EUPOPP Work Package 4

Deliverable 4.2

BAU and SC Scenario Assumptions and the MFA Database

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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 4.2 (D4.2) aims to provide data and key assumptions used in Work Package (WP) 4 tasks focusing on **scenarios** for the need areas of **food and housing** in the EU 27 until 2030:

- **Task 4.1** analyzed data on historic and future consumption and production trends compiled in WP2 (see Deliverable D 2.1) and **extended those to future trends** from 2005 onwards to 2030 to define the baseline (**BAU**) scenario.

- **Task 4.3** identified the impacts of SC strategies (instrument bundles, see Deliverable 4.1) on sustainability on the basis of material flow analysis in the BAU scenario. For this, a reference scenario (business-as-usual = BAU) was developed. The BAU scenario projects the future development in the need areas on the EU level until 2030, assuming **only current trends** in implementing SC instruments.

- **Task 4.4** determined the potential impacts of the full implementation of SC strategies in SC scenarios which project the future development in the need areas on the EU level until 2030, assuming fully implementing the SC instrument, and using the hypotheses from Task 4.2 (see Deliverable 4.1)

The Deliverable 4.2 is structured as follows:

After the introduction, Section 2 presents the definition of the BAU scenario with regard to food and housing in the EU 27 until 2030.

Section 3 gives the background for the sustainability consumption (SC) scenarios which assume implementing the SC instrument bundles.

In Section 4, the data for the MFA in the food area (excluding fish) is presented, while Section 5 gives the updated data on fish products, differentiated between aquaculture and capture.

Section 6 presents the MFA data used for food processing, and Section 7 discusses the data availability for housing (appliances, buildings, heating systems).

The quantitative data background is given in detail in the Annex.

1 Introduction

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

The BAU scenario represents a benchmark to compare future developments in which SC strategies are assumed to be implemented (SC scenarios).

Both scenarios are described in this paper. The quantification of the potential future success of those instruments uses material flow analysis (for details on MFA, see Deliverable 4.1).

"Behind" the scenarios are data for the material flows associated with the demands for food and housing.

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. It will not be possible to model all these features, therefore system boundaries limit the need area and so the model world of the scenario analysis. Furthermore, the data quality is discussed.

The need area of **housing** is focussing on buildings within the private (residential) sector, respective heating systems, and household appliances. The section on housing describes the methodology used to calculate the energy demand for the modelled house typology. In the case of housing, the main indicator is the final end-energy demand (kWh/m²) from which then further indicators (GHG and air emissions etc.) were derived (see Deliverable D 4.3).

The paper describes the upgrading of existing data and necessities for calculating material flows and scenarios within the need area of food and housing.

By means of literature research and national and international statistical databases system boundaries are described.

To guarantee the readability of the working paper, extensive data tables are given in the annex.

2   The BAU Scenario: A Reference Future

The scenario work in EUPOPP started with the definition of a "business-as-usual" (BAU) scenario to create a reference (or baseline) for the further work on sustainable consumption scenarios (see Section 3). The BAU scenario is comprised of two subsets of information for the need areas "food" and "housing".

2.1   The BAU Scenario for Food

The BAU scenario for food in EUPOPP is using the CAPRI Outlook, a baseline scenario created for DG AGRI. In the following, the respective methodology, inputs and assumptions of the CAPRI baseline is described[1].

Technically, the CAPRI outlook is established in three major steps: (1) constrained trends, (2) technical reference run, (3) final reference run (Figure 1).

Figure 1: Steps in the Agricultural Outlook Approach
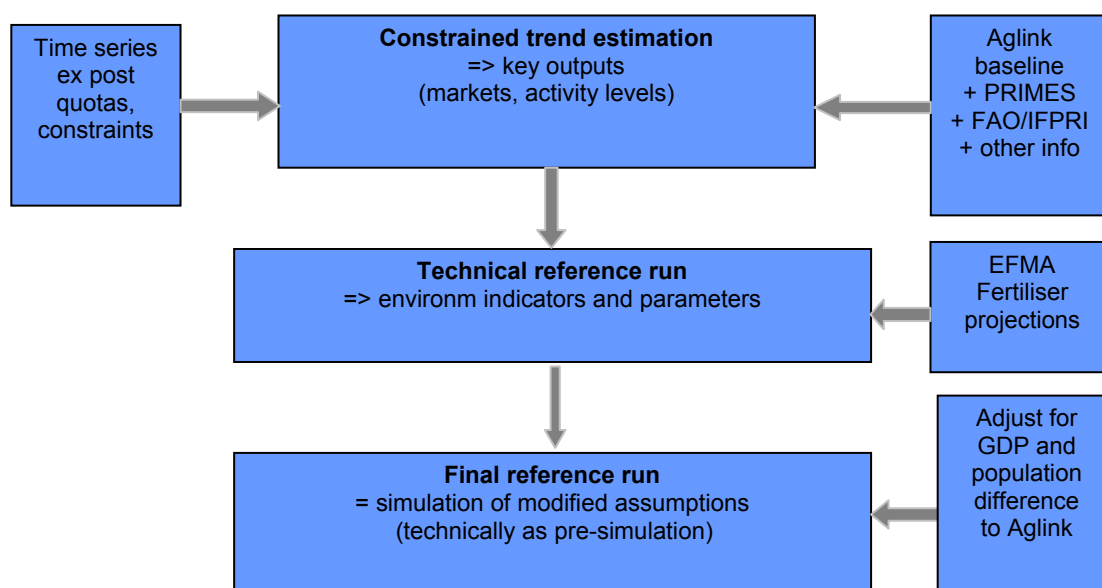
Source: own compilation

1. The constrained trend estimation merges the information in the ex post time series with the changes from an AGLINK baseline established for DG AGI in 2009 (OECD 2007), the PRIMES energy model (EC 2010), FAO data (FAO 2006), and IFPRI long run information[2] and other external information (national expert

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[1]   This section was prepared by Dr. Heinz Peter Witzke, Bonn; 16th of December 2010
[2]   See Chapter 5 in IAASTD (2009)

information, industry information) as will be explained in more detail below. The result of this first step is a first projection for the key variables in the agricultural sector (activity levels and market balances).

2. The "technical reference run" calibrates missing parameters and in this context also calculates missing variables that are related to the key variables, in particular complete nutrient balances in the crop and livestock sectors. For this step there has been a thorough revision of the methodology to acknowledge existing projections (EFMA 2007).

3. The third step gives the final reference run. This is a modification of any assumptions made in steps one or two (see details below) to obtain the desired starting point for further analysis. In this study it was necessary to correct for the differences in the macro assumptions of agricultural expert sources (AGLINK, FAO, IFPRI) and the macro assumptions of PRIMES. Technically this is handled as a pre-simulation, i.e. a specific scenario to represent the situation of the desired reference run.

Exogenous information may be classified into policy assumptions and market assumptions. Regarding the Common Agricultural Policy the reference run incorporates the implementation of the CAP Health Check baseline but does not anticipate a WTO agreement.

While there are Commission proposals on the table both for the future of the CAP in the next financial perspective (2013-2020) as well as for the Doha WTO round, it is uncertain to what extent these proposals will become part of future legislation, such that this reference run implies a rather conservative view on the future CAP.

The most important changes from the Health Check here are probably the abandonment of set aside and the expiry of the milk quota in 2015. The modifications to pillar 1 payments (increased modulation, degressive capping, Article 69 reallocation) are likely to be less important. Note that a WTO agreement has *not* been built into the reference run.

Market assumptions are exogenous macroeconomic developments, but also specific assumptions on biofuel production from agricultural feed stocks, on mineral fertiliser use, and agricultural markets in general.

In most cases the CAPRI reference run *tries* to stay close to this information but often cannot impose it strictly (see more details below).

The key assumptions under the 'market assumptions' heading are:

Table 1: Core market Assumptions for the August 2009 CAPRI Baseline

Variable	Source	Determines…
Macroeconomics (inflation, GDP)	**PRIMES for EU, AGLINK/FAO/IFPRI elsewhere**	**…some nominal prices, position of demand functions, starting point for future simulations**
Demographics	**PRIMES for EU, AGLINK/FAO/IFPRI elsewhere**	**… position of demand functions, starting point for future simulations**
EU market information available from DG Agri	**AGLINK 2009 projections, supplemented with national/industry sources**	**… target values for CAPRI estimator (e.g. beef supply)**
EU market information unavailable from DG Agri	**Constrained trends**	**… related variables (e.g. suckler cow herd)**
World markets	**AGLINK/FAO/IFPRI projections plus data consolidation**	**… international market variables, position of behavioural functions, starting point for simulations**
Yields	**AGLINK/FAO/IFPRI or constrained trends**	**…market results, position of behavioural functions, starting point for simulations**
Technological progress	**Often own assumptions (e.g. max yields, 0.5% input saving p.a.), sometimes IIASA (emission controls)**	**…market results, position of behavioural functions, starting point for simulations**
Fertiliser use	**EFMA projections and overfertilisation/availability parameter trends**	**… environmental indicators, farm income**

Source: own compilation

There are some recent revisions in the outlook methodology:

Step 1: Constrained trend estimation

The basic procedure of the constrained trend estimation is covered in detail in the CAPRI documentation (Britz/Witzke 2008)[3]. Like the whole CAPRI outlook its step 1 is also divided in three steps:

a. Independent trends provide some initial forecasts and statistics on the good-ness of fit or indirectly on the variability of the series.

b. Constrained trends impose identities (e.g. production = area * yield), technical bounds (like non-negativity or maximum yields) and consider specific expert in-formation like that from PRIMES

c. Expert information on aggregate EU markets is so important that it is treated in a separate final step. Currently, this is derived from AGLINK, FAO and IFPRI forecasts.

Expert information included in the context of step b stem from various sources

- National experts providing independent forecasts on 'their' animal sectors

- Industry experts for some information relevant to the sugar sector

- PRIMES biomass component projections on

    o Production, domestic use, and net trade of bio-fuels

    o Broad feedstock composition in biofuel production (waste oil, vegetable oil, cereals, sugar crops, second generation crops)

Step c adds expert information on aggregate EU markets from AGLINK, FAO, IFPRI. Here it was usually necessary to allocate the information on EU aggregate regions (EU15, EU12) to the MS level.

This is achieved based on the Step b results in such a way that the Step b differences among MS are maintained, but nonetheless the aggregate market information is in-cluded. Both in steps b and c any a priori information is included in the form of "target values", i.e. expectations with associated standard errors that define the penalties, if the targets are not met exactly.

To avoid a break in the projections at the transition of medium run expert information (AGLINK, up to 2020) and long run information (FAO/IFPRI for 2050) we have merged these with a variable weighting scheme that gives an increasing weight to our "long run" sources (FAO/IFPRI) as the projection horizon approaches 2050. This tends to give projections that gradually approach the long run sources, for example in year 2030, and has been the major adjustment to extend the CAPRI projection horizon to 2050.

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Step 2: Technical baseline

The past versions of CAPRI derive fertiliser projections from trend based forecasts of certain parameters describing changes in the fertiliser management of farmers. This approach had some drawbacks:

First of all, the trends are sometimes very weak or estimated with a high standard error. The second point is more important. Since a few years there are contacts to EFMA (European Fertiliser Manufacturers Association) which has always been the source of ex post information on fertilisers (through the International Fertiliser Association's (IFA) website) in an attempt to compare forecasts.

Given that EFMA/IFA information is known to be of high quality in general, this is an attractive source of expert information. So far it has been used in an ad hoc way only (manual corrections of trend estimated parameters).

The new solution is straightforward. We apply essentially the same methodology as the ex post data consolidation.

There is, however, an important difference: Ex post CAPRI treats the EFMA data as 100% hard information, and tries to comply with them as good as possible.

Ex ante EFMA provides projections based on considerable expert knowledge, but the national EFMA experts may nonetheless be wrong. Therefore they are treated as a priori information and penalise (but permit) deviations.

The other source of information for projections comes, as before, from the current trends on the "fertiliser parameters" that are now treated as a priori information as well, rather than being imposed strictly.

2.2 The BAU Scenario for Housing

The BAU scenario for housing in EUPOPP is using the PRIMES reference case (EC 2010).

PRIMES is a partial equilibrium model for the European energy system developed by the National Technical University of Athens (NTUA) for DG ENER since the late 1990ies, and is continuously updated and extended.

The overall data of the BAU scenario was derived from the PRIMES reference case, and is given in the following table.

Table 2: Key Data of the BAU Scenario for EUPOPP

	2010	2020	2030
Population (million)	499	514	520
Number of households (million)	217	231	241
Households size (inhabitants/household)	2,30	2,22	2,16
Final Energy Demand (in TWh)	3596	3647	3441
Heating and cooling (incl. cooking)	3155	3100	2821
Electric appliances and lighting	441	547	620
By fuel			
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

A detailed breakdown on the key PRIMES assumptions on the electricity and heating demands as well as the data on appliances, buildings and heating systems and the electricity supply system in the EU27 until 2030 is given in EUPOPP Deliverable 2.1 (EUPOPP 2009).

3 The SC Scenarios: Implementing Instrument Bundles

To contrast the BAU scenario, EUPOPP developed two sustainable consumption (SC) scenarios which assume the implementation of "bundled" SC instruments[4] from 2015 to 2030. The SC scenarios differ in their "ambition", i.e. the implementation of SC isntruments is modelled differently in the two SC scenarios.

3.1 Scenario SC-1: Moderate Ambition

The SC-1 scenario assumes a "moderate" ambition, i.e. only those SC instrument bundles are implemented which do not pose a major hurdle in terms of policy.

3.1.1 Food Instrument Bundle in SC-1

The food instrument bundles in SC-1 assume a reduction of meat consumption of 20 percent by 2030, compared to the BAU scenario in which meat consumtion is more or less stable.

The instrument bundle for food takes into account the shifts between meat and cereals, dairy, vegetables and fish, i.e. the different nutrition values of meat and low-meat diets are considered.

The instruments' implementation is assumed to start in 2015, and reach their full effect by 2030.

As meat is only one element of the overall diets in Europe, the shift to less meat induced by the instrument bundle affects just a part of the total food consumption.

3.1.2 Housing Instrument Bundle in SC-1

The instrument bundling for housing is disaggregated with regard to electricity consumption from appliances, efficiency of buildings, and mix of heating systems. In the SC-1 scenario, instrument bundles for all these demands are considered.

Appliances

The average lifetime of household appliances is below the scenario horizon of EUPOPP, so that it is assumed that all existing appliances are replaced until 2030.

As household appliances with labels consume only about 40% of the total household electricity, the instrument bundle influence only this share.

In the reference case, it is assumed that by 2030, new appliances have at least a C label. This results in a reduction of 25% compared to existing appliances.

Introducing Bundle A improves the market share of appliances with higher efficiency. We assume that this leads to an average reduction of 35%. Appliances which produce

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[4]   For the selection and definition of the SC instrument bundles see EUPOPP Deliverable D 4.1

heat using electricity have lower reduction rates, and cooling appliances have a higher reduction rate. Introducing Bundle B leads to a significant share of new applicance with advanced technology. This includes e.g. heat pumps for dryers, warm water tap for washing machines and dish washers, and advanced air conditioners. The expected reduction is 45%.

Compared to the reference efficiency increase of 25% by 2030, the instrument bundle would add 20 percent-points, i.e. the total efficiency gain would be 45%.

The real reduction of household electricity is somewhat lower due to decreasing average household sizes in the future. This leads to more households and, thus, more appliances which use more electricity than today, though more efficient.

The net efficiency change would, therefore, be 21% reduction for the reference, and 42% for the bundled instruments, both for the 2030 time horizon.

Buidlings

The affected housing stock in the EU is aproximately half of all houses, but the heat demand of this stock share is about 75% of the total heat consumption of all households, as in general, older buildings consume more heat.

Within the time horizon of the EUPOPP scenarios, not all houses will become subject to retrofitting[5] so that the rate of energy-oriented renovations of buidlings per year is crucial. It is assumed that the instrument bundles will result in both a higher specific reduction per building, and a higher retrofit rate. The assumptions are shown in the following table.

Table 3: Building Efficiencies in the SC-1 Scenario for EUPOPP

	Reference	Element A Optimized EPBD	Element B Optimized EPBD + Incentives
Reduction heat loss windows	40%	50%	60%
Reduction heat loss roof, façade	40%	60%	70%
Retrofitting rate windows	3%/a	4%/a	4%/a
Retrofitting rate roof and façade	1%/a	2%/a	3%/a
Resulting reduction all houses	9%	21%	29%

Source: own compilation based on EUPOPP (2009)

Heating and Hot Water Systems

The provision of residential heat and hot water is the third area of instrument bundling for the housing sector. Given the previous discussion on the instrument to reduce the heat demand of buildings, the choice and use of residential heating and hot water sys-

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[5] Even a very optimistic retrofitting rate of 3% would lead only to a share of 60% of renovated houses by 2030.

tems determine the overall end-use and respective environmental and cost impacts of the thermal energy needs of the housing need area.

It is assumed that the overall efficiency improvements of heating and hot water systems are implemented already in the reference scenario, as they are very cost-effective, and the life-time of heating systems is smaller than the scenario time horizon so that all heating systems existing in 2005 will be replaced by 2030.

The mandatory individual metering of heat and hot water consumption is assumed to achieve a specific reduction of 15%, and would address ⅔ of the existing heating systems in Central/Easern Europe (EU12) where conversion in the BAU case is assumed to be low.

The minimum quota for "green" heat must reflect that introducing renewable heating and hot water systems based on biomass (especially wood pellets) is limited by the available space for storage, while the potential for solar systems is restricted by the available shadeless and adequately sun-oriented roof space. Centralized high-efficient co-generation systems are restricted by the overall density of heat demand, and decentral (micro) co-generation is more costly than centralized systems.

Given those restrictions, the quota for "green" heating in the EU is set to 45% by 2030 which represents an additional share of 21 percent-points above the BAU scenario.

Starting in 2015, this represents a linear increase of 1.5 percent per year.

3.2 Scenario SC-2: High Ambition

The SC-2 scenario assumes a "high" ambition, i.e. **all** SC instrument bundles identified in EUPOPP Deliverable 4.1 are assumed to be implemented by 2030.

SC-2 builds on the definition of SC-1, but adds the following elements to the scenario:

- **Food** – in addition to the less meat/more sustainable diet bundle, SC-2 adds a shift towards more organic food (from 20% by 2030 in BAU to 40%), and a reduction of household food waste by 10% (2030).

- **Housing** – in addition to the energy retrofits of buildings, SC-2 assumed that obsolete very old buildings would be "scrapped" so that each year, 0.5% of these houses are replaced by new ones which would add another 8% reduction in overall energy consumption by 2030 (compared to BAU).

The sum of the sustainability instrument bundles for food and housing in SC-2 could **mobilize about ⅔** of the 2030 potential estimated in Deliverable 2.1 (EUPOPP 2009).

4   MFA Data for Food (excluding Fish)

Eating is more than having food or buying food products in the supermarket. The section gives a brief overview of food diversifications and diversification in production. The approach will have influence on the configuration of policy instruments (WP 4.2) and respective policy recommendations (WP 6).

4.1   Classification of Food

4.1.1 Food and Food Products

For the purpose of EU-regulation food law (EC) No178/2002[6]) **food** means "any substance or product, whether processed, partially processed or unprocessed, intended to be, or reasonably expected to be ingested by humans. Food includes drink, chewing gum and any substance, including water, intentionally incorporated into the food during its manufacture, preparation or treatment."

Semiluxury products are not included within the food definition. Semiluxury food will be consumed by gusto and pleasure, like alcohol, coffee, tobacco, tea or chocolate.

The term '**product of food**' defines a partial quantity of food, which overwhelmingly conduce to nutrition. Designated products of food like sugar, honey or chocolate imply both food and semiluxury food (Hengartner/Merki1999).

4.1.2 Organic Production

By definition of the European Commission 2009 organic production is an "overall system of farm management and food production that combines best environmental practices, a high level biodiversity, the preservation of natural resources, the application of high animal welfare standards and a production method in line with preference of certain consumers for products produced using natural substances and processes". This includes the following practices[7]:

- Multi-annual crop rotation

- Organic plant production should be fed through the soil ecosystem and not through fertilisers.

- Genetically modified organisms (GMOs) should not be used.

