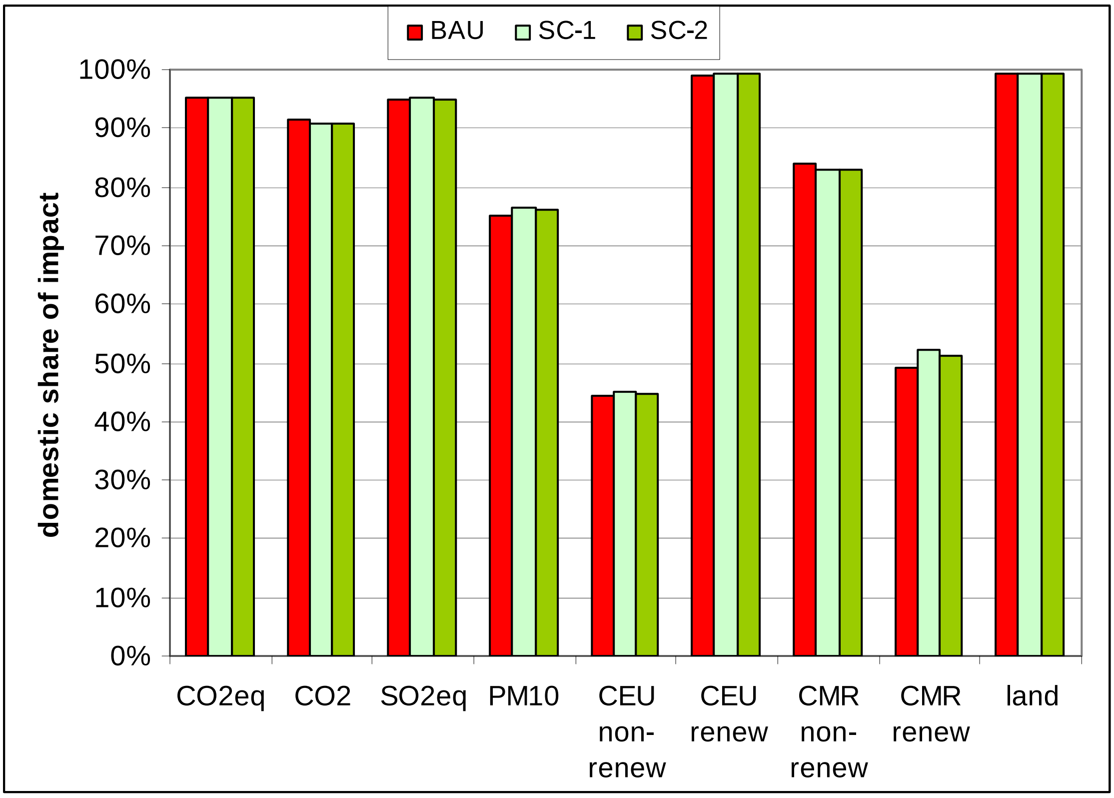
[13] It should be noted that for fishing and aquaculture, no land use is attributed. This is important, as the share of imports of fish products will increase until 2030.

Figure 21 Comparison of the Domestic Shares of Sustainability Impacts in the BAU and SC Scenarios, Year 2030



Source: own computation

The analysis of the international dimension of the scenarios indicates that for GHG and air emissions, renewable energy and land use, the overall origin is within the EU-27, i.e. the domestic shares dominate the patterns.

For non-renewable primary energy and nor renewable raw materials, the import shares form outside of the EU are around 50%, i.e. approximately **half** of the sustainability impacts will occur **outside** of the EU.

The full implementation of all assumed SC instruments in the SC-2 scenario will allow increasing the domestic shares both in relative and absolute terms, thus **reducing** the pressure on climate, air, land and respective impacts from non-renewable primary energy and raw materials.

Thus, the SC scenarios do **not** imply **any** burden shifting from the EU towards abroad, but contrarily contribute to more equity.

Still, the external shares of non-renewable primary energies and raw materials remain high even by 2030. This result indicates that SC instruments for food and housing are important, but will not be sufficient to allow for a full "internalization" of sustainability burdens within the EU-27 borders.

5 Excurse: Employment Effects

Besides environmental aspects and costs as quantified sustainability indicators, EUPOPP also tried to quantify employment impacts.

For this, a **hybrid** methodology was used which

- tracks the **direct** employment effects along life-cycles of energy and food systems, i.e. the jobs immediately associated to the operation of processes, and
- determines **indirect** effects from capital investments, operating costs, and auxiliaries of all processes and activities using **monetary** input-output tables (IOT).

The direct effects use the MFA accounting so that they are explicitly dynamic with regard to changes of the systems, their efficiencies, and employment intensities.

For the indirect effects, though, only the IOT for 2005 is available for the EU-27 which cannot be “projected” into later years due to its statistical nature. Therefore, the indirect employment effects using IOT give static results. In reality, employment effects will change over time, as working hours change, efficiency of production systems increase, and structural changes occur which effect monetary flows to other economic sectors and, thus, the employment balance per economic output of a given sector.