- Use of local resources

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[6] EC No 178/2002: of the European Parliament and the Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety

[7] EC No 834/2007 of 28 June 2007 on organic production and labelling of organic products and repealing Regulation EEC No 2092/91 amended by EC No 967/2008 of 29 September 2008

- Selection of plants and animals resistant to illnesses and adopted to local conditions

- Organic farming notes the animal welfare standards regarding species-specific behavioural needs. Animals should get organic fodder.

Detailed rules due to organic production and farming are reflected within EU regulation No 889/2008[8]. This regulation is amended by EC No 1254/2008 with detailed rules for implementation of Council Regulation 834/2007.

4.1.3 Regionality

Usually, a region's area covers the surroundings of an individual community or city, but stays below the size of a national state. Although the definition of a particular region often follows political or administrative borders, there are cases where natural or cultural features decide on the region's geographical coverage (Brohmann et al. 2006).

Schlich (2008) and Hardert (2008) divide the geographical dimension of food production in the case of transport distance into primary production up to point of sale. Therefore the "region" has no explicit meaning. Often it will be assumed that regional food includes distances around 100 km (Borowski 2009). Schlich (2008) defines products around 50 km up to 500 km as regional food.

There is no universal definition for region. It depends on abstraction processes against the background of economical, social or political developments. Therefore the meaning of a regional level is a subject to change. Otherwise the regional level opens alternatives and options for innovative policies and sustainable economic structures (Brohmann et al. 2006).

4.1.4 Seasonality

Seasonal food means due to fresh vegetables and fruits purchasing of seasonally caused products. Season calendar shows harvest time of specific fruit and vegetable sorts. Therefore, the recommendations regarding seasons are not related to cultivation in greenhouses or cloches (von Koerber et al. 2004).

The European sales volumes of organic food products in 2005 are approx. 13-14 million €. The market increases yearly by about 10-15% (Willer 2007). Regional and seasonal products do not have such a big economical impact, nevertheless, they set new quality standards and arouse consumer needs.

EUPOPP develops sustainability instruments fir the need area of food, including healthy products and products of high quality and aiming at food security and food safety. The focus is on policies that directly and purposively influence which products people buy or can buy. Aspects of regionality and seasonality in the best case combined with organic production are definitely an opportunity for consumer to switch from

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[8] EC No 889/2008 of 5 September 2008 laying down detailed rules for implementation of Council Regulation (EC) No 834/2007 on organic production and labelling of organic products with regard to organic production, labelling and control

current to sustainable food consumption. The purchase decision open ways for sustainable development, but for that, consumer must be sensitised. Regional "binding" can be a first step to implement a new food culture.

4.2 Availability of Market Data on Food

Within EUPOPP Deliverable 2.1 (2009), historic consumption and production trends were compiled as a data report to build upon. Based on the already defined product groups (meat, vegetables, cereals, fruits and dairy) the research in WP 4 disaggregated existing product groups to identify regionally specific consumption patterns. Build on official statistics, the data set started with 93 available food products (without fish). For reducing quantity it was necessary to implement selection criteria. These criteria has to be confirm with the aim of the work package – the identification and discussion of specific consumption patterns regarding sustainable future opportunities within EU 27 Member States. Fish is discussed in chapter 5.

4.2.1 Data Relevance

4.2.1.1 Consumption Quantities

The selection of relevant products based on an analysis of their specific consumption quantities. Base year is the year 2005 and the data were calculated per capita for each EU 27 member state and clustered by weighting with population per country. First we extracted all aggregated product groups, like alcoholic beverages, fruits-other, vegetables etc. The statistical analysis for EU27 consumption per capita resulted in an average consumption of 9 kg per capita and year. The median was located by 2.2 kg per capita and year. After further discussions with the project team it would be assumed to fix the relevance border at a minimum consumption quantity of 5 kg per capita. For this reason all products greater or equal 5 kg per capita and year were chosen.

The selected products reflect the current food products on the market and their obligatory properties. Therefore the product quantity could be reduced to 29 products without fish. By reason of consumption relevance of single food products, the existing product groups were broadened by three further groups to guarantee clarity and similarity with the statistical classification of economic activities in the European Community (NACE 2.0): vegetable oils, sugar and beverages (see Annex, Table 49).

The following Table 4 illustrates the main product groups and related disaggregated products.

Table 4: Main product groups and disaggregated products without fish

Product Group	Defined Products
fruits	apples, bananas, grapes, lemon, oranges/mandarine
vegetables	tomatoes, nuts, onions, potatoes
vegetables oil	olive oil, sunflowerseed oil, soybean oil
cereals	rice, maize, wheat, rye
sugar	sugar refined
beverages	beer, coffee, wine
meat	bovine, pork, poultry
dairy	butter, cheese, cream, eggs, milk

Source: own compilation

In addition to consumption quantities further data were relevant for the determination of disaggregated food products:

- production price per kg

- consumption price per kg

- kg CO_2 equivalents per kg product

- trade quantities to get an overview on trade relations.

All defined indicators are necessary input values regarding the material flow analysis so that it had to be validated that an adequate database can compiled.

4.2.2 Production and Consumption Prices

The core methodology of life cycle analysis (LCA) was applied to calculate costs and benefits of sustainable consumption. Different cost elements were taken into account along the value chain. The relevant cost aspects are production and consumption costs.

Production prices include all expenditures, which are necessary for the production of products. Here are not included consumption taxes or mark-ups at the whole sale or retail level. The official statistic offers data for production prices. In contrast to the data for production prices from official statistical data bases, consumption prices are not available. Within the project the focus is on consumer and consumer behaviour and therefore working with consumption prices demonstrate cost changes in the case of impact assessment of policy instruments. Consumer prices include value added taxes and mostly mark ups on an retail level. For this reason the project team decided to set the intersection at the retail market level. As already discussed, the data base within official statistics is in single cases/countries available, but mostly not on the defined

disaggregation level. As differences in consumption prices between the member states can be expected, four representative samples of member states with attention to re-gionally specific patterns was selected (analogue to country clustering described within deliverable 2.1). The analysis was carried out for the following countries:

Table 5: Representative Samples of Member States for Consumer Price Analysis

Cluster	Selected Country
North	Sweden
West	Germany
South	Spain
CEE	Czech Republic

Source: own compilation

Data uncertainties can be very high, therefore the project team decide to analyse the prices of the biggest supermarket chains in the specific countries. Cost data will be present in Euro by using the following exchange rates[9]:

1 € = 7.44 DK = 9.74 SEK = 25.1 CZK

To guarantee the similarity of prices, we calculated by help of annual food price indices published by FAO values from $EURO_{2010}$ in $EURO_{2005}$.

Table 6: Food Price Index

Year	Food Price Index
2004	100
2005	114,7
2006	122,4
2007	154,1
2008	191,3
2009	151,5
2010	172,4

Source: FAO 2010

The following table shows the supermarkets used for the data research.

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[9] www.finanzen.net, www.oanda.com, download from february 2010

Table 7: European Supermarket Chains

Sweden	Germany	Spain	Czech Republic
Netto	Netto	SuperValu	Billa
Rema 1000	Penny	Carrefour	Penny
SPAR	SPAR	SPAR	SPAR
7-Eleven	Aldi	Aldi	Tesco
Coop Norden	Rewe	Ahold	Ahold
Lidl	Lidl	Lidl	Lidl
Willys	Plus	Plus	Plus
ICA Maxi		Dunnes	

Source: own compilation

The consumer prices include country specific VAT as shown in Annex Table 48.

Table 8: Country-specific VAT

Selected Member State	Value Added Tax
Sweden	12%
Germany	7%/19%
Spain	7%
Chech Republic	9%

Source: own compilation

For the complete price date tables see Annex Table 47.

4.3 Data Extension for Other Food Products

The following data compilation for wine, rice and citrus fruit extends the previous GEMIS data with respect to GHG emission data.

4.3.1 Wine

The most specific and reliable data on grape yield derives form concrete farm case-studies. Primarily, these studies are available for European wine-producing countries such as Italy and Spain.

Aiming at different research targets, these studies provide different yield parameters. The results on grape yield from these assessments are summarised in the following table.

Table 9: Grape and Wine Yields in Europe

Country	Growing area [ha]	Yield [t]	Yield [t/ha]	Wine pro-duction [l]	Wine [hl/ha]	Wine yield [l/kg]
Italy	210	1269	6.0			0.75
Italy (org)	10	50	5.0			
Italy	120	750	6.2			
Italy (org)	10			35,000	35.0	
Italy	120			263,000	21.9	
Germany		13004		10,076,000		0.78
Spain			2.8		20.7	0.75

Source: Ardente et al. (2006); Pizzigallo et al. (2006); Schröder (2007) ; Aranda (2005)

In order to obtain statistics on grape yield from countries where comparable studies are unavailable, a second assessment was approached. Therefore, the average yield was estimated by using the global evaluation of wine production data from the Organisation Internationale de la Vingne et du Vin (OIV). The results for important international and European wine producing countries are presented in Table 10.

Table 10: International und European Wine Producing Countries

Country	Growing area [1000 ha]	Yield [1000 t]	Yield [t/ha]	Wine pro-duction [1000 hl]	Wine [hl//ha]	Wine yield [l/kg]
Argentina	204	2,665,800	13.1	15,396	75.54	0.58
Australia	158	1,781,700	11.3	14,269	90.16	0.80
Chile	117	1,216,000	10.4	8,448	72.33	0.69
France	838	6,714,500	8.0	52,127	62.20	0.78
Germany	99	1,224,700	12.4	8,916	89.88	0.73
Italy	732	6,822,800	9.3	52,036	71.05	0.76
South Africa	105	1,241,600	11.8	9,398	89.25	0.76
Spain	1100	6,083,900	5.5	38,137	34.68	0.63
USA	250	3,858,100	15.4	19,440	77.60	0.50

Source: OIV (2006)

For wine yield data, consolidating FAOSTAT is inappropriate, since it doesn't distinguish among wine grapes, table grapes and grapes for raisin production. Although the yield figures vary considerably, the rate of wine yield from 1 kg grapes is similar. Taking the different findings into consideration, the amount of wine processed from 1 kg of grapes appears to be about 0.75 litres.

Data on agrochemical use in viticulture were obtained from specific farm studies. Accordingly, reliable data is available for a limited number of European countries. These figures are presented in Table 11.

Table 11: Agrochemical Use in Viticulture and resulting GHG Emissions

Country	Fertilizer kg/l wine	CO_2e from fertilizer kg/l wine	Pesticides kg/l wine	CO_2e from pesticides kg/l wine	CO_2e from agrochemicals kg/l wine
Italy	0.030	0.094			0.094
Italy	0.021	0.099	0.006	0.067	0.165
Italy (org)	0.000	0.000	0.016	0.197	0.197
Italy	0.055	0.183	0.005	0.057	0.240
Spain	0.193	0.641	0.013	0.160	0.801
Italy	0.042	0.138	0.001	0.002	0.140

Source: Ardente et al. (2006); Notarnicola (2003); Aranda et al. (2005); Pizzigallo (2006)

The degree of accuracy differs among the studies. Ardente et al. (2006), Notarnicola (2003) and Pizzigallo (2006) provide specific amounts of N, P and K fertilizers. The conversion factors of agrochemicals to CO_2eq were taken from GEMIS.

Table 12: Energy Inputs During the Agricultural Phase

Country	Fuel use kg/l wine	CO_2e from diesel kg/l wine
Italy	0.025	0.076
Italy	0.065	0.197
Italy	0.010	0.031
Spain	0.115	0.351
Germany	0.029	0.077

Source: Pizzigallo (2006); Notarnicola (2003); Aranda et al. (2005, Jung 2008

The amount of CO_2eq from fuel combustion in these studies varies significantly. The data from Notarnicola (2003) and Aranda (2005) differ by more than a factor of 10.

Table 13: Energy Inputs During Processing and related GHG Emissions

Country	Energy kWh/l wine	kg CO$_2$e/l wine
Germany		0.455
Italy (org)		0.089
Italy		0.073
Germany	0.130	0.084
Italy	0.600	0.329
Germany		0.066

Source: Walg (2008); Pizzigallo (2006); Schröder (2007); Ardente (2006); Jung (2008)

For the conversion from kWh to CO$_2$eq, GEMIS data for country specific energy mix was used. Walg (2008) and Jung (2008) investigated the product carbon footprint of two different wine cellars in Rhineland-Palatinate. Therefore, the GHG figures seem to be quite reliable. For Pizzigallo (2006), the boundaries are not given. In his study, the process "wine production" includes both agricultural management and wine processing (e.g. pressing).

It here has been accounted for the diesel CO$_2$eq, resulting in a comparatively low figure for the processing CO$_2$eq.

Table 14: GHG Emissions in the Wine-Making Life Cycle

	Agrochemicals	Fuel	Processing	Sum
Average	0.273	0.146	0.183	0.602
Average excl. Spain	0.167	0.095	0.183	0.445

Source: own compilation; data given in kg CO$_2$e/l wine

The presented findings suggest CO$_2$eq emissions from the production of 1 litre of wine to be around 0.6 kg CO$_2$e for Europe.

It is important to notice though, that wine-making is made up of many different phases that can vary enormously from one producer to another, depending on the desired wine quality. It implies that the results of LCA regarding the production of different wineries are generally not comparable (Ardente et al. 2006).

4.3.2 Rice

The production of rice varies from country to country with regard to yields, as shown below.

Table 15: Farm-specific Data for Rice Yield

Country	Yield [t/ha]
Japan	5.6-6.0
Japan (org)	5.0
Malaysia	6.5
Pakistan	3.2
Thailand	3.0
USA	7.4

Source: own compilation

FAOSTAT data match these figures. It only considers paddy rice though, while the specific case studies provide data for different rice cultivation systems. FAOSTAT reveals that worldwide rice yields of important rice producers range from 7.4 t/ha (USA) to 3 t/ha (Thailand), with Japan in the 6 t/ha range (see Figure 12). In some countries, average yield is even considerably lower. These countries are not important for the world market though.

For agrochemicals it is important to notice that application is very different from farm to farm and mainly depends on the rice species and soil (Blengini 2009). A LCA study for the Vercelli region in Northern Italy showed agrochemicals made up for 10% (0.264 kg CO_2e/kg rice) of rice production's global warming potential (Blengini 2009).

Other studies provide detailed information of the average fertilizer use in different countries. They refer to the amount of input per hectare, without considering the yield. Interpolating these figures with FAOSTAT county-specific yields and GEMIS emission data per fertilizer unit results in increased uncertainty, although the CO_2eq emissions obtained (average of 0.234 kg CO_2e/kg rice) match the Italian specification.

Conclusively, GHG emissions from agrochemical use are assumed to be about 0.25 kg per kg rice.

In Blengini (2009), energy use for field operations causes 3.6% (0.1 kg CO_2eq/kg rice) of the total GHG emissions in rice productions. Kasmaprapruet (2009) reports a similar amount for Thailand (0.11 kg CO_2eq/kg rice). In Malaysia, Bockari-Gevao et al. (2004) observed a lower value of 0.04 kg CO_2eq/kg rice. This figure matches a study from India which determines 0.03 kg CO_2eq/kg rice. In Pakistan, Khan et al. (2009) observed 0.05 kg CO_2eq/kg rice, which is more or less between the different findings of the studies mentioned. Therefore, an average CO_2eq emission from energy use in field operations is estimated to be about 0.04 kg CO_2eq/kg rice.

The amount of CO_2eq depends on different cultivation techniques and the degree of mechanisation.

Due to cultivation techniques, rice fields release great amounts of methane. In paddy rice cultivation, flooding constraints the amount of oxygen available and therefore en-

hances anaerobic fermentation of soil organic matter. This metabolic process releases methane (Wang et al. 2009). The methane emissions are estimated to account for 43% (Kasmaprapruet 2009) to 68% (Blengini 2009) of the total global warming potential of rice production.

The average methane emissions from the production of 1 kg rice are 0.6 kg CO_2eq with a high standard deviation of 0.5. The highest emissions observed were 1.3 kg, the lowest 0.04 kg (Wassmann 2000). The variation of methane fluxes observed mirrors the multiple parameters that influence the emissions. Primarily, these are the soil type, the amount and type of fertilizers applied and the duration of stagnant moisture inducing anaerobic metabolism (Blengini 2009).

IPCC (2006) provides a default methane emission factor for rice cultivation as 1.3 kg CH_4/ha*d, assuming no flooding for less than 180 days prior to rice cultivation, and continuously flooded during rice cultivation without organic amendments (IPCC 2006).

The vegetative phase of rice varies between 120 and 150 days (IRRI 2008).

Methane emissions based on the IPCC emission factor, an average vegetative duration of 135 days and an average yield of 4 t/ha add up to 1.1 kg CO_2eq.

For a farm in Thailand, Kasmaprapruet 2009 claims the process GHG-emissions to be 0,472 kg CO_2e/kg rice. This equals 17% of the total GHG emissions observed. In the Blengini 2009, the processing of rough rice (here: drying, storing, refining, packing) releases 0,218 kg CO_2e/kg rice, accounting for 7,9% of the total production's GWP. In both studies, fuel combustion, electricity and heat use are included in the declared CO_2e emissions. However, their share of the emissions is not stated.

The emissions from the processing step depend on the size and efficiency of the facility and the primary resources for its energy provision.

According to Blengini (2009), the total GHG emissions of rice production excluding transport in Northern Italy add up to 2.6 kg CO_2eq. This suits the findings of a Thai study, reporting the GHG emissions to be at 2.8 CO_2eq/kg rice produced and processed (Kasmarparpruet et al. 2009). A Japanese study observed GHG emissions of rice production at 1.5 kg CO_2e/kg rice (Hokazono et al. 2009).

The addition of the average GHG emissions from the different categories of this summary equals 0.7 kg CO_2e/kg rice. This figure doesn't seem to be appropriate to base further calculation upon, as it likely underestimates methane emissions due to volatility and site-specificity. Therefore, country specific data should be used where possible.

4.3.3 Organic Banana Production

FAOSTAT data estimate the yield of banana in Ecuador about 27.7 t/ha and 31.1 t/ha in the Dominican Republic. Both countries are main banana exporter to the EU 27. Ecuador and the Dominican Republic produced 6.1 million t and 0.55 million t, respectively. This data correspond to global production, there are no available specific data about yield or production of organic banana.

For the production of 50 t of organic banana, the plant needs 300 units of nitrogen and 600 units of K_2O. Organic cultivation adapts the treatment and application of fertilizers considering the characteristics of soil, which are locally very different. In this case it is more complicated than in conventional cultivation to know which concrete treatment was applied.

In the Dominican Republic, fertilization 16 g CO_2eq/kg banana, i.e. 2 % of the GHG emission during the complete process (until arriving in Europe). For Ecuador, this percentage is 5% (46 g CO_2eq/kg banana) of total GHG emission (Lange et al. 2007).

The maturation process occurs after the transport to destination and causes 14% and 17% of the GHG emissions of bananas from Ecuador and the Dominic Republic, respectively. In both cases the calculated GHG emission for is 133 g CO_2eq/ kg banana.

The cultivation process for one kg of bananas causes 5% (37 g CO_2eq) of the GHG emissions in Dominican Republic and 10% (101 g CO_2eq) in Ecuador, compared with approx 69-70% of GHG emissions caused in both cases by transport to Europe.

4.3.4 Citrus Fruit (Oranges, Lemons)

There are only few studies on citrus fruit, mainly on lemon and oranges.

Table 16: Average Farm and FAO Data for Oranges Yields

Reference	Country	Cultivation Type	Farm Yield [t/ha]	FAOSTAT Yield [t/ha]
Coltro et al. (2009)	Brazil (Sao Paulo)	Pera, Valencia and Natal/ Conventional	30.5	80.6
Sanjuán et al. (2005)	Italy (Sicilia)	Conventionial	20 – 30	13.3
Beccali et al. (2009)	Spain (Valenci-ana)	Oranges Navelina integrated cultivation (gravity/drip irrigation	30	13.9

Source: own compilation

FAOSTAT data do not match the farm-specific case data. A possible reason for this difference could be the selected region for the study: the most productive regions in the country were observed for these studies. In some countries, average yield is even considerably lower. These countries are not important for the world market though. According to FAOSTAT data, Brazil is in the first position of producer of oranges, Spain and Italy are in the 6th and 7th position.

The cultivation of oranges requires the use of fertilizers as sources of macronutrients like nitrogen (N), phosphor (P) and potassium (K) and micronutrients. These elements are mainly supplied to the soil in the form of inorganic salts, such as urea, phosphates, boric acid etc. (Coltro 2009).

As shown in the following table, a data comparison is difficult due to the use of different products and cultivation practices. Agrochemical use ranges depending whether on the country, or on the farm. In northern region of Sao Paulo (Brazil) only 38% of the farms applied fertilizers in quantities lower than the average (Coltro 2009).

Table 17: Use of Fertilizers in Orange Production

Country	NPK	N	P_2O_5	NH_4NO_3	K_2O	KNO_3	H_3PO_4
Brazil	0.0003 – 0.065						
Italy		0.0118	0.0049		0.0088		
Spain	0.02[a]			0.02[a]-0.03[b]		0.0098[c]	0.0004[c]

[a] = gravity irrigation; [b] = drip irrigation; [c] = liquid fertilizer, only for drip irrigation

Source: own compilation; data given in [kg/kg oranges]

The relative contribution of the fertilizers production to every impact depends on the cultivation practices (tillage, irrigation…). In a LCA study for the Comunidad Valenciana (Spain) with groundwater, drip irrigation and no tillage, the fertiliser production greatly contributes to acidification and resource depletion (86 and 84% of total impact, respectively). It also contributes to the greenhouse effect (52%), photochemical oxidant formation (42%) and to ozone layer depletion (Sanjuan 2005).

Table 18: Energy Inputs During Cultivation of Oranges

Country	Diesel [kg/kg]	Energy [MJ/kg]	Water [kg/kg]
Brazil (Sao Paulo)	0.04 – 1.1[a]	0.12 – 4.4[a]	1.7 - 54.5
Italy	0.017	0.009	206[b] + 0.5[c]
Spain			188[d] – 200[e]

[a]= Oranges cultivation and distribution [b] = water for cultivation; [c] = water for washing; [d] = drip irrigation; [e] = gravity irrigation

Source: own compilation

4.4 Update of MFA Data for Food

In addition to the data extension, the previous GEMIS 4.6 database was updated for livestock breeding processes with a focus on feed demands, and characteristics of the processes involved.

4.4.1 Lifestock Breeding

The cultivation of grassland in GEMIS is characterized by a yield of 23.5 t FM/ha*a (19.1 t grass silage/ha*a). The grassland is assumed to be cut 3-4 times per year. In the following paragraphs, recent information on grassland cultivation summarized.

According to KTBL (2005), the yield of the most common grasslands in Germany varies between 8-13 t DM/ha*a. At a dry matter content of about 35% (KTBL 2005), the grassland yields about 22-37 t grass silage/ha*a. A second publication of KTBL (2008) states an even wider range of 20-43 t grass silage/ha*a. The yield level for grasslands with a modest natural fertility is at about 28 t grass silage/ha*a.

This is in accordance to the 8.2 – 9.3 t DM/ha*a (23.4 – 26.5 t grass silage/ha*a) that are stated as an average from 2004-2008 by Schaumann.

The following table contains fertilizer application suggested in different sources. Each value represents the average of the advised dung amounts for 3 and 4 cuts per year

Table 19: Fertilizer Use on Grassland

Fertilizer Use [kg/ha*a]	KTBL	LWK NRW	LWK NI	LfL Bayern	average
N	260	275	235	220[10]	247
P (P_2O_5)	80				80
K (K_2O)	230				230

Source: own compilation; data for average values from 3 and 4 cuts

KTBL (2005) estimates a diesel use of 43 l/ha for the forage harvesting.

4.4.2 Feed Production

Kool et al. (2009) assessed the carbon footprint of several feed crops in order to determine the GHG emissions pork production in four European countries. Considering both conventional and organic agriculture, they came up with data diverging from the GHG emissions assessed by current GEMIS processes for the same feed crops.

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[10] LfL Bavaria suggests distributing 30-40 kg N/ha with each cut, accompanied by 2*20 m³/ha of thinned slurry (ratio 1:1; Galler 2004) per ha. At an N content of 5 kg/m³ (KTBL 2005; 2.5 kg N/m³ for thinned slurry) and four cuts, this adds up to about 220 kg N/ha*a.

Table 20 gives the emissions for conventional and Table 21 for organic crops.

Table 20: GHG Emissions from Conventional Feed

[kg CO$_2$e/t]	Wheat	Barley	Rye	Triticale
Netherlands	456	310	432	311
UK	481	328	423	353
Denmark	479	317	420	341
Germany	461	288	395	314
GEMIS	402.3	353.5	416.3	409.3

Source: own compilation

Table 21: GHG Emissions from Organic Feed

[kg CO$_2$e/t]	Wheat	Barley	Rye	Triticale
Netherlands	336	292	340	282
UK	350	302	379	315
Denmark	355	316	312	259
Germany	341	272	379	315
GEMIS	271.9	230.5	239.3	255.6

Source: own compilation

4.4.3 Chicken Meat and Egg Production in Europe

Chicken meat production is concentrated in 7 Member States, as shown below.

Table 22: Chicken Meat Production in Europe in 2005

Country	Production [t]	EU 27 share
United Kingdom	1,333,789	15.7
Spain	1,083,968	12.7
France	920,503	10.8
Poland	795,824	9.4
Italy	694,997	8.1
Netherlands	628,000	7.4
Germany	605,117	7.1

Source: FAOSTAT 2010

The countries account for 71 % of the European chicken meat production.

The minor differences among production systems were obtained from Loyon et al. (2009): Broiler (meat) poultry production is mostly carried out on litter in closed build-ings with forced ventilation, the exceptions being France. Here, natural ventilation is

commonly used with the option of forced ventilation. The use of a phase and multi-phase feed regime for an improved feed conversion is widespread.

The feed supplements to limit the release of nitrogen and phosphorous are similarly used in the Netherlands, Czech Republic, Italy, Germany, Spain, Finland, Poland, Denmark, Portugal and France.

From DLG (2008) it can be derived that the underlying data for the current GEMIS broiler processes are still up to date.

For eggs, the production is also rather centralized in a few EU countries, as shown below.

Table 23: Egg Production in Europe in Year 2005

Country	Production [t]	EU 27 share
France	930,100	14.1
Germany	795,000	12.1
Italy	722,200	11.0
Spain	708,446	10.8
United Kingdom	609,000	9.3
Netherlands	607,000	9.2

Source: FAOSTAT

The countries account for about ⅔ of the European chicken meat production.

There are some minor differences among production systems (Loyon et al. 2009): The bulk of egg production is still achieved from birds kept in compact "battery" cages, but due to consumer demands and animal welfare reasons alternative systems like floor housing or aviary systems are increasing (e.g. in Germany). Rearing birds in the alternative systems (floor housing, aviary system, on managed cage or free range systems) is common in the United Kingdom, Netherlands, Italy, Germany, Sweden, Cyprus, Finland, Lithuania, Poland, Denmark und France. Both, phase and multi-phase feed regimes adapted to the needs of the animals are widespread as much as the addition of supplements (amino acids, phytase and/or the use of digestible inorganic phosphorous) to reduce nitrogen and phosphor losses.

Information about production parameters were obtained from different sources. Firstly, KTBL offers rough average data for the egg production system. Furthermore, laying hen breeders offer specific information about their products on their websites.

Studies revealing differences among production practices in the above listed countries were not found. However, several experts asserted the poultry production in the EU to be even more homogeneous than the pork production.

4.4.4 Beef Production Systems in Europe

There are five basic distinct production zones within the EU regarding cattle production (EC 2001):

- Northern mountain zone

This zone comprises much of Scandinavia except Denmark as well as the mountain and moorland regions of the UK and Ireland. There is only little cattle production in these areas (except around the coasts) as the environmental conditions are unfavourable.

- Northern lowland zone

In this zone, fodder production from grasslands dominates. The zone runs up the western coastal area of temperate maritime climate from the north-west of Spain through western and northern France, the lowland areas of the UK and Ireland to the low landscapes around the Baltic coast. Due to the favourable maritime weather conditions, this zone is ideal for grassland.

- Central zone and the Po Valley

In this area, the weather tends to be more continental. Thus, the climate conditions are suited for crop production rather than grassland. Accordingly, forage maize has become a most important feed for both milk and beef production.

Being highly fertile, the Po Valley has been a focal point for the development beef production with maize silage and maize grain as major diet components.

- Alpine zone

The Alps, the Pyrenees and the Dinaric Alps are included in this zone. Main characteristics of this high mountainous area are it's narrow but often fertile valley.

Much of the alpine area is barren and sub marginal for cattle production though. In Austria nevertheless, milk production is important though there is a tendency for cattle to be removed from mountainous areas.

- Mediterranean zone

The climate in this region is unfavourable to cattle production. Therefore, sheep and goats are more important.

Table 24: Beef Production in the EU 27 in 2005

Country	Production [t]	Share EU 27 [%]	Production Intensity
France	1,516,912	18.8	Intermediate
Germany	1,166.900	14.5	Intermediate
Italy	1,101,972	13.7	Intensive
United Kingdom	762,000	9.5	Extensive
Spain	715,329	8.9	Intensive

Source: FAOSTAT, Weidema et al. (2008)

According to FAOSTAT, the most important milk producing countries within EU 27 are Germany, France, UK, Poland, Italy and the Netherlands. They account for 65,4% of the total European cow milk production. The findings of Weidema et al. (2008) support these findings: "More than 90% of the total EU-25 consumption of beef/veal is produced in EU-15 countries. An increase is expected in the import. The major suppliers (in descending order) are France, Germany, Italy, United Kingdom, Spain, and Ireland, representing together 75 % of total EU-25 production. The beef systems in these countries therefore largely represent the total systems for beef production."

A study by the European Commission characterizes different beef production systems in the EU in quite some detail (EC 2001). Other authors have tried to simplify this complex approach by highlighting the most important core systems representing the majority of European beef production (Weidema et al. 2008, Nguyen et al. 2010).

Table 25 presents the approach of Weidema et al. (2008). It also includes average annual feed intakes. For the fattening systems based on suckler calves, there are figures for the aggregated feed intake of cow and calve per year only.

Table 25: Beef Fattening Systems in Europe

	1	2	3	4
origin of calves	dairy herd	dairy herd	suckler herd	suckler herd
main forage	maize silage grass silage cereals	grass (grazing + silage) cereals	grass (grazing + silage) cereals	grass (grazing + silage) maize silage cereals
age at slaughter	16 month	24 month	12 month	16 month
degree of intensity	intermediate	extensive	intensive	intermediate
typical for	FR, DE	UK	IE, ES	FR, DE

Source: Weidema et al. 2008

Based on the number of dairy cows in the EU-27 (Weidema et al., 2008), it has been estimated that almost half of EU beef comes from culled dairy cows and the remaining is produced in specialized beef production systems. Taking the latter as a whole, a rough estimate gives that suckler beef takes up 70% and dairy bull beef takes up the rest (Nguyen 2010).

Two thirds of the EU's suckler herd is concentrated in only three Member States - France at a distance followed by the United Kingdom and Spain - while dairy herds are more evenly spread. About 65% of the suckler herd is kept in less favoured areas.

The more intensive bull production tends to be concentrated in Germany and Italy, which together account for nearly half of the EU's bull output, while the generally more

extensive steer production is mainly limited to the UK, Ireland and France. Female beef production, i.e. from heifers and cows, is more widely spread. (EC 2000)

50% of the European suckler herd is located in France and Spain (Brömmer 2005).

The beef sector in North America, as in much of Europe, has not industrialized as rapidly as other animal production industries (pork, poultry). At the same time, the market share for beef in household meat consumption has dwindled. Apart from a penalizing price effect, various studies in North America (Wachenhein and Singley, 1999; Goldsmith et al., 2002; Schroeder and Kovanda, 2003) have accounted for this in terms of a lack of vertical coordination in the sector, the absence of a channel captain at the processing stage, and the dearth of product differentiation initiatives directed at customer expectations (Sans & de Fontguyon, 2008).

4.4.5 Dairy Production Systems in Europe

Of the total milk production in EU-25, 85 % is produced within EU-15 countries. Five countries – Germany, France, United Kingdom, Netherlands and Italy – produce more than 60 % of the EU-25 milk (EC 2006b). Outside EU-15 Poland is the main producer with 8 % of EU-25 production. Among and within these countries, production conditions differ (Weidema et al. 2008).

According to FAOSTAT, the most important milk producing countries within EU 27 are Germany, France, UK, Poland, Italy and the Netherlands. They account for 68% of the total European cow milk production.

Table 26: Milk Production in the EU 25 in 2005

Country	Production [t]	Share EU 27 [%]
Germany	28,452,950	19.1
France	24,885,376	16.7
United Kingdom	14,473,000	9.7
Poland	11,922,778	8.0
Italy	11,012,957	7.4
Netherlands	10,847,000	7.3

Source: FAOSTAT 2010

In general, EU dairy production can be broadly divided into four main systems, although there is still considerable variation within each system. These are High input/output, Low input/output, Mountain and Mediterranean. There is a dominance of high input/output systems accounting for 83% of dairy cows and 85% of milk production. The main characteristics of the high input/high output system are

- Large average herd size
- High stocking rates
- Intense fertilization
- >25% maize silage
- Specialist dairy breeds of which "Holstein Frisians" dominates

The majority of EU milk production comes from intensive production systems in the lowlands of the Atlantic Region. Key trends on dairy farms in this Region have been: moves to larger average herd size; higher yields per cow; increased use of fertilisers; and, at the same time, fewer dairy farms. Whilst this trend for intensification of production is rather a broad generalisation and there are some notable regional differences (particularly between northern and southern Member States), it is a picture which reflects the dominant trend across most of the major dairy farming areas of Europe (CEAS 2002).

The intensity of dairy production varies widely within EU 27. Average yield ranges from 8157 kg/year (Sweden) to 3146 kg/year (Romania) (FAOSTAT).

Irish dairy production was summarised by an average dairy unit comprising 47 milking cows producing 4822 l per cow per 290 days of lactation (equivalent to l yr^{-1}). The cows are fed on grazed grass from mid-March to late October (housed at night at the extremes of the 200 day grazing season) and supplementation is achieved with silage and concentrates (Table 1) up to 819 kg cow yr^{-1} supplied when necessary. (Casey & Holden, 2005)

Almost 85% of all dairy farmers in the NMS can be found in **Poland** (53%) and **Romania** (31%). Most countries show a strong dual dairy farm sector, with a large number of relatively small-scale producers and a small percentage of large producers which however handle a large share of the total dairy herd. (van Berkum 2009)

About a third of the dairy production in **France** comes from the areas of forage crops of the West of France and the foothills, characterised by plains and low hills. The soil and climate conditions, with a marked oceanic influence, are by and large favourable to dairy production. The soils enable both temporary grassland and maize to be cultivated. Taking the rural density into account, dairy farms are relatively average, which has led to specialisation and intensification. The dairy farming systems are rather intensive (1.6 to 1.8 LSU.ha-1 FA) and include forage maize, which accounts for between 30 and 50% of the forage area. Temporary grassland is included in the rotations with maize and cereals (from which the straw provides manure). About half of this sown grassland is an association of grass and white clover. Under these conditions, milk production is between 6,000 and 7,500 kg per cow and 6,500 and 9,500 kg.ha-1 FA.

These are transition regions between the major livestock regions and the cash crop regions. They represent 25% of French production. The farms concerned, situated on land with good potential, combine dairy production and cereal production. The forage systems are therefore often based on cultivated grassland, unless livestock uses permanent pasture that cannot be ploughed. Taking the level of mechanisation into account, maize silage often figures largely (between 40 and 60% of the FA). In these conditions, the level of dairy intensification is considerable, between 7,000 and 10,000 kg milk/ha FA.

The grassland areas of the Northwest and the East represent about a quarter of French milk production. Their dairy farms are relatively large, with a considerable proportion of

permanent grassland. Forage maize represents 10 to 30% of the forage area. Under these conditions, the stocking rate is moderate, i.e. between 1.2 and 1.6 LSU/ha FA.

The wet mountains of the Massif Central, Franche Comté and the Alps cover all the mountainous areas in the country, representing 12% of national milk collection of which a good part is used by AOC (Appellation d'Origine Contrôlée) products. The climate in these regions is characterised by cold winters and summers with relatively high rainfall. The forage systems are for the most part based on permanent pasture and hay, as the use of silage is forbidden for cheese-making. The stocking rates are moderate, between 1 and 1.4 LSU/ha FA (Bos et al. 2003).

The male calves from the dairy herd enter veal fattening units or are fattened as young bulls and slaughtered at 16 to 22 months of age. Animals finished in France are slaughtered at 18 to 24 months of age (55% from suckler herds and 45% from dairy herds). Charolais and Limousin bulls are slaughtered at 18 to 19 months of age with carcass weights in the range of 410 to 430 kg. These animals are fed a diet of maize silage and concentrate in specialised beef fattening units. In addition, steers, mainly in the North west of France, are fattened and slaughtered at 2,5 to 3 years of age using Holstein Charolais and Normand breed (EC 2001).

The bull production is mainly located in the arable areas of the western and northern part of France. The main part is shared between the cow calf and bull producers from the intensive areas and from the grass areas of Limousin and North East and the dairy and bull producers from West. The typical farms are chosen on those areas to represent crops and bull activity and cow calf and bull production. The French suckler-cow herd is mainly located on the grasslands and mountains areas of the Centre of France. Those farms are dedicated to the cow calf production for exportation to Italy and Spain. A third of this herd is on the intensive plains of West and grass lands of the northeast and is dedicated to beef finishing production (bull and heifers). Two typical farms are coming from the Limousine area and one from the Pays de la Loire area (Agribenchmark).

The beef production in **Spain** can be characterized as intensive (Weidema et al. 2008). An important share of calves purposed for fattening is from suckler herds (EC 2000, Brömmer 2005). France exports a lot of weaned calves to Spain, where they enter feedlot fattening units. The management of the calves is similar. They are weaned at 6 to 8 months of age, weighing 170 to 300 kg, and are then transferred to fattening units. They are slaughtered at 14 to 15 months of age with a mean carcass weight of 260 kg for bulls and 230 kg for heifers carcass (EC 2001). In Spain 80% of the total beef production is from feedlots located near cities. In the feedlots the cattle is fed a fattening diet of concentrates plus roughage (EC 2001, Deblitz et al. 2007). Heifer fatting makes up for about ¼ of the Spanish beef production. Therefore, an exemplary diet was composed based on information from Kirchgeßner et al. (2008).

The housing, feeding and milking of dairy cows in **Poland** shows extreme diversity. At one end of the spectrum, one cow is housed in a pen or tied outside to a stake and fed and milked by hand. At the other extreme, several hundred cows are housed in modern, free stall barns with drive-through feeding and liquid manure handling; milked in an automated computer-connected parlor; and fed a total mixed ration. Facilities, herd management and milk yields on the most modern farms are equivalent to those observed on state-of-the-art U.S. dairy farms. In between these extremes are pre-1950 barns with hand milking, and Soviet era barns and milking systems. Some of these facilities have been retrofitted in the last decade and many others will likely be modernized using funds provided as part of Poland's accession process (Poland Country Study Team 2005).

The quality of arable land in Poland is rather poor. Very good and good soils constitute as little as 11.5% and poor and very poor soils constitute over 34% of the total area of arable land. Lower quality than that of agricultural land is noted for grassland, where very good and good land covers as little as 1.5% and poor and very poor covers over 42% (Ministry of Agriculture and Rural Development, 2007). Grassland accounts for 22% of agricultural land use (Wälzholz 2003).

In **Italy**, cattle production is traditionally concentrated in the northern regions (particularly in the Po plain) where soil, climatic and infrastructural conditions are the most favourable. More than 68% of cattle and 77% of dairy cows are concentrated in these regions. In dairy farming, the average farm area (30.4 ha farm-1) is slightly larger than in other farming types, but farm units are often smaller than in other European regions. The average stocking density is just above 1.7 t LV ha^{-1}, while it is much higher for pig and poultry production. However, animal density in dairy farming is very variable and a great number of farms might significantly exceed the average value. The distribution of crops shows that maize is traditionally the reference crop for dairy farming. This cereal is both grown for the production of grain (26% of the farm surface) and for silage (20%). Maize silage is directly used on the farm. Maize grain (dried and stocked inside or outside the farm) contributes also directly to the feeding of farm animals. More traditional forages are represented by rotational and permanent meadows (approx. 19% of farm area). Meadows normally produce hay; however the first and the last cuts are less frequently used for silage production. Grazing is very rare.