The **combination** of the dynamic MFA-related direct employment calculation with the static IOT-based quantification of indirect effects requires caution in the interpretation of results.

Therefore, the employment balances are not included in the other quantified sustainability indicators (see previous sections) even if they were quantified, but are reported separately in this excurse section.

The results of the hybrid modelling of the employment impacts of the BAU scenario are given in the following table.

Table 49 Direct and Indirect Employment Impacts of the BAU Scenario

million person-years	**direct**	**indirect**	**total**
food + housing 2010	24	79	103
food + housing 2020	25	96	121
food + housing 2030	25	101	127

Source: own calculation using GEMIS 4.7

The direct employment effects will remain more or less constant, while the indirect effects will increase until 2030.

The following table gives the respective results for the SC scenarios

Table 50 Direct and Indirect Employment Impacts of the SC Scenarios

	direct	indirect	total
food+housing 2010	24	79	103
food+housing 2020 SC-1	29	93	122
food+housing 2030 SC-1	34	94	129
food+housing 2020 SC-2	28	91	118
food+housing 2030 SC-2	38	90	128

Source: own calculation using GEMIS 4.7

The employment effects of the SC scenarios are in the same order of magnitude as in BAU, but there will be more direct jobs and less indirect employment. This is mainly an effect of the incremental building retrofits in the housing sector which have more direct jobs, and of the reduced energy and food demands which imply less indirect employment.

Still, the total balance of the SC scenarios over BAU is positive, i.e. there will be more jobs, especially within the EU.

When interpreting the results it should be kept in mind that the indirect employment effects were calculated with a static IOT based on 2005 values. Thus, the future dynamics of specific employment in various economic sectors is not included in the results. Furthermore, the IOT methodology for the indirect employment does not consider job effects outside of Europe, as the respective IO data are not available.

The direct employment data are more robust, as they consider explicitly the technological changes and life-cycle impacts across borders.

Given the constraints on the methodology for the employment data, and considering further the uncertainty associated with the (direct) employment data for outside of Europe (see Section 7), the results presented here should be taken **as indicative**, i.e. given a principal direction of effects.

6 Impacts of SC Instruments on Qualitative Sustainability Indicators

In addition to the quantified sustainability impacts of the BAU and SC scenarios discussed in the previous sections, the EUPOPP indicators also address **non-quantitative** impacts in a qualitative manner. For this, the changes in “intensity” of relevant drivers are considered. The section especially focuses on land-use related biodiversity impacts, and briefly discusses social implications.

6.1 Land Use and Biodiversity

As discussed in Section 4, the land use associated with the SC scenarios is – slightly - lower than in BAU, and less of land is “used” outside of the EU-27. But beyond the hectare data, the quality of the land use is important with regard to biodiversity:

In the SC-2 scenario, the **organic** share of food consumed is assumed to increase significantly above BAU, so that far more agriculture will follow organic cultivation rules. Thus, the intensity of the land use in SC-2 will be lower than in BAU, and the reduced use of industrial fertilizers and the broader genetic variety of plants used in organic farming will contribute to agro-biodiversity.

With less agrochemicals being applied, also ecosystem functions will be enhanced compared to BAU.

Another important qualitative aspect is that in SC-2, more fish will come from certified aquaculture so that overexploitation of marine resources will be reduced accordingly. This will not only help to stabilize fish populations, but also to reduce energy for fishing and respective GHG and air emissions.

All these qualitative sustainability impacts are positive for the SC-2 scenario.

6.2 Social Impacts

The quantification – even if indicative only - of employment (see Section 5) should be seen as a qualifier in the social domain. Employment is less an economic indicator than an expression of inclusion in modern societies, and as an opportunity for income generation. The analysis of the BAU and SC scenarios with regard to employment indicated that especially the SC-2 scenario will create more direct jobs in Europe, which will contribute to social development.

Furthermore, the distribution of these direct jobs shows a peak in the construction sector which will occur widely dispersed across Europe, following the distributed needs to retrofit existing buildings not only in cities, but also in rural areas.

Similarly, increasing the bioenergy share from domestic resources will improve rural development, as both employment and income from agriculture and forest operations will increase, and those are spatially well distributed.

7 Data Uncertainties and Sensitivities, and Research Recommendations

The quantification of sustainability indicators associated with the BAU and SC scenarios is, by necessity, uncertain, as it concerns potential future developments which cannot be known today.

Given this fundamental uncertainty, the methodological approach of EUPOPP is to measure the **differences** between a baseline scenario, and alternative developments driven by implementing SC instruments.

These differences are mainly determined by the hypotheses on the effects (physical and economic changes) of the instrument implementation (see OEKO 2011b).