If Italian dairy production is compared with that of other European countries it should be noted that the main difference is the lack of grazing, as animals are normally housed indoors year-round (Bos et al. 2003).

4.4.6 International Trade

Another important information fort the material flow analysis is knowledge about trade relations of agricultural products. The demand side is structured into domestic production with material flows and resource use and on the other side imports from all over the world. We explicit exclude intra EU27 trade that means trade within EU27 member states. The project just gives attention to extra EU27 trade relations.

Figure 2: Demand-Side Structure Scheme for Beef
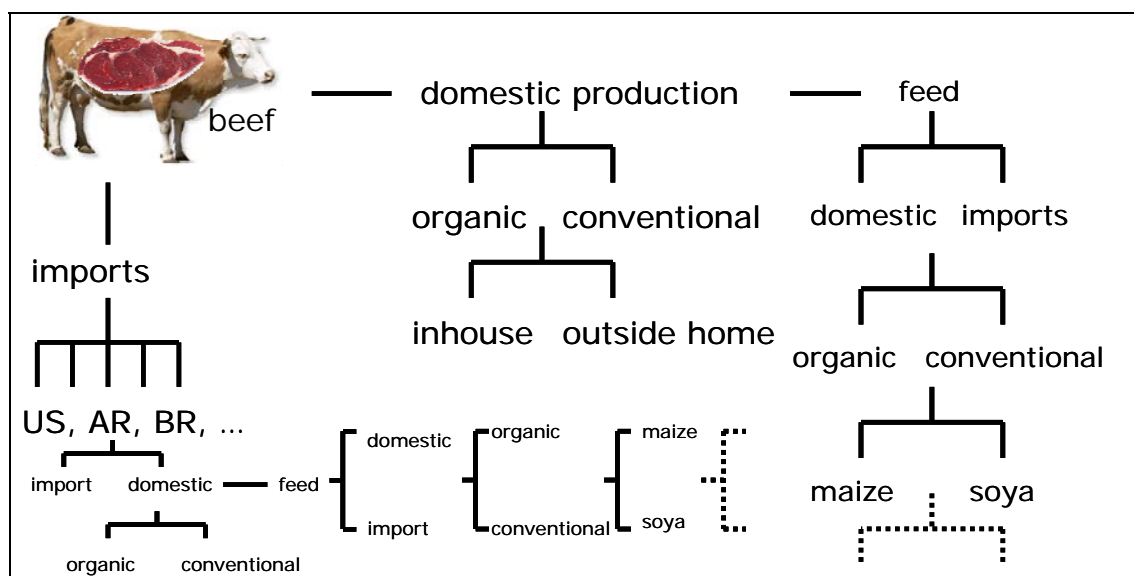
Source: own compilation

The identification of relevant import products based of official statistical databases. The analysis included the already defined specific products within our eight product groups. The aim of the analysis was the identification of relevant import countries in relation to trade products with relevant trade quantities. The identification of typical import countries and typical import products based on a defined relevance border about three percent share on whole EU 27 trade. Base year was 2005 (see Annex,).

The specification of the most important production (in and outside EU 27) and import countries (within EU 27) based on statistical analysis regarding production quantities, trade quantities and self supply. In the following a country overview will be given, to get an impression of production systems.

Beef production in **Brazil** is based on continuous grazing all year around. Apart from a very small share of the cattle being held in feed-lot systems and fed mostly with silage, grass from cultivated and native pastures is the predominant feed source. Tropical and sub-tropical grasses are often poor in essential macro- and micro-nutrients for cattle, and mineral feed supplements are therefore important for herd productivity. In Brazilian beef production, the use of feed-lots is still rather uncommon, and according to ASSOCON, 5 % of the slaughtered cattle in 2006 were raised in intensive systems where mechanically harvested fodder is given to the livestock. Pasture is the overall dominant feed in Brazilian beef production. Only five percent of the slaughtered animals in 2006 were raised in feedlots, with the remaining 95 % of production coming from grazing livestock. The GHG emissions in the primary production of Brazilian beef production (not including land-use changes) are at least 30-40 % higher than current European production. High emissions of methane is the main cause and explained by

high slaughter ages and long calving intervals, and also that the majority of beef is produced in cow-calf systems, not as by-products from milk production. The use of energy in Brazilian beef production is very low, approximately a tenth of European production. Land use in beef production is considerable higher than in European production.

In **Argentina,** the number of feedlots grew significantly in the past couple of years, and many existing ones expanded their capacity. The local chamber of feedlots indicated that in 2008, roughly 5 million fed cattle went to market from feedlots, and they expect over 6 million in 2009. This would represent 40 percent of the expected total slaughter (including cows and bulls). Many analysts believe that Argentina's cattle sector is moving more and more towards a system by which breeders will put on the largest amount of weight on grass and the last 80-150 kilos will be produced with grain or corn silage at the ranch or in feedlots (USDA 2009). Though farmers shifted much pastureland to crop production, they did not reduce the size of their herds. Cattle production methods had to adjust. Feeder cattle production became more intensive by utilizing higher energy rations.

An important change in Argentina's cattle sector in the past couple of years has been the utilization of corn as feed. Before, alfalfa pastures were the most common source of feed. Many owners are now able to increase their herd sizes as cattle are placed on more marginal land and in smaller lots are being fed inexpensive and highly productive corn.

As a result, the feed lot industry expanded significantly. Cattle feeders copied the vibrant domestic dairy industry and incorporated the use of corn silage and corn grain into cattle rations. (Steiger 2006)

Beef production in Argentina is characterized by low input year-round grazing systems. Barns do not exist. The stocking rate is low at levels of 500 kg live weight per ha and less. Hereford and Angus and their crosses are the prevailing breeds. To a lesser extend Holstein calves form the dairy herd and crosses with zebuine breeds, mainly from the Northern provinces, are used. The following table gives and overview on main productive indicators of beef production.

Table 27: Main Productive Indicators for Beef

Item	Value Range	Unit
weight at start of finishing	130-180	kg LW
final weights for steers	380-450	kg LW
age at start of finishing	210-260	days
duration of finishing period	300-500	days
age at end of finishing period	575-759	days
daily weight gain	500-650	g/day
number of weaned calves per 100 cows and year	75-80	head

Source: Deblitz/Ostrowsky (2004)

5   MFA Data for Fish

Global fish production supplied about 144 million tonnes of food fish in 2006, providing an apparent per capita supply of 16.4 kg (live weight equivalent) in 2005 (FAO 2009). Facing the fact of natural resource depletion the problem of coping with increasing global fish consumption is subject of scientific and political discussion. Regarding fish production, two main categories have to be distinguished: production from capture fisheries and aquaculture.

According FAO (2004), the global potential for marine capture fisheries has been reached. Rigorous plans are needed to rebuild depleted stocks and prevent the decline of those being exploited at or close to their maximum potential.

The contribution of aquaculture to global supplies of fish products increased from 3.9 % of total production by weight in 1970 to 29.9 % in 2002, i.e. aquaculture has grown more rapidly than all other animal food-producing sectors (FAO, ibid).

The two production systems production from capture fisheries and aquaculture differ from each other concerning their energy input, material input and resource input. Furthermore it has to be considered that fish is as a quite heterogeneous food resource category. This food category comprises a huge group of biological species that differ widely in their ecological needs. The diversity of capture and aquaculture techniques reflects this fact. The complexity of fish as a food category has to be kept in mind by modelling the material flow of this food category.

The most comprehensive and reliable data on fish production are provided by the Fisheries and Aquaculture Department of the FAO[11].

In general FAO statistics on production from capture fisheries and aquaculture are available for different biological fish and invertebrate (e.g. molluscs, squids, octopuses, crustaceans) groups that are used for human consumption. Data on the consumption of fish and fish products are available as well but less detailed.

5.1   Classification of Fish

Facing the diversity of fish products and fish production systems a material flow analysis of fish consumption in the EU 27 can not cover every detail of the existing production systems. Therefore it is firstly necessary to identify the most important product categories and classify them into groups that reflect the main input differences of the production.

From this perspective, following classification was determined:

- non-predatory freshwater fishes, produced in aquaculture, encompassing as main species groups carps, barbells and other cyprinids and tilapias and other cichlids

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[11]   see http://www.fao.org/fishery/statistics/en

- carnivore diadromous fishes, produced in aquaculture, encompassing as main species groups salmon and trout

- crustaceans, produced in aquaculture, respectively shrimps and prawns

- marine fishes, production from capture fisheries

- molluscs, including squids, cuttlefishes and octopuses

"Molluscs" are produced by capture fisheries and aquaculture. The only difference in these two systems is that in aquaculture, sometimes seed mussels are reared. In this case energy is needed for controlling the temperature and salinity of the water. The EUPOPP data compilation did not differentiated between these two systems of molluscs production. Molluscs are reared in: coastal zones either on natural grounds or in racks, bags or cages or on artificial maturation tanks, and are not fed. Except for rearing seed mussels, the only energy input consists in using fuel for necessary shipping activities (e.g. mollusc collection). Therefore, it is assumed that the two mollusc production systems do not differ much regarding their energy inputs.

Regarding their low quantity importance, following fish products groups have not been taken into account to model the fish consumption in the EU 27:

- freshwater fishes produced in inland capture fisheries,

- marine fishes produced in aquaculture,

- crustaceans produced in capture fisheries.

5.2   Data Compilation for Fish

Base year of the data compilation for fish products is 2005, exceptions are marked. Sources of the data compilation are FAOSTAT and the European Commission - Fisheries[12].

5.2.1 Consumption Quantities

Base year for the data compilation of consumption quantities of fish consumption in the EU 27 is the year 2005. The consumption data are the amount consumed fish per capita for each EU 27 member state. The average consumption is 21.15 kg per capita and year. The amount of consumed fish-products in the EU 27 member states range between 4,15 kg (Bulgaria) and 55,42 kg (Portugal) per capita and year. The median was located by 18.26 kg per capita and year.

Consumption data in FAOSTAT are comprehensive of capture and aquaculture, therefore farmed fish, like salmon (carnivore fish) and carp (non-predatory fish), is included in the group freshwater fish. The reason why it is not possible to calculate separate consumption for aquaculture is that international classifications used to collect trade

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[12] see http://ec.europa.eu/fisheries/stat_import/statistics__imports_en.pdf

statistics do not distinguish between farmed or wild origin[13]. Therefore it is not possible to present consumption data for all fish categories defined for EUPOPP. The groups "non-predatory freshwater fishes, produced in aquaculture" and "carnivore diadromous fishes, produced in aquaculture" are included in the group freshwater fish.

Table 28: Per capita consumption of fish per year in the EU 27

Per capita consumption year	Total (kg)	Percent (%)	Arithmetic average (kg)	Median value (kg)
Freshwater fish	28.64	5.45	1.15	0.12
Crustaceans	22.38	4.26	1.02	0.75
Marine fishes	272.12	51.77	10.88	10.42
Molluscs	202.46	38.52	8.10	6.97
Total	525.6	100	21.15	18.26

Source: FAOSTAT (2009)

5.2.2 Economic Values

The compiled data on the estimated value are based on the year 2006. The data are provided by FAO 2010 (ftp://ftp.fao.org/fi/stat/summary/applIybc.pdf). The highest prices are realised by aquaculture fish products, respectively carnivore diadromous fish species and crustaceans like shrimps and prawns.

The prices per fish category were calculated as the weighted arithmetic value of fish species prices and the respective quantities consumed. Data is presented using an exchange rate of 1 € = 1.21 US $ (exchange rate from 06/01/2006[14]).

Table 29: Prices for Fish

Fish group	Price in Euro per kg
Freshwater fish aquaculture and capture fisheries	2.47
Crustaceans aquaculture	8.91
Marine fishes capture	6.70
Molluscs aquaculture	1.56

Source: FAOSTAT (2009)

5.2.3 Fish Production in the EU 27

The total fish production of EU 27 Member States in 2005 is given in Table 30.

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[13]   According   Statistics   and   Information   Service, Fisheries   and   Aquaculture   Policy   and   Economics   Division, FAO Fisheries and Aquaculture Department (email from 07/23/2010).

[14] *Source: http://www.oanda.com/lang/de/currency/historical-rates?date_fmt=us&date=01/06/06&date1 =01/06/06&exch=USD&expr=EUR&format=HTML& argin_fixed=0 (URL visited in June 2010).*

Table 30: Total Fish Production of the EU 27

Total production (t)	Capture	Aquaculture
Freshwater fish	115,192	94,620
Diadromous fish	27,605	346,389
Crustaceans	220,443	260
Marine fishes	4,964,818	132,981
Molluscs	359,567	669,320
Total	**5,687,625**	**1,243,570**

Source: FAOSTAT

5.2.3.1 Capture

The group of marine fish accounts for the highest proportion of capture fisheries pro-
duction, about 5 million t fish (87 % of total), see Table 31. Capture fisheries of fresh-
water and diadromous fish accounts only for 2.5 % of total capture in the EU 27.

Table 31: Capture Fisheries Production of the EU 27

Inland waters	Capture (t)
Freshwater fishes total	**115,192**
Carps, barbels and other cyprinids	35,793
Miscellaneous freshwater fishes	79,399
Diadromous fishes total	**173,65**
Salmons, trouts, smelts	14,823
Crustaceans total	**1,786**
Marine areas	
Diadromous fishes total	**10,240**
Shads	2,026
River eels	1,489
Salmons, trouts, smelts	6,665
Crustaceans total	**218,675**
Marine fishes total	**4,964,818**
Tunas, bonitos, billfishes	520,689
Cods, hakes, haddocks	914,422
Flounders, halibuts, soles	212,169
Herrings, sardines, anchovies	2,019,735
Miscellaneous coastal fishes	264,654
Miscellaneous demersal fishes	162,289
Miscellaneous pelagic fishes	706,449
Sharks, rays, chimaeras	98,812
Molluscs total	**359,567**
Total	**5,687,625**

Source: FAOSTAT

The main producing countries are:

- For marine fishes:
    - o Denmark 821,240 t
    - o Spain 781,276 t
    - o United Kingdom 553,844 t
    - o Netherlands 526,843 t
    - o France 475,481 t
- For freshwater fishes:
    - o Finland 35,805 t
    - o Germany 21,814 t
    - o Poland 22,088 t
- For crustaceans:
    - o United Kingdom 47,025 t
    - o Italy 29,895 t
    - o Germany 23,381 t
    - o Netherlands 17,626 t
    - o Denmark 17,305 t
- For diadromous fishes:
    - o Finland 10,530 t
    - o Sweden 3,613 t
    - o Spain 1,953 t
    - o Greece 1,877 t
- For molluscs:
    - o France 78,810 t
    - o Denmark 71,184 t
    - o United Kingdom 67,855 t
    - o Italy 59,044 t
    - o Spain 46,096 t

5.2.3.2 Aquaculture

Aquaculture fish and invertebrate production of the EU 27 member states amounted about 1.2 Mio tonnes in the year 2005. The group of molluscs accounted with 669,320 t

or 54 % for the highest proportion of the aquaculture production in the EU 27, followed by the group of diadromous fishes with 346,389 t or 28 % (see Table 32).

Table 32: Aquaculture fish production of the EU 27 member states

	Aquaculture (t)
Europe - Inland waters - Freshwater	
Freshwater fishes total	**94,620**
Carps, barbels and other cyprinids	81,107
Miscellaneous freshwater fishes	13,117
Tilapias and other cichlids	396
Diadromous fishes total	**346,389**
Salmon, trouts, smelts	346,061
Diadromous fishes	328
Crustaceans total	**260**
Crustaceans	120
Shrimps and prawns	140
Marine fishes total	**132,981**
Molluscs total	**669,320**
Total	**1,243,570**

Source: FAOSTAT

The main aquaculture fish producing countries are:

- For Freshwater fishes:
    - Poland 20,570 t
    - Czech Republic 19,683 t
    - Germany 15,343 t
    - Hungary 13,607 t
- Crustaceans:
    - Spain 153 t
    - France 58 t
- Diadromous fishes:
    - United Kingdom 142,613 t
    - France 35,393 t
    - Italy 30,741 t
    - Denmark 29,922 t
    - Spain 26,171 t
- Marine fishes:
    - Spain 28,028 t

- o Italy 14,057 t
- o Greece 76,945 t
- Molluscs:
  - o France 194,470 t
  - o Italy 133,290 t
  - o Spain 164,533 t

5.2.4 Production inputs in capture fisheries

1.1.1.1   Energy Inputs

Main energy inputs in capture fisheries are caused by diesel consumption for the ship-ping trip to the capture area and by diesel consumption for all necessary fishing activi-ties. In general fish will directly be processed on board and has to be transported cooled or frozen. No separate data is available on the diesel consumption of these processes, so that a "top-down" estimate is made based on the considerations dis-cussed below.

Data are available for fuel consumption for different fishing methods (see Table 33).

Table 33: Fuel use for different fishing gears

Gear type	Allocation by mass of species caught	Allocation by value of spe-cies caught
	average (kg fuel/kg fish)	
Bottom trawl	0.28	0.26
Double trawl	1.01	1.01
Pelagic trawl	0.09	0.06
Gillnet	0.19	0.18
Hook	0.15	0.11
Longline	0.31	0.32
Shrimp trawl	1.04	1.08
Purse seine/ring seine	0.09	0.13
Danish seine/round-fish trawl/flat fish trawl	0.11	0.19
Trap	0.13	0.24

Source: Schau et al. (2008)

The GEMIS default dataset for fishing uses 0.25 kg Diesel/kg fish as an average.

5.2.5 Production Inputs in Aquaculture

5.2.5.1 Energy Inputs

Energy inputs in aquaculture depend of the reared species and the used aquaculture techniques. In general, energy use in pond- or lake-based aquaculture of freshwater fish species (like carps or other cyprinids, tilapia) is quite low. Energy is used for aeration during grow-out phase in pond-based systems and for aeration during tank-based hatchery production. In general, the fingerlings have to be transported to the grow-out place and feed has to be transported to the aquaculture facility. These processes account for fuel consumption.

Data are available for Indonesian tilapia production (Pelletier/Tyedmers 2010).

Table 34: Energy and fuel use for the production of 1 live-weight tonne of tilapia in pond-based and lake-based farms in Indonesia in 2007

Input	Lake production	Pond production
Feed transport by barge (km)	8.2	-
Feed transport by truck (km)	260	300
Fingerlings (kg)	18	21
Fingerling transport by barge (km)	7.3	0
Fingerling transport by truck (km)	130	60
Electricity (MJ)	0	2730
Diesel (MJ)	391	51
Gasoline (MJ)	55	0

Source: Pelletier/Tyedmers (2010)

Trout production is generally carried out in freshwater, flow-through raceway-type installations, mainly using river water. Energy is also used for aeration during grow-out phase and for aeration during tank-based hatchery production. Since trout is a species that lives in rivers and becks, energy-use for aeration in trout production is generally higher than in carp or tilapia production. Data on energy consumption in trout production are available for French trout production (Papatryphon et al.). The fingerlings have to be transported to the grow-out place and feed has to be transported to the aquaculture facility. These processes account for fuel consumption.

Salmon aquaculture takes place in marine net-cages at coastal sides. Therefore no energy inputs are necessary in the grow-out phase. Energy inputs are necessary for aeration in hatchery production and for transport processes. Energy consumption differs widely. Data are available for salmon production in Norway, Canada, Chile and the United Kingdom (Pelletier et al. 2009).

5.2.5.2 Feed

The amount and composition of feed (the proportion of fish meal and fish oil) inputs in aquaculture production varies between different fish species and fish groups (see Table 35). The required feed amount is stated in the "feed conversion ratio" (FCR). The FCR is calculated from the number of kilos of feed that are used to produce one kilo of whole fish.

Table 35: The FCR of different fish groups

Reared fish (1kg), gobal average	FCR	proportion fish meal (%)	proportion fish oil (%)
Trout	1.35	35	21.5
Salmon	1.3	35	22
Tilapia	1.95	10	5
Catfish	1.9	21.5	7.5
Shrimp	2.05	22.5	5.25
Chinese carps	1.9	10	1

5.2.5.3 Other Inputs

Other inputs in capture fisheries and aquaculture are e.g. gill material for capture fisheries, antifouling paints, net-cages in aquaculture or the application of pharmaceuticals and vaccines. These inputs will be neglected due to lacking data base.

5.2.6 GHG Emissions

The greenhouse gas emissions were presented in kg CO_2 equivalents per kg of fish. The system boundary ends in most of the cases at the harbour (for capture fisheries production) or at the farm level (aquaculture production), respectively (see Fig. 1: Food value chain).

5.2.7 Freshwater Fish Aquaculture (Non-Predatory)

For the group "Non-predatory freshwater fish, produced in aquaculture", representative GHG emissions are based on tilapia production in Indonesia (Pelletier/Tyedmers 2010) which give GHG emissions of tilapia at farm level as **1.8 kg CO_2eq/kg fish**.

5.2.7.1 Crustaceans from Aquaculture

According to a study of Sun (2009), the GHG emissions of shrimps are 5.9 kg CO_2eq/kg shrimps. The major inputs are energy used for seawater transportation, aeration and temperature controlling and feed.

5.2.7.2 Carnivore Diadromous Fishes from Aquaculture

Pelletier et al. (2009) surveyed GHG emissions of salmon faming in the four major producing regions: UK, Chile, Norway and Canada. The authors calculated all the in- and outputs of the cradle-to-farm-gate production. According to their results, the weighted

average[15] for 1kg live-weight salmon is **2.2 kg CO$_2$eq**. This value can be taken as representative for this fish category, because salmon accounts for the major part of production of this fish category.

5.2.7.3 Marine Fishes from Capture Fisheries

The GHG emissions from capture fisheries in the Baltic Sea account for **2.43 kg CO$_2$eq/kg caught fish** (mix of different fishing types) according to Ziegler et al. (2003). Our own analysis using the energy inputs of fish trawlers and different modelled transport distances give the following disaggregated results:

Table 36: GHG Emissions for Fish Products in EUPOPP

CO$_2$eq in kg/kg	2010	2020	2030
capture-marine-EU-fresh	1,11	0,99	0,87
capture-marine-EU-canned	2,89	2,61	2,29
capture-marine-EU-frozen	3,14	2,84	2,51
capture-marine-imported-canned	4,37	4,32	4,29
capture-marine-imported-frozen	4,81	4,77	4,76

Source: GEMIS 4.7 calculation

5.2.7.4 Molluscs

According to different descriptions of molluscs aquaculture, hardly no energy and no feed is used in this type of aquaculture. Energy inputs result of diesel consumption for the exposure of seed-mussels and the harvest of the mussels.

Therefore, a GHG emission value of **0.58 kg CO$_2$eq/kg** is estimated, taking in account the necessary diesel consumption.

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[15] For calculating the average of GHG emissions, the production quantities of the four major producing regions were multiplied with the respective GHG emissions.

5.3 International Trade of Fish

Trade relations give important information for the material flow analysis so that external trade of the EU 27 Member States is of interest.

5.3.1 Imports of the EU27 Member States

The EU 27 Member States import fish products from all over the world. Altogether they import about 2.5 Mio tonnes fish products (fish, crustaceans and molluscs) from extra EU countries (see Table 37). The majority of fish imports come from Northern Europe (respectively salmon from Norway), the majority of imported crustaceans come from South and North America and Asia and the majority of molluscs come from Asia and South America.

Table 37: Imports from extra-EU to EU 27

Exporting country	Fish (t)	Crustaceans (t)	Molluscs (t)
Russia	126,410	-	-
Northern Europe	870,250	-	-
Southern Europe	18,344	-	-
South America	152,727	101,196	129,361
North America	207,671	83,842	16,974
North Africa	42,946	-	42,853
South Africa	209,310	11,986	-
Asia	176,663	97,154	162,516
Australia	-	-	28,451
Total	**1,804,320**	**294,178**	**380,155**

Source: http://ec.europa.eu/fisheries/stat_import/statistics_imports_en.pdf 2009.

5.3.2 Capture Areas of the EU 27 Member States

The capture areas of the EU 27 member states are distributed around the global waters. The highest proportion of capture fisheries production, with about 4 million t of fish products, takes place in the Northeast Atlantic (see Table 38).

The group "Others" (see Table 38) encompasses following fishing regions: Northwest Atlantic, Southeast Atlantic, Southwest Atlantic, Western Central Atlantic, Pacific Ocean, Southern Ocean and Inland waters.

Table 38: Capture Areas of the EU 27 Member States

Species	Atlantic, Northeast	Atlantic, Eastern Central	Mediterranean and Black Sea	Indian Ocean	Others
Freshwater fish	13,477	-	-	-	100,810
Diadromous fishes	8,238	-	2,002	-	18,745
Crustaceans	142,374	6,526	38,325	555	32,663
Marine fishes	3,652,193	456,180	400,360	314,004	146,765
Molluscs	265,225	15,287	76,901	637	6,609
Total	**4,081,507**	**477,993**	**517,588**	**315,196**	**305,592**

Source: FAOSTAT; data given in tonnes.

6 Food Processing

6.1 Analysis of Existing Studies

A literature review focused on finding material quantifying energy demands to produce selected food products has been carried out to substantiate data selection for the MFA elements of food processing. The following description shows a short summary of studies evaluated. For each, a summary is made which includes main characteristics (author, title, year and institute) and scope of the study. In the next subchapter, the relevance of the data for EUPOPP is discussed.

Authors: A. Carlsson-Kanyama, M. Faist

Title: Energy Use in the food sector: A data survey

Institution: Environmental Strategies Research Group Department of Systems Ecology Stockholm University, Department of Civil and Environmental Engineering Swiss Federal Institute of Technology (ETH Zürich)

Date of Publication: 2005

Scope of the study: The study is a survey of data estimates energy requirements in the food sector. It contains data about agricultural production, food processing, storage and food preparation. (Appendix: Data on energy use for various types of food processing). The report includes an example for the mass flow and energy use for a hamburger (BigMac).

Authors: D. Antoni, W. Ruß

Title: Minderung öko- und klimaschädigender Abgase aus der industriellen Anlagen durch rationelle Energienutzung" - Milchverarbeitender Betrieb-

Institution: Technische Universität München – Lehrstuhl für Energie- und Umwelttechnik

Date of Publication: 2000

Scope of the study: The study analyses the energy demand in a dairy production plant (Andechser Molkerei). The dairy has 170 employees and processed up to 338.000kg milk each year to different dairy products. After the measuring of the energy demand the potential which energy efficiency instruments could offer and the profitability is evaluated.

Authors: K. Wiegmann, Dr. U. Eberle, U. R. Fritsche, K. Hünecke

Title: Datendokumentation zum Diskussionspapier Nr, 7 " Umweltaus-wirkungen von Ernährung - Stoffstromanalyse und Szenarien"

Institution: Öko-Institut

Date of Publication: 2005

Scope of the study: The study gives an overview of the data basis which is used in "Umweltauswirkungen von Ernährung - Stoffstromanalyse und Szenarien" The first chapter includes material flow data for agri-cultural production, processing, retail, storage, transport and the preparing of meals. The second chapter describes different sce-nario data for changing diets.

Authors: C.A. Ramírez

Title: Monitoring the Energy Efficiency in the food industry

Institution: PhD Thesis; Utrecht University (NL)

Date of Publication: 2005

Scope of the study: The study examines the role that energy efficiency has played in the development of energy use of non-energy intensive sectors, in particular in the food sector. Therefore the developments in energy use and energy efficiency have been explored. Energy ef-ficiency indicators for monitoring changes have been developed.

Authors: C. Foster, K. Green, M. Bleda, P. Dewick, A. Flynn, J. Mylan

Title: Evironmental Impacts of Food Production and Consumption

Institution: UK Defra (Department for Environment Food and Rural Affairs)

Date of Publication: 2006

Scope of the study: The objective of the study is to determine, what evidence is available relating to the environmental impacts that occur in the life cycles of a range of products. The review of evidence has fo-cused on studies that use the technique of environmental LCA.

Authors: IPPC

Title: Reference Document on Best Available Techniques in the Food, Drink and Milk Industries

Institution: Integrated Pollution Prevention and Control (IPPC)

Date of Publication: 2006

Scope of the study: The document reflects the whole range of activities producing food for human consumption and animal feed. It does not cover small scale activities (catering or restaurants). Chapter two describes processes at the unit operation level. Many of these are applied in several individual FDM sectors. Chapter 4-6 contains detailed information to determine BAT for the FDM sector.

Authors:	P. Eder, L. Degado
Title:	Environmental Impact of Products (EIPRO) – Analysis of the life cycle environmental impacts related to the final consumption of the EU-25
Institution:	JRC - Institute for Prospective Technological Studies (IPTS)

Date of Publication: 2006

Scope of the study: The objective of this project was to identify those products that have the greatest environmental impact through their life-cycle. The study describes only the current situation. A list of studies most relevant for the research task was reviewed in order to establish the state-of-the art in the area and to find the most suitable methodological approach for this project. The analysis is based on the CEDA EU-25 Products and environmental model, the new input-output (IO) model developed in the study

Authors:	E. Masanet et al.
Title:	Energy Efficiency Improvement for the Fruit and Vegetable Processing Industry
Institution:	US Environmental Protection Agency (EPA)
Date:	2008

Scope of the study: This Study discusses energy efficiency practices and energy-efficient technologies that can be implemented at the component, process, facility, and organizational levels. A discussion of the trends, structure, and energy consumption characteristics of the U.S. fruit and vegetable processing industry is provided along with a description of the major process technologies used within the industry.

Further data are published on the website www.lcafood.dk which provides LCA data on basic food products produced and consumed in Denmark. The site covers processes from primary sectors such as agriculture and fishery through industrial food processing

to retail and cooking. The LCAfood database is created by Weidema et al. (2003) and is hosted by Faculty of Agricultural Sciences in Denmark.

6.2 Summary

The data availability regarding food processing encompasses a manageable size of scientific literature. Some few experts are specialised on food processing combined with life cycle analysis, therefore the study quantity and in parallel the data quantity is less. The existing data are always country-related. Due to this fact it was not possible to examine data within all EU27 member states, or European specific data. Therefore it will be assumed that food processes within EU27 have similar production practises and for these reason similar energy intensities - nevertheless country-related energy mixes diverse within EU27 and will be another approach for the material flow analysis.

6.3 Literature Evaluation for BAU (Food)

The BAU scenario projects the future development until 2030. To make the BAU scenario as realistic as possible, EUPOPP collected most recent data for the EU developments in the respective need areas.

The environmental impact of the food processing industry is an important step in the food chain. The indicator to measure the environmental impact of food processing is the energy demand and the corresponding greenhouse gas emissions. The boundaries of the regarded products are the arrival in the production plant and the leaving. Only what happens in the production plant will be taken into account.

In this case the studies regarded in the above chapter will be grade in marks from 1 (very good) to 5 (very bad) to evaluate the utility of their data in the framework of the project. The studies were analysed by examining and comparing the aggregation of products and the way, the environmental impacts are expressed.

Figure 3: Evaluation levels regarding utility of data

1	2	3	4	5
very good	good	satisfactory	adequate	inadequate
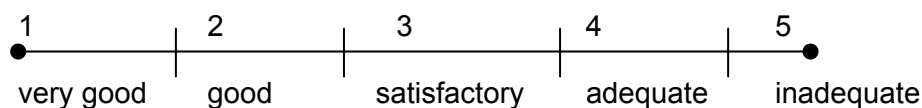
Source: own compilation

Table 39: Evaluation of existing literature

Study	Data Quality	Mark
Carlsson-Kanyama et. al. 2005	The survey is based on published material or information communicated directly to the authors. Data for various steps are listed separately. Data for food processing are given in MJ/kg	1
Ruß et. al. 2000	The study had measured the energy demand within one week. They don't give an allocation within the various products.	4
Wiegmann et. al. 2005	The data are evaluated by a literature review and information communicated directly to the author.	1
Ramírez 2005	The study gives an overview about the energy demand for processing of 46 food products.	1
Foster et. al. 2006	The study shows the environmental impacts from various food products. Not always the impacts are shown on the individual levels within the LCA steps.	2
IPPC 2006	Chapter 3.3 gives data about consumption and emission levels in some individual FDM sectors. The energy demand is expressed in various units (e.g. kg steam per kg output).	2
Eder et. al. 2006	The study uses an input-output model. The results aren't comparable to data of a LCA	5
Masanet et. al. 2008	The study gives energy data for some fruit and vegetable products. The data based on literature survey	2
www.lcafood.dk 2010	The data based on literature survey. There are data for the energy demand and the material efficiency for 15 food products.	2

Source: own compilation

Data of the material efficiency of production processes are given in IPPC 2006, GEMIS 4.5, Carlsson et.al. 2005 and also on the webside www.lcafood.dk.

6.4 Product Comparison: Data Review on Energy Consumption and Consumption Quantities

The first step was to extracted all values from the graded studies and set them on the same unit. The following step was to build a matrix which combined the relevant products with the results from the literature review. Each product from the product matrix can be process in different ways, so that there are several outputs, which are available to the consumer or destined for further processing. For example "potatoes" can be processed to "peeled potatoes", "potato chips" and "potato starch". The table (Table 40) below show the energy demand for some milk products from the matrix

Table 40: Final energy use for some milk products (in MJ/kg)

	Milk	**Milk powder**	**Cheese**	**Butter**
GEMIS 4.5	0.34	12.03	3.45	0.65
Carlsson et. al. 2005	0.73	16.11	2.54	2.47
Ramírez 2005	0.77	10.44	3.32	1.74
Foster et. al. 2006	0.66		8.5	
IPPC 2006			3.87	
Faist et. al.	0.15		2.53	0.07
www.lcafood.dk 2010	0.37	8.43	6.95	1.19
Average	*0.50*	*11.75*	*4.45*	*1.22*

Source: own compilation

Normally the energy demand increases with the number of process steps, which are require producing a certain form of output. The processes in the Food and Drink Sector are diverse and consist of a wide range of raw materials, products and processes and the numerous combinations of each. IPPC (2006) describes the most commonly used processes in the sector in nine categories i.e. materials reception and preparation; size reduction, mixing and forming; separation techniques; product processing technology; heat processing; concentration by heat; processing by removal of heat; post processing operations; and utility processes. The following picture shows usual processes for drying, which are one of the most energy intensive processes in the sector.

Figure 4: Drying-technologies
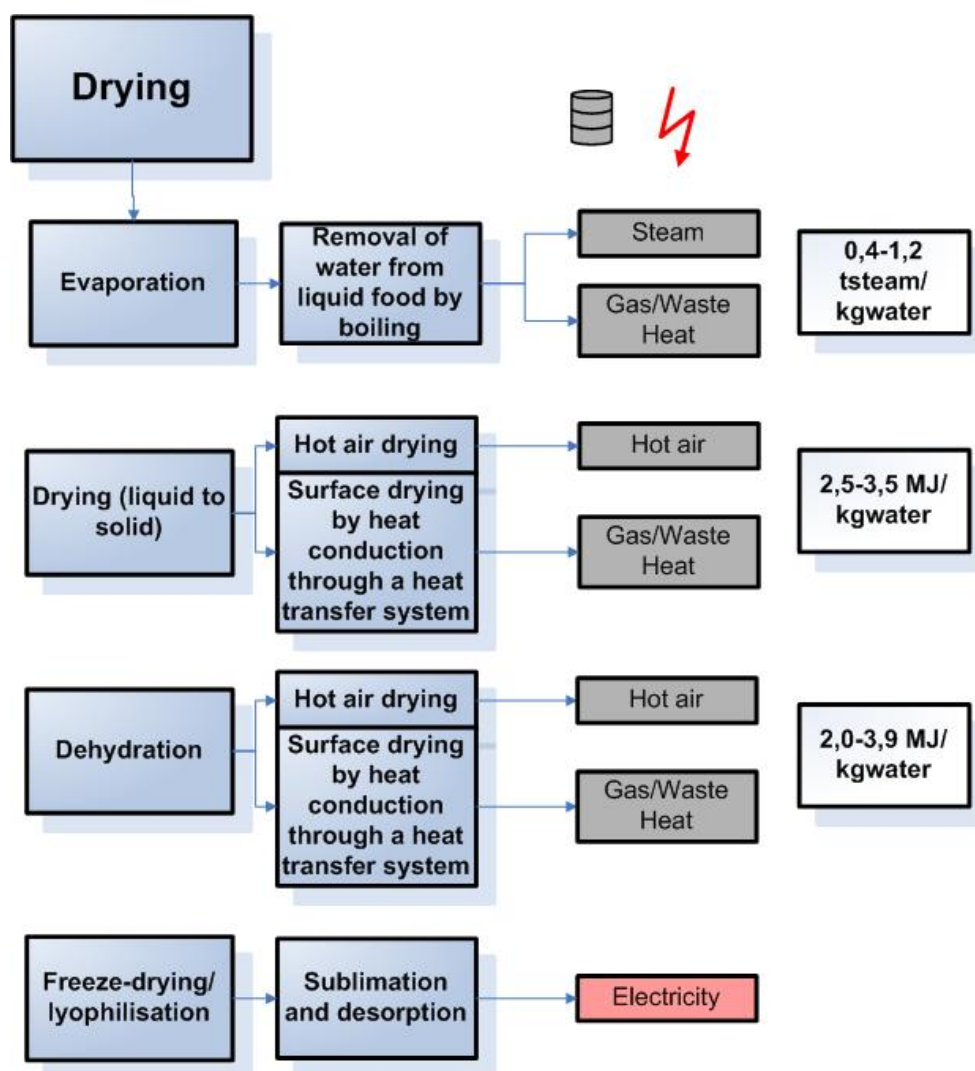
Source: IPPC (2006)

While several processing steps are well described, there is less information about the allocation of the energy demand within the processing steps. Some more allocation factors can be found in Masanet et al. 2008 and Ramírez 2005. Where no information can be found the allocation factors were estimated. The following table shows an example for frozen fruit and vegetables:

Table 41: Allocation of electricity and heat use for frozen fruits and vegetables

	Electricity (%)	**Electricity (MJ/kg)**	**Heat (%)**	**Heat (MJ/kg)**
Inspection, grading, peeling and slicing	6%	0,06	72%	0,86
Washing and peeling				
Blanching			27%	0,32
Freezing	90%	0,92		
Packing	3%	0,03		
Others	1%	0,01	1%	0,01

Source: Masanet et al. (2008)

Regarding the future trends of the energy efficiency in the food processing industry Wallgreen et al. (2009) estimates reductions of energy intensity that are based on technological development, of approx. 75% in a 50 year perspective. Ramírez (2005) developed an energy efficiency indicator for the dairy and meat industry. In the dairy industry this indicator decreased by approx. by 1.9% each year in the last 10 years. A further future prospect for the energy demand in the food industry is given by the U.S. Environmental Protection Agency. They estimate an annual change in energy intensity (energy consumption per dollar value of output) of -0.5%. The overall change in energy use is 19% from 1997 up to 2020. The best case scenario shows a decrease of energy intensity of -0.9% each year and an overall change in energy use of 8% from 1997 up to 2020 (US EPA 2007).

In a study from UK (Mistry et al. 2007) energy saving projects for a short, medium and long-term perspective are described. The short to long-term opportunities are shown in the Table below (Table 42).