The quantification of sustainability impacts from these changes is comparatively straight-forward, and uncertainties are stemming mainly from the overall dynamics of emission factors, import mixes, and similar data.

As these factors (and their respective uncertainty) are **the same** for the BAU and the SC scenarios, the calculation of the differences between the scenarios cancels out a large part of the uncertainty so that the results of the quantified differences between the sustainability indicators for the scenarios should be **seen as robust**.

There are a few exceptions, though:

In the SC-2 food sub-scenario, an increasing share (over BAU) of organic products is assumed. The current life-cycle and material flow data for organic products imply uncertainties with regard to GHG and air emissions, and land use. The future dynamics of organic farming is an issue of debate, as there is little empirical evidence, both with regard to time series, and overall land use. Thus, it is important to intensify the research of **sustainability indicators of organic farming**.

The employment effects of retrofitting existing buildings all over Europe in the 2020 – 230 timeframe are speculative still, as there has not been such an activity on a reasonable scale anywhere in Europe yet. Similarly, the costs associated with high-efficient retrofits are quite uncertain.

Last but not least, the **hypotheses underlying** the SC scenarios were derived based on explicit assumptions (see OEKO 2011b) which should be consolidated with more data from real-world implementation especially of instruments in the food domain.

In perspective, the methodology and database developed within EUPOPP for the need areas of food and housing should be **considered for extension** to the (private) transport sector, and possibly to selected other key product areas such as clothing and washing. Also, the qualitative analysis and the international (outside of the EU-27) dimension are deemed interesting areas for improvement of both data, and scope.

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Abbreviations and Acronyms

BAU	business-as-usual
CEE	Central and Eastern Europe
ECOI	Eco-Institut Barcelona
EEA	European Environment Agency
EPBD	Energy Performance of Buildings Directive (of the EU)
EU	European Union
EUPOPP	European Policies to Promote Sustainable Consumption Patterns (EU FP 7 collaborative research project)
EUROSTAT	European Statistical Office
FAO	Food and Agriculture Organization of the United Nations
GHG	greenhouse gas(es)
LCA	life-cycle analysis (or assessment)
MFA	material flow analysis
NCRC	National Consumer Research Council (of Finland)
OEKO	Oeko-Institut (Institute for appliec Ecology)
PRIMES	Partial equilibrium model for the European energy system
SC	sustainable consumption
UCL	University College London
UNEP	United Nations Environment Programme
WHO	World Health Organization of the United Nations

Annex: Disaggregated Data for the BAU Food Sub-Scenario

Development of Total EU Food Consumption, BAU Scenario

Consumption in mio t/a	2010	2020	2030
FRUITS	**40,4**	**43,6**	**44,3**
Apples	15,4	16,3	16,3
Bananas	3,7	3,9	3,6
Grapes	4,2	4,3	4,0
Lemons, Limes	2,0	2,3	2,3
Oranges, Mandarines	15,0	16,9	18,0
VEGETABLES	**21,1**	**22,3**	**20,9**
Tomatoes	7,3	7,6	6,8
Nuts	2,2	2,3	2,2
Onions	4,3	4,7	5,2
Potatoes	7,3	7,6	6,8
VEGETABLE OIL	**8,6**	**9,7**	**10,3**
Vegetable Oils	2,2	2,6	2,8
Olive Oil	2,4	2,8	3,1
Sunflowerseed Oil	2,5	2,7	2,8
Soyabean Oil	1,5	1,7	1,6
CEREALS	**19,2**	**19,1**	**19,9**
Rice (Milled Equivalent)	3,2	3,6	3,8
Rye	2,7	2,0	2,2
Maize	5,2	5,2	5,6
Wheat	8,1	8,3	8,3
SUGAR	**14,7**	**14,5**	**14,8**
BEVERAGES	**49,0**	**46,5**	**46,7**
Beer	35,4	35,2	36,7
Coffee	2,3	2,5	2,8
Wine	11,2	8,8	7,2
DAIRY	**22,0**	**22,9**	**24,5**
Milk	3,6	3,1	3,0
Butter	2,0	1,9	1,9
Cheese	7,9	8,9	10,2
Cream	1,5	1,5	1,5
Eggs	7,0	7,5	7,9
MEAT	**41,0**	**42,0**	**42,5**
beef meat	8,2	8,3	8,3
pork meat	20,9	22,1	22,4
chicken meat	11,8	11,5	11,8
FISH	**11,2**	**11,6**	**12,0**
Freshwater fish (aq. & capture)	0,6	0,7	0,7
Marine fishes capture	6,1	6,4	6,6

Consumption in mio t/a	**2010**	**2020**	**2030**
Crustaceans aquaculture	0,4	0,4	0,4
Molluscs aquaculture	4,0	4,2	4,4
ALL FOOD	**454,2**	**464,8**	**471,7**
ALL FOOD + BEVERAGES	**503,2**	**511,3**	**518,3**

Source: own computations based on EUPOPP Deliverable 4.2