Table 42: Saving potential of F&D industry sector

Industry by SIC [16]Codes	Manufacturing sector	Sectoral saving potential (S-M)%	Saving of F&D industry
Meat processing and production	Meat	15.2%	0.7%
	Poultry	12.5%	0.4%
	Renderers	12.4%	0.2%
Fish products	Fish processing	8.4%	0.2%
Fruit & vegetables	Fruit & vege.	9.9%	0.5%
Oils & fats	Oils & fats	9.5%	0.3%
Dairy products	Dairy	12.0%	0.8%
	Ice Cream	14.9%	0.6%
Grain milling & prod	Milling & products	4.5%	0.3%
Animal feeds	Animal feed	10.5%	0.5%
	Pet food	15.3%	0.6%
Other food products	Bakery	15.0%	1.5%
	Ambient Food	12.0%	0.8%
	Sugar manufacture	12.6%	1.3%
	Confectionery	14.6%	0.7%
Beverages	Spirits	7.8%	0.4%
	Brewing	13.4%	0.8%
	Malting	10.4%	0.3%
	Soft drinks	13.6%	0.2%
Storage & distribution	Cold store	14.0%	0.4%
	Bulk storage and distribution	10.8%	0.2%
Total F&D sector		12.0%	12.0%

Source: Mistry et al.(2007)

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[16] Standard Industrial Classification

Table 43: Estimated energy saving potential by technology areas

Technology area	Saving potential in F&D industry %
Boilers & steam	1.7%
Refrigeration	1.7%
Buildings	1.4%
Process control	1.4%
Fans	1.2%
Stirring and mixing	1.1%
Compressed air	0.9%
Drying	0.8%
Pumps	0.8%
Cooling system	0.5%
Distilling	0.3%
Total energy use	12.0%

Source: Mistry et al. (2007)

6.5   Analysis of Studies on Future Trends

The following table shows a short summary of some studies. For each study a summary report was made, which include the main characteristics (author, title, year and institute) and the scope of the study.

Authors: Unknown

Title: Energy Trends in Selected Manufacturing Sectors: Opportunities and Challenges for Environmentally Preferable Energy Outcomes

Institution: US Environmental Protection Agency (EPA)

Date of publication: 2007

Scope of the study: The report developing strategies to promote environmentally preferable outcomes with respect to energy consumption in 12 industrial manufacturing sectors. Across the 12 sectors, this analysis characterizes energy consumption within the context of recent and expected future energy trends and provides a broad overview of the environmental and economic context surrounding sector energy usage.

Building on this overview, the analysis provides sector-specific "base case" and "best case" energy scenarios, identifying opportunities for promoting environmentally preferable energy outcomes as well as potential regulatory and nonregulatory barriers to improved environmental outcomes.

Authors:	P. Mistry et al.
Title:	Resource use efficiency in food chains- Priorities for water, energy and waste opportunities
Institution:	Defra (Department for environment food and rural affairs (UK))
Date of publication:	2007
Scope of the study:	The study identify opportunities for improving resource use efficiency, and for reducing waste generation in key parts of the food production chain. The studies providing a prioritised list of potential research projects that would provide cost-effective ways to encourage reduction of water and energy consumption and waste generation. Opportunities for resource efficiency in the food production chain may be characterised as: Low cost, often short-term opportunities, Medium-cost opportunities and Long-term opportunities.

Authors:	E. Audsley et al.
Title:	How long can we go? – An assessment of greenhouse gas emissions from the UK food system and the scope for reduction by 2050.
Institution:	World Wide Fund for Nature-UK (WWF-UK) and Food Climate Research Network (FCRN)
Date of publication:	2010
Scope of the study:	The overall aim of this study was to develop a set of scenarios that explore how greenhouse gas emissions from the UK food system may be reduced by 70% by the year 2050. This report identifies the size and sources of present emissions and identifies scenarios from these for reductions. The scenarios set out possible directions of travel.

Authors:	E. Burgeat et al.
Title:	Global Trends in the Dairy Industry – Outlook for the baltics
Institution:	Organisation for Economic Cooperation and Development (OECD)
Date of publication:	2002
Scope of the study:	The study describes in the first session the structure of milk production, processing and marketing in Estonia, Latvia and Lithuania. In the second chapter market and structural changes in the dairy sector are describe. The third chapter gives an Prospect for the Baltic dairy industry and market infrastructure.

Authors : R. Lahidjil et al.

Title: The Future of Food – Long-Term Prospects for the Agro-Food Sector

Institution: Organisation for Economic Cooperation and Development

Date of publication: 1998

Scope of the study: The study includes expertises of different authors regarding the future of food (trends and key issues, risks affecting long term food demand and supply, influence of biotechnology and future of agricultural production structures.

Authors: Wallgren et al.

Title: Eating energy – Identifying possibilities for reduced energy use in the future food supply system

Institution: Royal Institute of Technology, Stockholm, Sweden

Date: 2009

Scope of the study: The paper explores the possibilities for reducing future energy use for eating to a sustainable level. A backcasting approach is used to generate an image of the future where energy use for eating is 60% lower in 2050 than in 2000. The currently known potential to reduce energy use in the food supply system for pro-ducing, transporting, storing, cooking and eating food is explored and described in terms of a number of distinct changes that are numbered consecutively and presented in both a quantitative and qualitative way. Sweden is used as the case and all data regard-ing energy use apply for Swedish conditions.

Authors: M.W. Rosegrant et al.

Title: 2020 Global Food Outlook – Trends, Alternatives and Choices

Institution: International Food Policy Research Institute (IFPRI)

Date of publication: 2001

Scope of the study: This report shows how and how much, certain policy decisions and social changes will affect the world's future food security. It projects the food situation in 2020 if the world continues on more or less its present course, and it then shows how alternative choices could produce a different future.

Authors: F. Duchin

Title: Sustainable Consumption of Food:

A Framework for Analyzing Scenarios about Changes in Diets

Institution: Rensselaer Polytechnic Institute

Date of publication: 2004

Scope of the study: This paper proposes an integration of life-cycle assessment methods with a new input-output model of the world economy to analyse the environmental and economic implications of alternative future diets. The paper reviews findings by industrial ecologists about the energy and land required for the production and consumption of alternative foods and diets in several European countries. It also reviews those attributes of foods and diets identified by nutritionists as reducing the risks of obesity and major chronic diseases.

Authors: E. Weichselbaum

Title: Trends of Average Food Supply in the European Union – On the Basis of the FAO Food Balance Sheets

Institution: Food and Agriculture Organization of the United Nations (FAO)

Date of publication: 2004

Scope of the study: The study describes and illustrates the supply of different food groups in the participating countries based on the FAO food balance sheets, as well as the EU calculated average (EU 15). The developments in food supply are given in five year intervals starting in 1961. During these four decades the highest and lowest food supply levels were usually observed in different countries.

Authors: OECD

Title: Sustainable Consumption: Sector Case Study Series – Household Food Consumption: Trends, Environmental Impacts and Policy Responses

Institution: Organisation for Economic Cooperation and Development

Date of publication: 2001

Scope of the study: The report traces household food consumption patterns and related environmental impacts in Austria, Poland, Sweden and the US. It looks at different factors driving food consumption and policy options for reducing negative impacts. The study gives an outlook between 2000 and 2020 and discusses changes within the food sector.

Authors: K. von Koerber et al.

Title: Globale Ernährungsgewohnheiten und –trends (Global Food Use
                      and trends

Institution: Beratungsbüro für ErnährungsÖkologie

Date of publication: 2008

Scope of the study: The study discusses the future food security in a growing world
                      on the basis of land use and climate changes of food consump-
                      tion patterns. The last chapter gives an overview of future poten-
                      tials of food production considering land use and climate change.

Authors: S. Ambler-Edwards et al.

Title: Food Futures:
                      Rethinking UK Strategy

Institution: Chatham House

Date of publication: 2009

Scope of the study: The study describes the development of factors, which will
                      change the global food system over the next few decades (popu-
                      lation growth, the nutrition transition, energy, land, water, labour
                      and climate change). Story-lines were constructed around these
                      'future potentials', turning them into a set of global scenarios of
                      food supply.

Authors :   R. Antes et. Al.

Title1:   Die Zukunft der Ernährung in Deutschland – Qualitative Szena-
                      rien zum nachhaltigen Konsum im Jahr 2020

Titel2:   Konzeption einer Integration der theoretischen Ansätze des
                      Wenke2-Projektes in ein agentenbasiertes Modell für nachhaltige
                      Konsummuster (MONAKO) – Quantitative Szenarien zum Praxis-
                      feld Ernährung

Institution: Diskussionspapierreihe WENKE² (Carl von Ossietzky Universität
                      Oldenburg et. al.)

Date of publication: 2008

Scope of the study: The first study gives qualitative scenarios of sustainable con-
                      sumption by the year 2020 for Germany. They develop three
                      scenarios (best case, mixed case and worst case) and describe
                      the situation of food consumption behaviour for different house-
                      hold types.

The second study discusses economical approaches regarding a change within sustainable consumption markets. Quantitative scenarios will developed by using agent-based models.

Table 44: Literature evaluation regarding future trends

Study	Data Quality	Mark
U.S. EPA 2007	For the food manufacturing sector in USA, the study characterizes energy consumption within the context of recent and expected future energy trends. Building on this overview, the analysis provides sector-specific "base case" and "best case" energy scenarios, identifying opportunities for promoting environmentally preferable energy outcomes.	2
Mistry et.al. 2007	The study estimates theoretical short to medium-term energy savings for each sector and technique in the food processing industry in UK. In the next chapter the several energy projects are prioritize.	2
Audsley et. Al. 2010	This report, especially the scenarios for reductions, is not presenting a model or components of a model for working out the full effect of policy choices. This report identifies the size and sources of present emissions and identifies scenarios from these for reductions.	3
Burgeat et. Al 2002	The study gives market prospects for main dairy products and structural changes and production trends in the Baltic dairy sector	3
Lahidjil et. Al. 1998	The publication consists of several studies from different authors. They describe a multitude of trends for the whole food sector in a qualitative way	4
Wallgreen et. Al. 2009	The paper proposes 14 direct and indirect changes for the future food chain (e.g. Technical improvements in agriculture, Change 12 Eating more seasonal products) and describes the environmental impacts. The paper does not present forecasts, but illustrates the kind of changes needed in order to achieve sustainable energy use in the food system.	2
Rosegrant et. Al. 2001	The study describes the global food projections model called the International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT), developed by the International Food Policy Research Institute (IFPRI). We then present an overview of the baseline demand and supply projections, including rojecttions of crop area harvested and crop yields, food demand, price and trade projections for these commodities, and the effects of these projections on childhood malnutrition. Next we explore several alternative regional and global scenarios, ling optimistic and pessimistic paths for the future world food situation.	3
Duchin 2004	The study is based on a literature review and summarizes in the first chapter the results to characterize individual foods, menus, and diets by their use of land or energy and their greenhouse gas emissions. Section 4 describes an analytic framework based on a model of production, consumption, and trade for examining the implications of scenarios about dietary changes more systematically and in the context of the global economy.	4
Weichselbaum 2004	The study describes and illustrates the supply of different food groups in the participating countries based on the FAO food balance sheets. No further prospect is given.	5
Ambler-Edwards et. Al. 2009	The study gives a qualitative picture of the impacts on the global food system. With stakeholder and expert interviews four scenarios were developed.	4
Antes et. Al. 2008	The first study gives qualitative scenarios by the year 2020 for Germany and tries to explain food consumption behaviour.	3

Source: own compilation

7 Availability of Data in the Need Area of Housing

7.1 Appliances

7.1.1 Methodology

Modelling the electrical consumption of household is often done using statistical data. Historical data series are available from metering the consumption of each household. There are some matching problems because not every meter is dedicated to only a household. Forecasting is done using the historical or estimated growth rates.

We can find the historical data in every statistical unit. Some projections for the near future are made by the European Environmental Agency.

State of the art modelling of electrical consumption is done using stock models of most appliances used in every household.

Total consumption = ∑ consumption (appliance)

Consumption (appliance) = # of appliances * average consumption of appliance

# of appliances = # of households * level of equipment

# of households = population / average size of household

The population forecast can be found in statistical units. Based on the actual size of households the future number of household can be calculated.

The level of equipment can be derived from census. Future values for the levels are always growing. The level for some 'luxury' devices depend on the income of the households.

The electrical consumption of a given appliance depends on the energy efficiency indicator and the degree of usage. A refrigerator is always used 8760h/a. The usage of a dish washer depends on size of the household and eating habits.

The average lifetime of an appliance depends on the technology and the resistance to substitute it with a new one. Average lifetimes for given devices can be found in Seebach (2009).

The development of energy efficiency indicators for various appliances is described in several EuP studies. In these studies you can also find information on level of equipment and typical lifetime.

The following diagrams show typical developments of the number of appliance and resulting electrical consumption. In this example, a lifetime of 12 years, an annual growth of 0.5% and a reduction of 15% for every new generation of appliances is assumed.

Figure 5: Dynamics of Appliances and Relative Total Consumption Trend
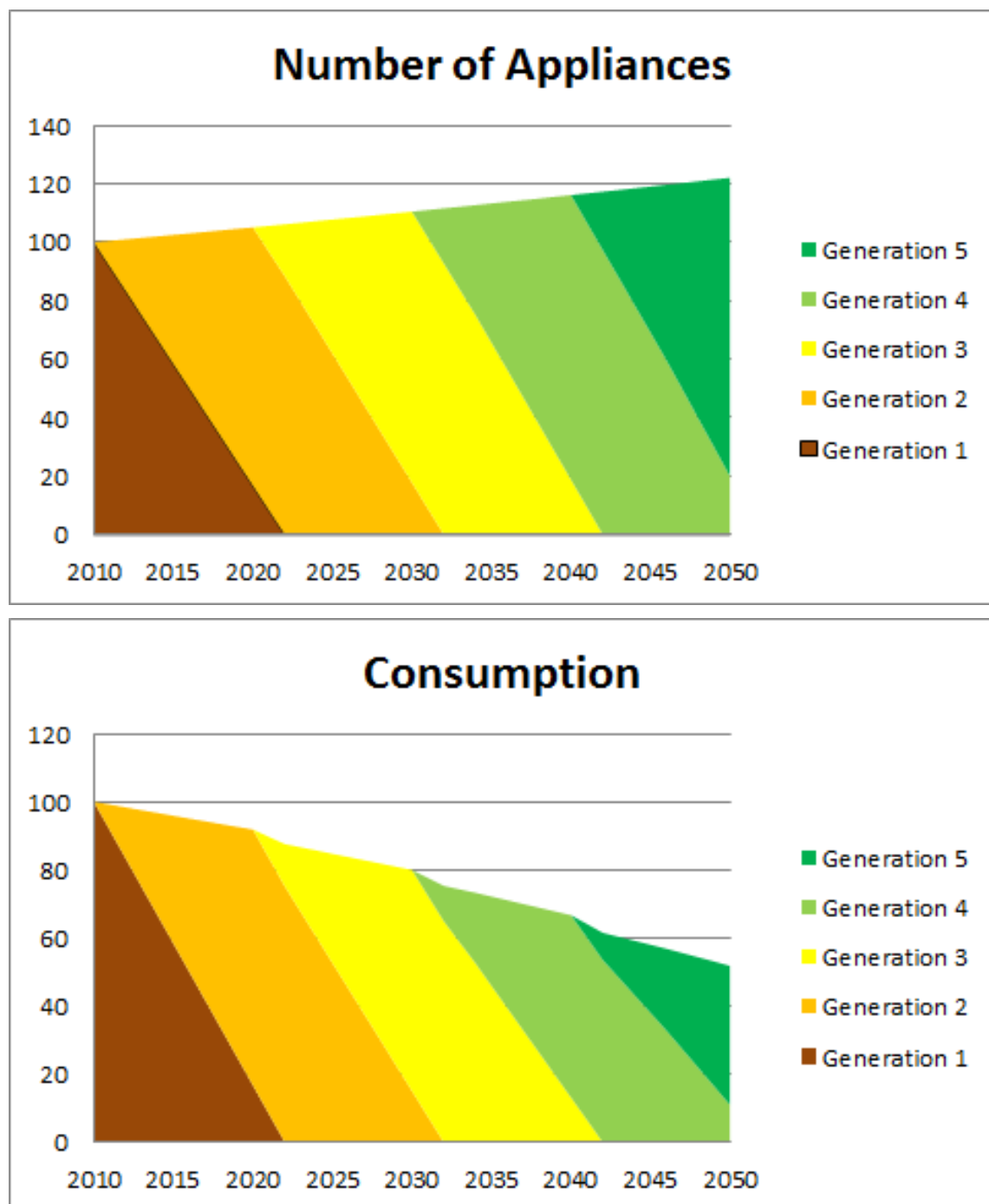
Source: own calculation

The calculation using the approach to look at each appliance is more accurate for modelling the future trends. There are some gaps, because not every kind of appliance is discussed in the studies. Often small appliances like toasters, kitchen machines are

subsumed in 'other devices'. New devices like video consoles and computers are sometimes forgotten to include into the calculation.

7.1.2 Data availability

The PRIMES study can be used as a base for further investigation. The "Preparatory Studies for Eco-design Requirements of EuP" give information on future energy efficiency indicators and estimated growth rates. On a national level the transpose project on 'Identification, quantification and systematization of technical and behavioural electricity savings potential of private households' (Bürger 2009) can give several hints which can be used for the European discussion.

7.2 Houses

7.2.1 Data relevance

Modelling of energy consumption for housing can be done using statistical data or physical data. Statistical data derived from "Housing statistics in the European Union 2005/2006" is useful for some years forecasting. The problem of introducing measures into this type of model is very complicated. A long range forecast is therefore not possible. On the other hand there are physical house models. One of the latest databases is compiled in JRC 2008 (IMPRO Building). Physical models can be used for long range forecasting and scenario analysis.

A comparison with the statistical data shows an overestimation in the calculated energy demand. A fitting of the physical model can be done if there are only small deviations between modelled and real data. But introducing further variables into the model allow a better fitting. A well-known fact is that badly insulated houses are not fully heated. There are cold zones in the house. Houses with a closed insulated surface do not have cold zones.

The rate and the depth of retrofitting is discussed in several studies. New U-Values for building parts are given in JRC 2008 and Ecofys 2006.

7.2.2 Methodology

Modelling the housing data includes the stock of existing buildings and the erection of new ones. For existing buildings a simple house typology is used to describe the effects of retrofitting different parts of the houses. There are some 10% of houses that do not fit into this typology. The extension of the typology is not feasible. The easiest way to fit with the number of houses from statistical data is to upscale the model.

The calculated energy demand for the modelled house topology is then fitted with statistical data. Based on this data a stock/exchange model calculates the number of houses in future.

The measures for retrofitting the different parts of the houses aim to a lower energy demand. Based on retrofitting rates and depth the future energy demand can be calculated.

The calculation of energy demand of a given house can be done using available software such as epiqr®.

Figure 6: Principle Scheme for the Energy Balance of Residential Housing
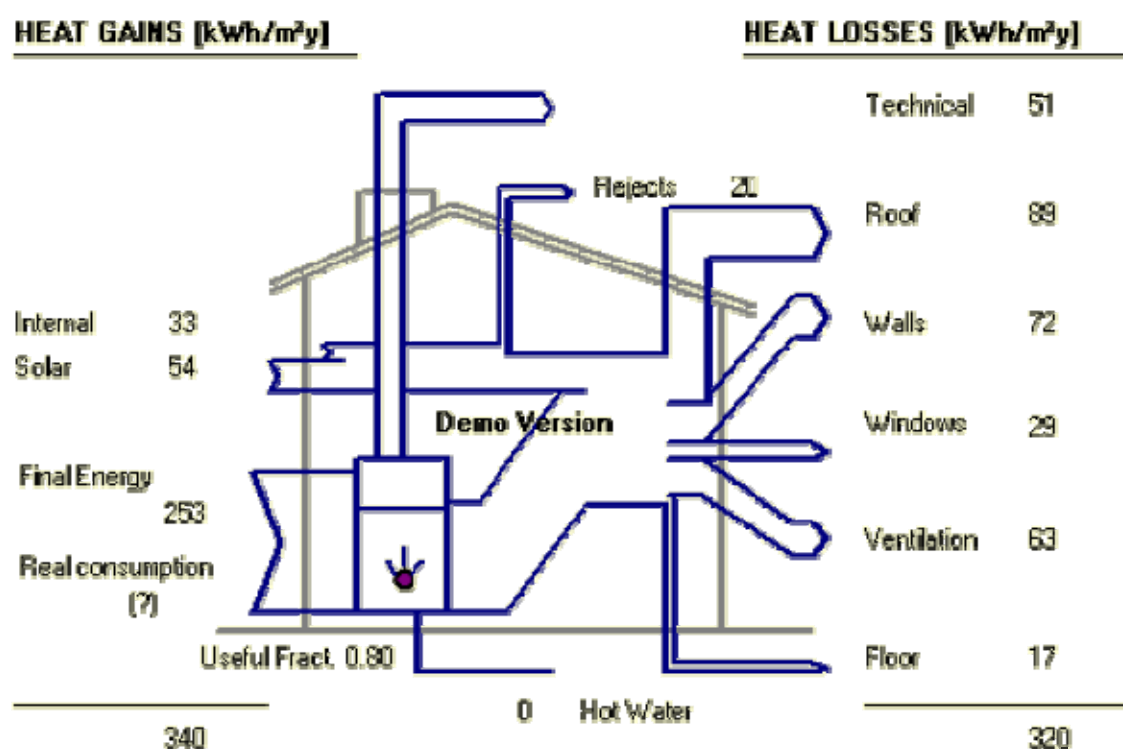
7.3 Heating Systems

The demand of warm water is calculated using the demographic development and a slightly higher demand resulting from increased wellness demand.

The last step to calculate the final energy demand is done with a model of the development of heating systems and share of energy carriers.

7.3.1 Analysis of existing studies regarding housing

The following literature evaluation gives an overview about data relevant literature within the need are housing. Before defining the methodology it was necessary to check the scientific debate and database. Furthermore the literature review supported the methodology. Therefore the following studies include whether the basis for data collection or the fundament for the methodology.

Authors: Eichhammer et al.

Title: Study on the Energy Savings Potentials in EU Member States, Candidate Countries and EEA Countries

Institution: Fraunhofer ISI

Date of publication: 2009

Scope of the study: The study developed four scenarios (BAU-, low policy intensity-, high policy intensity- and BAT-scenario) for the energy consumption in the European residential building sector from 2004 until 2030. The main focus is on preparing of the analytical basis for an in-depth discussion of economic energy efficiency potentials in the different energy-end uses.

Authors: Nemry et. al.

Title: Environmental Improvement Potentials of Residential Buildings (Impro Building)

Institution: JRC, IPTS

Date of publication: 2008

Scope of the study: The study presents an overview of the environmental life cycle impacts of residential buildings in EU-25. In the first step the study define an appropriate building stock typology and provide its characterization regarding several aspects (e.g. population and residential area, building type, age, structure) and define building models that are the most "representative" buildings for the EU-25. The first step was primarily based on existing data and information taken from previous EU-funded projects and expertise in various EU countries regarding the most relevant aspects of buildings (e.g. structure, age, energy efficiency). The 72 selected building models (53 existing buildings and 19 new building types), were assessed to be representative of about 80% of the residential building stock in the EU-25.

Authors: Boemans et.al.

Title: U-Values - For better energy performance of buildings

Institution: Ecofys

Date of publication: 2006

Scope of the study: The study calculated an economic optimum for insulation levels (U-values) derived from the necessary investment costs and according energy cost savings from reduced heating and cooling

energy demand. Another approach was to calculate necessary insulation levels to meet climate protection targets. The national U-value requirements for building components (roof, floor, wall, windows, etc.) often describe minimum requirements that do not reflect the economic optimum or specific environmental targets. In the annex are lists with "Optimum U-Values based on cost-efficiency and climate protection targets" and "Requirements on component level" for several European Meber States.

Authors:	Sunikka et. al.
Title:	Better buildings through energy efficiency - A roadmap for Europe
Institution:	Ecofys
Date of publication:	2006

Scope of the study: This report presents the results of a quick scan of best practices in building energy efficiency policies and programs, and recommends suitable instruments to endorse building energy efficiency in Europe. Following a review of a literature on projects & programs, around 30 best practices were selected for further analysis. The analysis shows in a qualitative way strengths and weaknesses of best practice programs.

Authors:	Italian Ministry of Infrastructure and federcase - Italian Housing Federation
Title:	Housing statistics in the European Union 2005/2006
Institution:	
Date of publication:	2006

Scope of the study: The report contains the most updated housing statistics of the 25 European Union member countries. The document is a follow up to the work carried out by the countries that drafted the previous 11 reports and gradually refined the methodology of data organization and presentation.

Authors:	Petersdorf et. al.
Title:	Mitigation of CO_2 - Emissions from the building stock
Institution:	Ecofys
Date of publication:	2004

Scope of the study: The analysis sets out to establish the impact of the Directive on CO2 emissions, the impact of extending the Directive towards the retrofit of smaller buildings, whether the trend for growing energy consumption for cooling can be offset or reduced by increased levels of insulation.

Authors: Odyssee/MURE

Title: Database on http://www.odyssee-indicators.org/

Institution:

Date of publication: 2010

Scope of the study: The Odyssee project has provided valuable and detailed energy efficiency indicators for five sectors (Industry, Transport, Residential, services and agriculture). Time series data for the residential sector are e.g. Space heating, Specific consumption by dwelling , end uses and by equipment, Stock of dwellings, New dwellings or Floor area of dwelling.

Table 45: Literature evaluation regarding housing data and methodology

Study	Data Quality	Mark
Eichhammer et. al. 2009	Boverket et. al.(2005), Ecofys (2005), data from Odyssee and Primes. Relevant data are: The average living area per dwelling until 2030, average surface components of residential building types, some U-values for different climate zones and construction period of buildings and refurbishment rates per year until 2030. The most data are given in a highly aggregated form.	2
Nemry et. al. 2008	The database is primarily used from existing data and information taken from previous EU-funded projects and expertise in various EU countries regarding the most relevant aspects of buildings (e.g. structure, age, energy efficiency). The 72 selected building models (53 existing buildings and 19 new building types), were assessed to be representative of about 80% of the residential building stock in the EU-25.	1
Boemans et.al. (Ecofys for EURIMA)	The study calculated an economic optimum for insulation levels (U-values) derived from the necessary investment costs and according energy cost savings from reduced heating and cooling energy demand.	4

Sunikka et. al. (Ecofys for EURIMA)	Scan of best practices in building energy efficiency policies	4
Ministry of Infrastructure of the Italian Republic and federcase - Italian Housing Federation	General data, quality of the housing stock, availability of housing, affordability of housing and the role of government. Particular the second and third chapter include relevant statistics such as average useful floor areas, age distributions of buildings and the dwelling stock by type of building.	2
Petersdorf et. al. (Ecofys for Eurima)	Data on impact of the Directive on CO_2 emissions	4
Odyssee/Mure	The Odyssee project provided valuable and detailed energy efficiency indicators for five sectors (industry, transport, residential, services and agriculture). Time series data for the residential sector are e.g. space heating, specific consumption by dwelling, end uses and by equipment, stock of dwellings, mew dwellings or floor area of dwelling.	3
PRIMES	PRIMES is a modeling system that simulates a market equilibrium solution for energy supply within the EU member states. Therefore a large number of data support policy analysis in the fields of energy policy, security of supply, costs, taxation, standards on technology, environmental issues.	2

Source: own compilation

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Annexes

A-1 Abbreviations

BEF	Baltic Environment Forum
BMU	Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
BMELV	Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz (Federal Ministry of Food, Agriculture and Consumer Protection)
CEE	Central and Eastern Europe
ECOI	Eco-Institut Barcelona
EEA	European Environment Agency
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
FiBL	Forschungsinstitut für biologischen Landbau
GHG	Greenhouse gas(es)
IPCC	Intergovernmental Panel on Climate Change
NCRC	National Consumer Research Council (of Finland)
OEKO	Oeko-Institut (Institute for appliec Ecology)
PPP	purchasing power parity

Policies to Promote Sustainable Consumption Patterns

PRIMES	Partial equilibrium model for the European energy system
RES-D	EU Directive for the Promotion of Renewable Energy Sources
UBA	Umweltbundesamt (German Federal Environmental Agency)
UCL	University College London
UNFCCC	Framework Convention on Climate Change
UNEP	United Nations Environment Programm

A-2 Product-Specific GHG Emissions

Table 46: GHG Emissions in kg CO$_2$eq/kg Product (Retail)

	kg CO$_2$eq/kg product	
product	**conventional**	**organic**
FRUITS		
fruits	0.45	
apple	0.55	
bananas		0.97
grapes	0.27	
lemons, limes	0.18	
oranges, mandarines	0.18	
VEGETABLES		
vegetables fresh	0.15	0.12
tomatoes	0.33	0.23
nuts	0.42	0.42
onions	0.09	0.11
potatoes fresh	0.20	0.13
VEGETABLES OIL		
vegetable oil	1.02	0.66
olive oil	0.97	
sunfloweroil	0.76	0.55
soybeanoil	1.13	0.72
CEREALS		
rice	1.93	
rye	0.42	0.24
maize	0.26	
wheat	0.59	0.42
BEVERAGES		

product	kg CO$_2$eq/kg product	
	conventional	**organic**
beer	0.46	0.43
coffee	0.36	
wine	0.25	0.16
DAIRY		
milk	0.93	0.88
butter	23.74	23.74
cheese	8.48	8.48
cream	2.01	1.89
eggs	1.91	1.53
joghurt	1.22	1.15
MEAT		
beef	13.28	11.36
pork	3.21	2.99
chicken	3.46	3.01

Source: own calculation using GEMIS 4.7 (OEKO 2011)

A-3 Producer and Consumer Prices

Table 47: Producer and Consumer Prices in Comparison (in Euro$_{2005}$/kg)

Product	Consumer Prices	Producer Prices
FRUITS		
Apples	0.88	0.33
Bananas	0.65	0.30
Grapes	1.2	0.55
Lemons, Limes	1.06	0.32
Oranges, Mandarines	0.65	0.23
VEGETABLES		
Tomatoes	1.56	0.44
Nuts	4.96	1.27
Onions	0.37	0.36
Potatoes	0.39	0.12
VEGETABLES OIL		
Vegetable Oils	0.95	0.66
Olive Oil	3.44	7.00
Sunflowerseed Oil	0.82	0.54
Soyabean Oil	0.95	0.34

Product	Consumer Prices	Producer Prices
CEREALS		
Rice (Milled Equivalent)	1.66	0.16
Rye	0.5	0.07
Maize	1.77	0.09
Wheat	0.37	0.09
BEVERAGES		
Beer	0.91	0.60
Coffee	3.5	7.28
Wine	1.81	3.5
DAIRY		
Milk, Whole	0.53	0.20
Butter, Ghee	2.82	4.88
Cheese	4.94	8.08
Cream	1.3	9.75
Eggs	0.91	0.87
MEAT		
Bovine Meat	3.66	2.43
Pigmeat	2.76	1.23
Poultry Meat	3.76	0.90

Source: FAO 2010

Table 48: Reference Consumer Prices (in Euro 2005/kg)

	Sweden	Germany	Spain	Czech Republic
Fruits				
Apples	0.37	0.86	1.23	1.06
Bananas	1.30	0.73	0.57	0.00
Grapes	1.94	1.32	0.00	1.53
Lemons. Limes	1.29	1.05	1.03	0.86
Oranges. Mandarines	1.10	0.53	0.51	0.47
VEGETABLES				
Tomatoes	1.94	1.19	0.96	2.16
Nuts	5.71	5.66	3.57	4.89
Onions	0.38	0.39	0.49	0.22
Potatoes	0.19	0.32	0.60	0.45
VEGETABLES OIL				
Vegetable Oils	1.00	1.00	0.80	1.00
Olive Oil	0.00	3.98	2.27	7.53
Sunflowerseed Oil	0.97	0.66	1.00	0.66
Soyabean Oil	1.00	1.00	0.80	1.00
CEREALS				
Rice (Milled Equivalent)	1.75	3.31	0.57	1.01
Rye	0.50	0.50	0.50	0.50
Maize	2.53	1.05	2.20	1.29
Wheat	0.39	0.17	0.57	0.37
BEVERAGES				
Beer	2.59	0.36	0.31	0.38

	Sweden	Germany	Spain	Czech Republic
Coffee	2.99	3.98	4.18	2.84
Wine	2.76	1.76	1.70	1.02
	Sweden	**Germany**	**Spain**	**Czech Republic**
DAIRY				
Milk. Whole	0.51	0.43	0.63	0.55
Butter. Ghee	2.80	2.10	3.35	3.03
Cheese	6.69	3.75	4.50	4.82
Cream	1.30	1.20	1.30	1.42
Eggs	1.16	0.86	0.87	0.75
MEAT				
Bovine Meat	3.89	3.78	2.65	4.33
Pigmeat	1.94	3.98	2.57	2.55
Poultry Meat	4.87	3.79	3.31	3.06

Source: own compilation

A-4 Per-Capita Food Consumption

Table 49: Consumption per capita/year (in kg/capita*year)

Product	Cluster I North	Cluster II West	Cluster III South	Cluster IV Central/East	EU27
	kg/capita*year				kg/capita*year
FRUITS					
Apples	28.3	26.2	19.3	21.8	23.3
Bananas	13.0	8.7	8.4	4.5	7.6
Grapes	6.2	8.4	13.4	4.3	8.9
Lemons, Limes	1.6	1.9	10.3	1.9	4.3
Oranges, Mandarines	41.6	30.5	39.3	9.4	28.1
VEGETABLES					
Tomatoes	17.1	19.2	64.1	23.4	32.9
Nuts	2.4	4.3	7.5	1.7	4.6
Onions	7.0	6.5	11.3	11.9	9.1
Potatoes	76.4	80.0	57.8	101.4	78.6
Vegetable Oils					
Vegetable Oils	12.0	17.8	26.4	14.7	19.5
Olive Oil	0.9	1.3	12.4	0.0	4.2
Sunflowerseed Oil	0.9	3.9	6.2	6.5	5.2
Soyabean Oil	1.0	3.3	4.5	2.5	3.5
other Oil	9.2	9.3	3.2	5.6	6.7
CEREALS					
Rice (Milled Equivalent)	4.9	4.4	7.3	2.9	4.9
Rye	11.3	4.5	0.7	14.9	5.9
Maize	3.6	9.5	4.3	9.4	8.0
Wheat	90.3	92.2	121.3	79.5	97.5

Product	Cluster I North	Cluster II West	Cluster III South	Cluster IV Central/East	EU27
	*kg/capita*year*				*kg/capita*year*
BEVERAGES					
Beer	85.6	77.9	48.8	81.9	70.6
Coffee	9.0	4.7	5.1	3.0	4.4
Wine	16.2	32.3	40.9	11.3	29.9
total	**473.3**	**482.2**	**541.1**	**445.0**	**490.3**
DAIRY					
Milk, Whole	92.9	77.3	71.6	90.2	78.7
Butter, Ghee	3.4	5.8	2.1	2.6	4.0
Cheese	17.5	19.4	15.7	9.8	16.1
Cream	8.3	4.0	2.5	2.4	3.2
Eggs	11.5	12.3	11.8	12.6	12.3
other dairy products	52.2	35.8	39.5	62.8	43.1
total dairy	**92.9**	**77.3**	**71.6**	**90.2**	**78.7**
MEAT					
beef meat	23.9	18.7	20.1	7.6	16.5
pork meat	40.0	41.6	45.6	39.4	42.2
chicken meat	18.2	20.4	20.4	21.5	20.7
total meat	**82.0**	**80.7**	**86.1**	**68.5**	**79.4**
total food	**707.9**	**687.4**	**760.1**	**620.6**	**692.6**

Source: FAO (2010)

A-5 Per Capita GHG Emissions and Costs

Table 50: Total matrix – GHG and costs per capita

	kg CO$_2$eq/cap*a based on German GHG data					costs in Euro per cap/a based on EU-27 prices					mass shares of total food				
	Cluster I	Cluster II	Cluster III	Cluster IV	EU27	Cluster I	Cluster II	Cluster III	Cluster IV	EU27	Cluster I	Cluster II	Cluster III	Cluster IV	EU27
Product	North	West	South	CEE	*weighted av.*	North	West	South	CEE	*weighted av.*	North	West	South	CEE	
FRUITS															
Apples	13	12	9	10	10	9,3	8,6	6,4	7,2	7,7	4%	4%	3%	3%	3%
Bananas	6	4	4	2	3	3,9	2,6	2,5	1,3	2,3	2%	1%	1%	1%	1%
Grapes	3	4	6	2	4	3,4	4,6	7,3	2,4	4,8	1%	1%	2%	1%	1%
Lemons, Limes	1	1	5	1	2	0,5	0,6	3,3	0,6	1,4	0%	0%	1%	0%	1%
Oranges, Mandarines	19	14	18	4	13	9,7	7,1	9,1	2,2	6,5	6%	4%	6%	1%	4%
VEGETABLES															
Tomatoes	6	6	21	8	11	7,5	8,4	28,2	10,3	14,5	2%	3%	9%	3%	5%
Nuts	1	2	3	1	2	3,1	5,5	9,5	2,2	5,9	0%	1%	1%	0%	1%
Onions	1	1	2	2	1	2,5	2,3	4,0	4,2	3,2	1%	1%	2%	2%	1%
Potatoes	15	16	11	20	15	9,2	9,7	7,0	12,3	9,5	11%	11%	8%	14%	11%
VEGETABLE OIL															
Vegetable Oils	12	18	27	15	20	7,9	11,8	17,4	9,7	12,9	2%	3%	4%	2%	3%
Olive Oil	1	1	13	0	4	6,6	9,1	87,1	0,0	29,1	0%	0%	2%	0%	1%
Sunflowerseed Oil	1	3	5	5	4	0,5	2,1	3,4	3,5	2,8	0%	1%	1%	1%	1%
Soyabean Oil	1	4	5	3	4	0,3	1,1	1,5	0,9	1,2	0%	0%	1%	0%	0%
CEREALS															
Rice (Milled Equivalent)	9	8	14	6	9	0,8	0,7	1,2	0,5	0,8	1%	1%	1%	0%	1%
Rye	5	2	0	6	2	0,7	0,3	0,0	1,0	0,4	2%	1%	0%	2%	1%
Maize	1	2	1	2	2	0,3	0,8	0,4	0,8	0,7	1%	1%	1%	1%	1%
Wheat	53	55	72	47	58	8,3	8,5	11,2	7,3	9,0	13%	13%	17%	11%	14%

|	kg CO₂eq/cap*a based on German GHG data					costs in Euro per cap/a based on EU-27 prices					mass shares of total food				
	Cluster I	Cluster II	Cluster III	Cluster IV	EU27	Cluster I	Cluster II	Cluster III	Cluster IV	EU27	Cluster I	Cluster II	Cluster III	Cluster IV	EU27
Product	North	West	South	CEE	weighted av.	North	West	South	CEE	weighted av.	North	West	South	CEE	
SUGAR															
Sugar, Refined Equiv	52	54	43	49	49	34,7	35,5	28,5	32,3	32,8	5%	5%	4%	5%	5%
BEVERAGES															
Beer	39	36	22	37	32	51,4	46,7	29,3	49,1	42,3	12%	11%	7%	12%	10%
Coffee	3	2	2	1	2	65,6	34,1	36,9	21,8	32,0	1%	1%	1%	0%	1%
Wine	4	8	10	3	8	56,6	113,2	143,1	39,5	104,6	2%	5%	6%	2%	4%
DAIRY															
Milk, Whole	87	72	67	84	73	18,9	15,7	14,6	18,4	16,0	13%	11%	10%	13%	11%
Butter, Ghee	80	139	50	62	96	16,5	28,5	10,4	12,8	19,7	0%	1%	0%	0%	1%
Cheese	148	165	133	83	137	141,1	156,9	126,7	79,4	130,3	2%	3%	2%	1%	2%
Cream	17	8	5	5	6	81,1	38,5	23,9	23,0	30,8	1%	1%	0%	0%	0%
Eggs	22	24	23	24	23	10,0	10,8	10,3	11,0	10,7	2%	2%	2%	2%	2%
MEAT															
beef meat	318	249	267	100	219	58,0	45,4	48,8	18,3	40,1	3%	3%	3%	1%	2%
pork meat	128	133	146	126	135	49,2	51,3	56,2	48,5	52,0	6%	6%	6%	6%	6%
chicken meat	63	70	70	74	71	16,3	18,3	18,3	19,3	18,5	3%	3%	3%	3%	3%
total	1021	1039	987	699	945	637	641	680	414	599	1	1	1	1	1

Source: own compilation

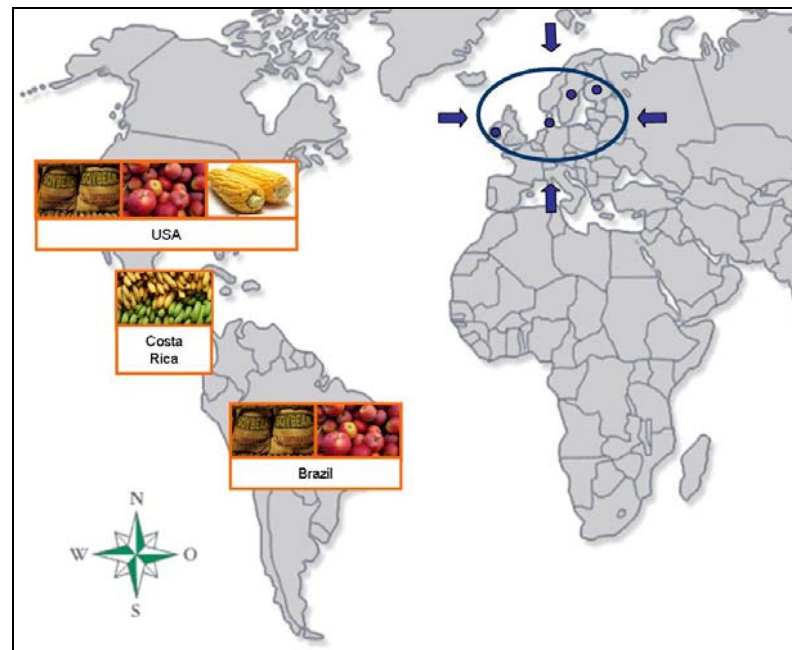*Figure 7: Total Matrix EU 27*
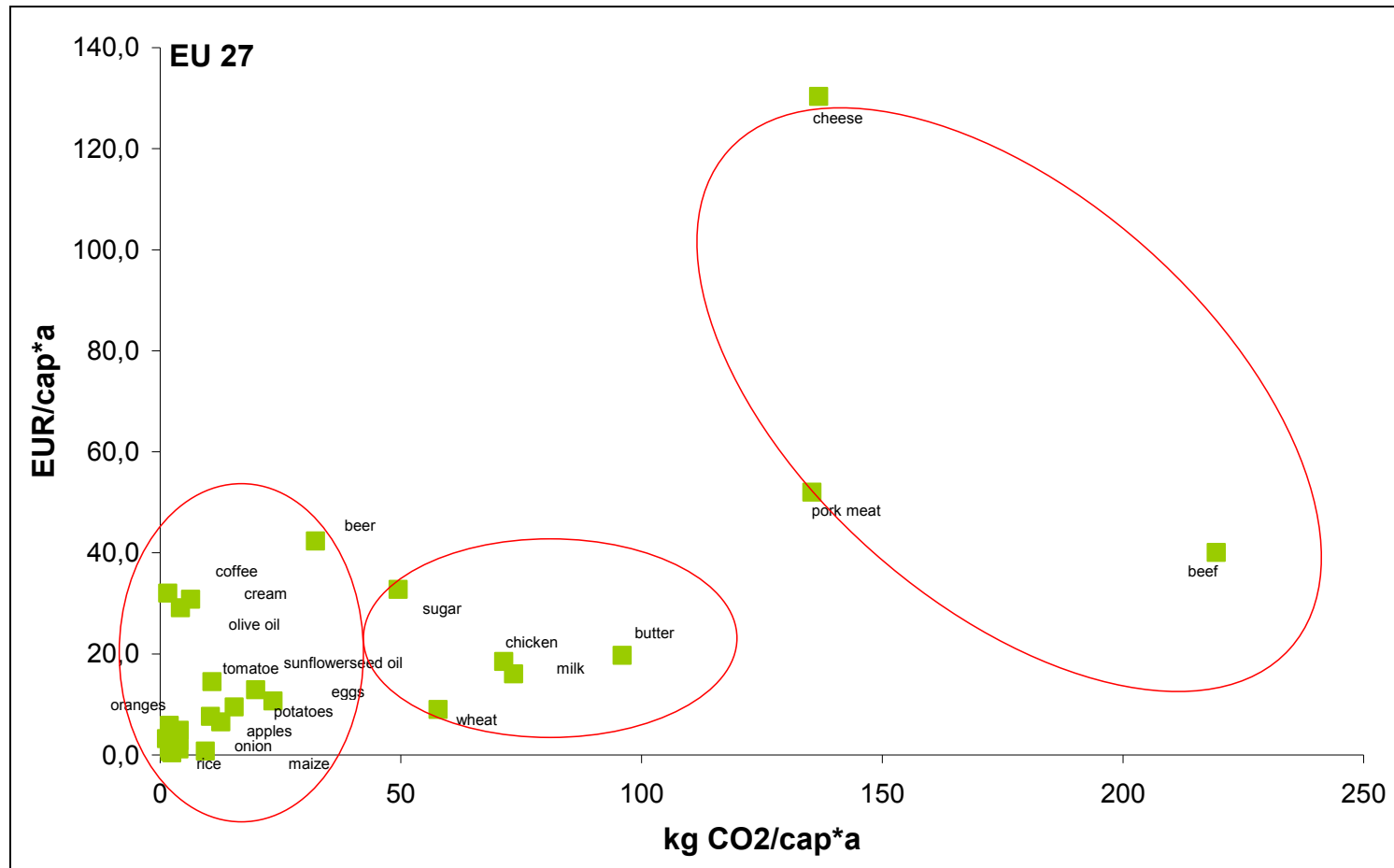
Source: own compilation

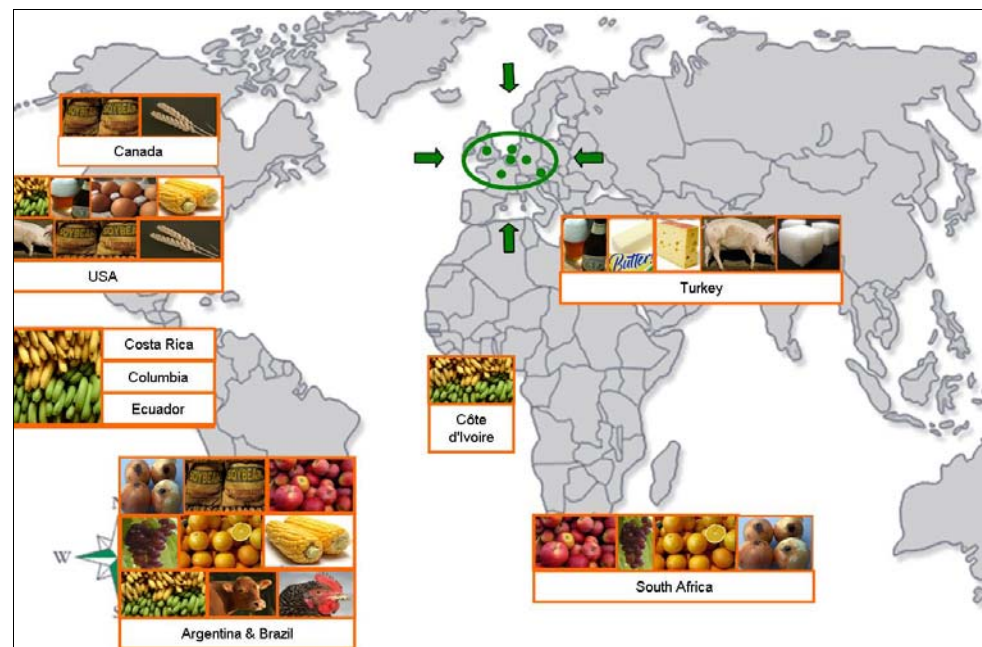Figure 8: Total Matrix Cluster
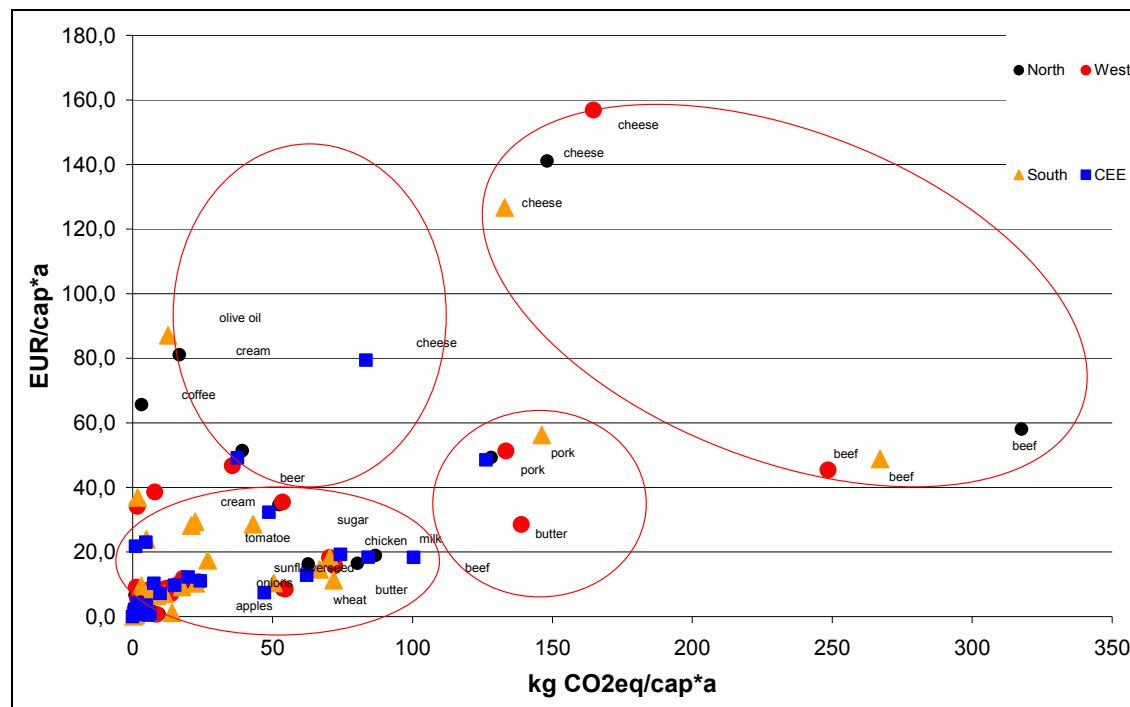
Source: own compilation

A-6 Food Import Patterns of the Country Clusters

Figure 9: Import Cluster I

Source: own illustration

Figure 10: Cluster II Imports

Source: own illustration

Figure 11: Imports Cluster South

Source: own illustration

Figure 12: Imports Cluster CEE

*Source: own illustration*

A-7 Energy Use for Food Processing

Table 51: Energy use for processing of relevant food products

Products	vertical range of manufacture	Gemis	Carlsson-Kanyama et al.	Ramírez	Foster et. al	IPPC	EPA	Faist	lcafood.dk	*Average*
		2001	2005	2006	2006 b	2008	2000			
					Final Energy Use in MJ/kg					
cheese	cheese	3.45	2.54	3.32	8.50	3.87		2.53	6.95	*4.45*
beef	meat (slaughtering)	1.74		0.88	4.20			0.71	0.31	*1.57*
	sausages	4.40	6.10	4.70		5.28		6.39		*5.38*
pork meat	meat (slaughtering)	1.74		1.58	8.50			0.71	1.04	*2.71*
	sausages	7.95	6.10	4.70		5.28		6.39		*6.09*
vegetables	frozen vegetables	1.60	1.42	2.54		2.57	2.94	2.21		*2.21*
	canned vegetables	2.92	2.40	2.18		2.63	2.78	1.94		*2.48*
vegetables oils	oil	4.38	1.38	0.67		3.60				*2.51*
beer	beer	1.97		1.73		1.96				*1.89*
sugar	sugar	9.97	17.42	5.88		7.15			6.18	*9.32*
milk	milk	0.34	0.73	0.77	0.66			0.15	0.37	*0.50*
	milk powder	12.03	16.11	10.44					8.43	*11.75*
butter	butter	0.65	2.47	1.74				0.07	1.19	*1.22*
wheat	bread	2.00	3.67		3.90			2.29		*2.97*
	pasta	2.03	1.32	0.65		0.65		2.37		*1.40*
	flour	0.29	0.41	0.45				0.31	0.81	*0.45*
Chicken	meat (slaughtering)	1.30		1.58				0.71	1.34	*1.23*
	sausages	4.40	4.51	4.70		5.28		5.44		*4.87*
cream	cream	0.99	0.99							*0.99*
olive oil	oil	4.38	1.38	0.67		1.68				*2.02*
sunflowerseed oil	oil	4.38	1.38	0.67		1.68				*2.02*
tomatoes	canned tomatos		1.30			2.63				*1.97*

Products	vertical range of manufacture	Gemis	Carlsson-Kanyama et al.	Ramírez	Foster et. al	IPPC	EPA	Faist	lcafood.dk	Average
			2001	2005	2006	2006 b	2008	2000		
					Final Energy Use in MJ/kg					
	puree and paste		4.18	3.50		3.41				*3.70*
soybeen oil	oil	4.38	1.20	0.67		1.68				*1.98*
onion	fried onions	2.92	14.33	6.00				15.77		*9.76*
rye	Flour	0.31	0.26	0.45				0.31	0.92	*0.45*
apples	juice	8.55	2.88							*5.71*
potatoes	peeled potatoes	0.10			0.60					*0.35*
	potato chips		14.33	5.72				15.77		*11.94*
	french fries	48.00			5.00		3.01	7.10		*15.78*
	potato starch	4.80	29.42	4.99		0.76	24.48		1.44	*10.98*
maize	maize starch			3.33		1.80				*2.57*

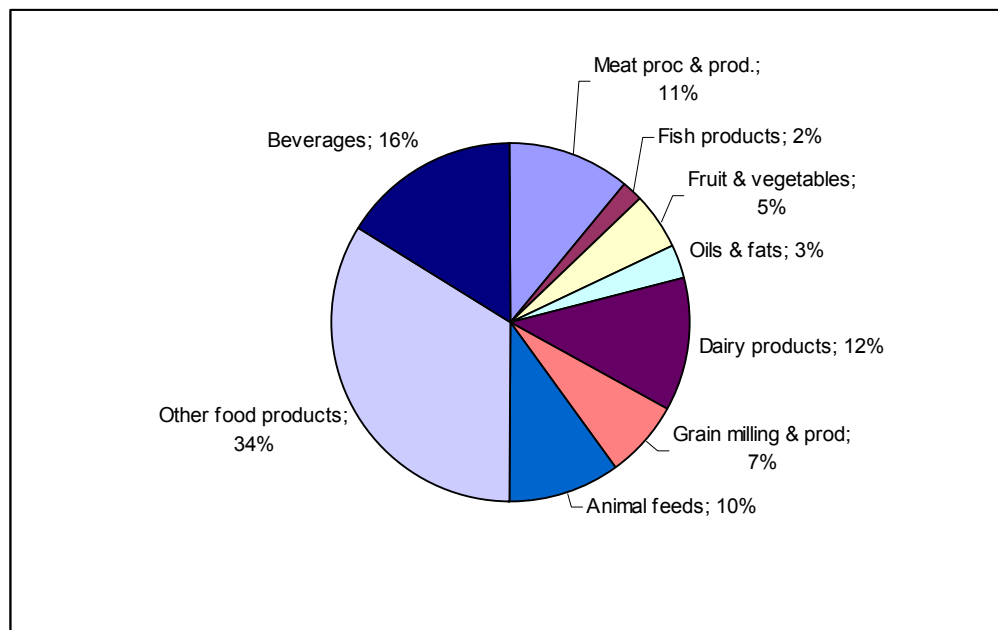*Figure 13: Final energy consumption in the food, drink and tobacco industry in EU-27*

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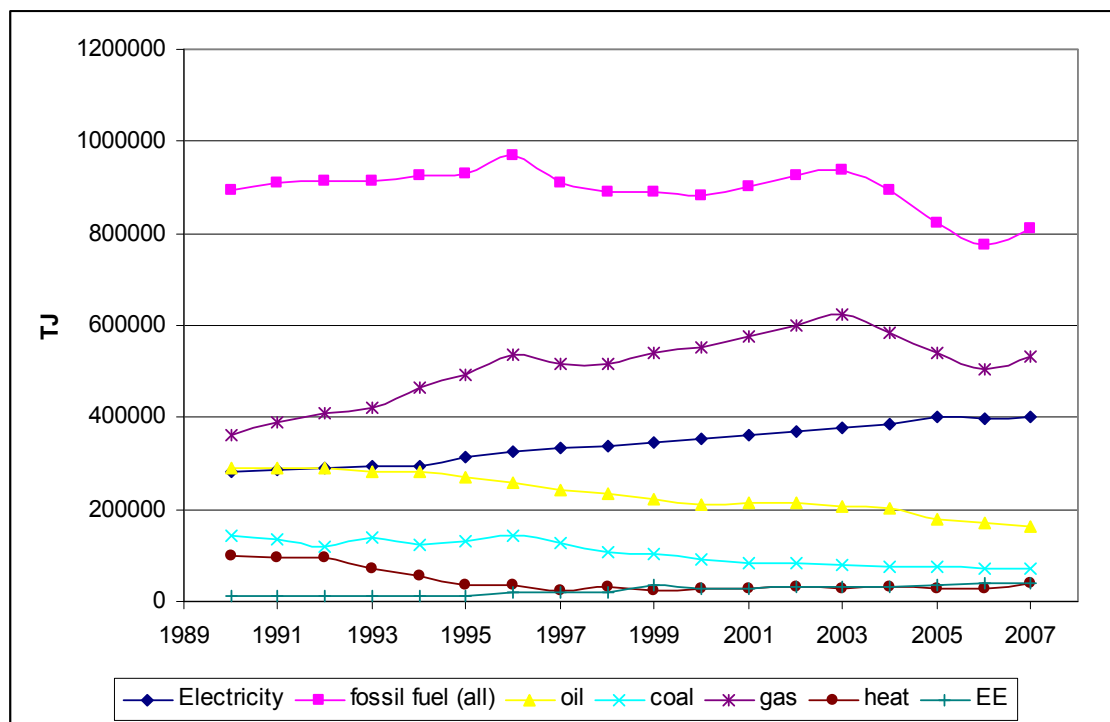
[1] http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database
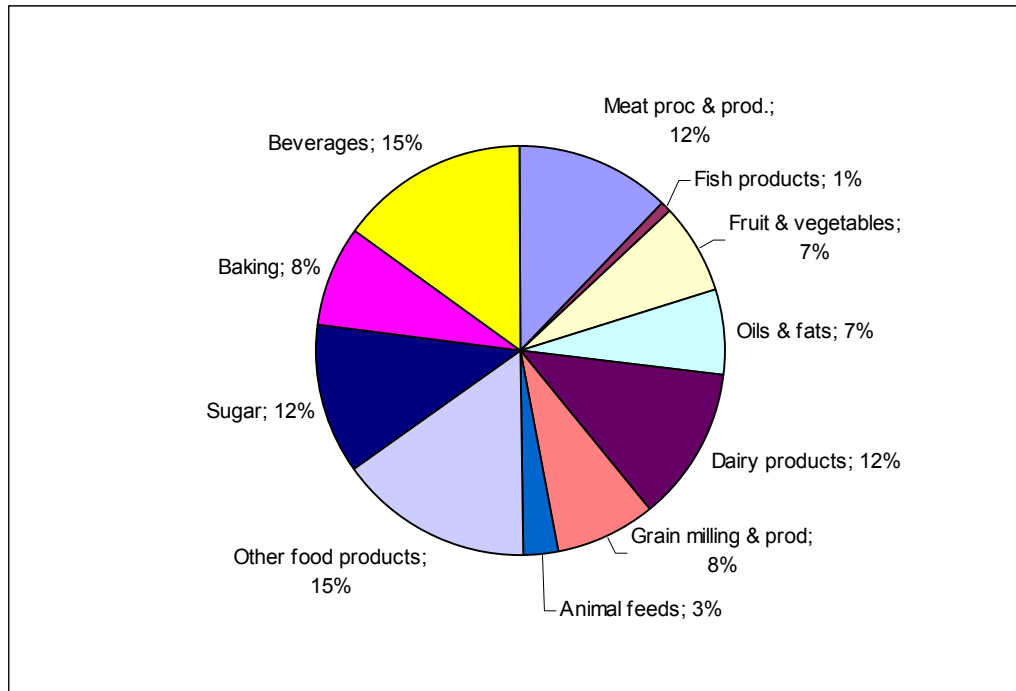
Figure 14: Distribution of total energy use in F&D industry in United Kingdom

Source: Mistry et al. 2007

Figure 15: Distribution of total energy use in F&D industry in Germany

Source: BMELV 2007