

MERLIN

DEVELOPMENT GENESIS DATABASE V2

-DRAFT-
-Confidential-

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Preface

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Summary

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1 DATABASE structure GENESIS-v2.0

1.1 The Genesis database

The GENESIS V2.0 database holds information on air pollutant emissions and options to reduce the air pollutant emissions for all relevant economic sectors in European Countries¹. With the database it is possible to calculate the (technical) emission reduction potential and the related costs per sector per country for different scenario's for different future years. In this case the scenarios provide the information on the development of the volume (like number of households, steel production etc) in the different economic sectors and the database hold the information on the emissions related to these activities.

Figure 1 gives a principle outline of the database:

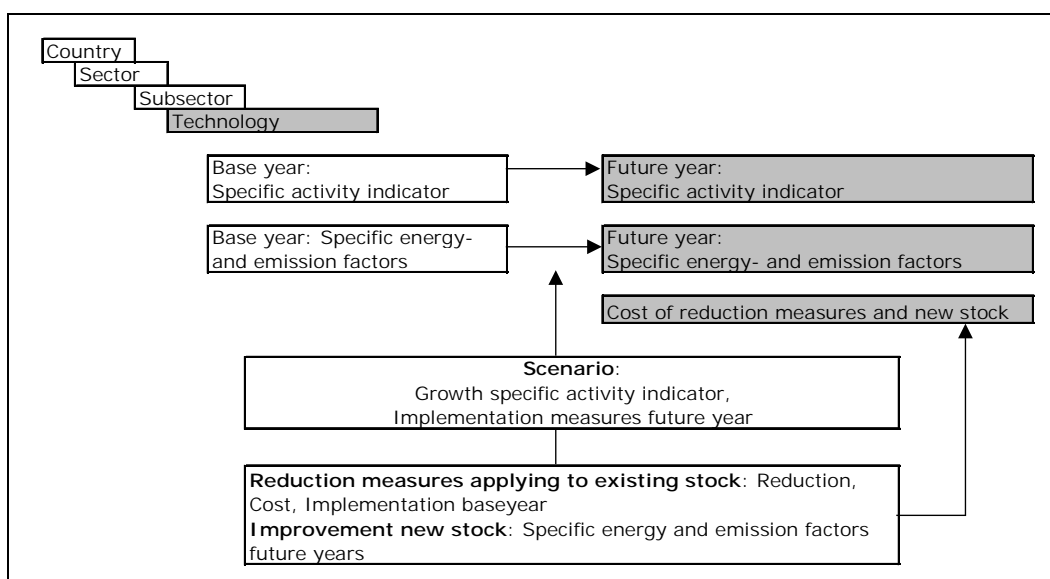


Figure 1: Principle of the GENESIS V2.0 database

1.2 Terminology and definitions

The following term's definitions are used:

- **Technology:** all social production and consumption activities that have a substantial environmental impact.
- **Specific activity indicator (SAI):** (physical) input or output of the technology that has a strong correlation to the level of emissions
- **Specific energy and emission factors:** amount of emissions/energy per unit of SAI

¹ Currently included are 15 EU Member States, Norway, Switzerland, Poland, Estonia, Latvia, Lithuania, Hungary, Slovenia, Czech Republic.

- Reduction measures: technical options that can be applied to a technology that is leading a decrease of the specific energy and emission factors.
- Cost a reduction measures are defined as:
 - Fixed costs: Additional once-only investment cost, compared to the reference technology, for hardware and installation to implement the reduction measures
 - Running Cost: Additional yearly cost, compared to the reference technology, to keep the reduction measure into operation (operating and maintenance cost, insurance costs etc)
 - Benefits: Yearly saving on cost resulting from the implementation of the technical measures (mainly savings on material and on energy costs) compared to the reference technology.

1.3 Technical outline of the database

The database is divided into three parts to ensure that the information characterising the technologies, which is independent of the used scenario is separated from the scenario inputs. Figure 1 provides an overview of the general database structure.

In principle the database works as follows. Five input files provide the data needed to calculate scenarios. The input files provide information on emission (factors) of the different economic sector in the base year and information on efficiencies and cost of emission reduction option that can be implemented in the different economic sectors. Furthermore two files hold the scenario information. The scenario calculations are performed through queries written in Access and the results can be analysed in Excel files.

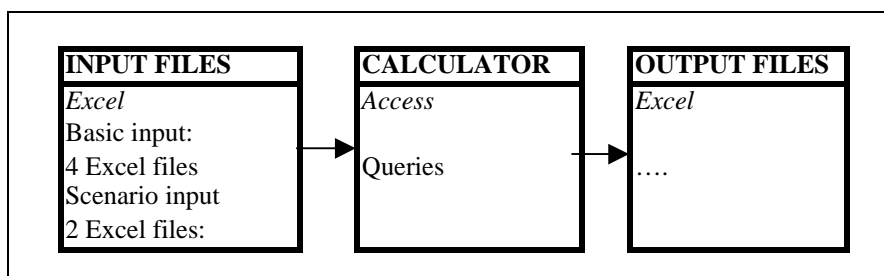


Figure 2: Outline of the database structure for GENESIS V2.0

1.4 Type of changes that can be analysed

The following type of developments can be analysed with the database:

- Growth of (economic) activity on emissions in future years.
- Changes in the type of technology used for the production of heat or electricity on emissions in future years.
- Effect of implementation of emission reduction options to the existing technology stock on emissions in future years.
- Cost of the implementation of emission reduction options.

- Effect of (accelerated) replacement of existing technology stock with new stock on the emission level.
- Cost of the accelerated replacement.

1.5 Definition of database contents

Economic sectors

- Energy production, Industry, Transport, Households, Services, Agriculture, Waste

Pollutants:

- CO₂, CH₄, N₂O, HFC, PFC, SF₆, NO_x, SO₂, NH₃, PM_(2.5), PM₍₁₀₎, VOC, Benzene, CO, Heavy metals

Countries:

- EU-15, Norway, Switzerland, Latvia, Lithuania, Estonia, Czech, Hungary, Poland, Slovenia

2 INPUT files

2.1 Introduction

The input files are divided into two groups:

- 1 **Basic input:** These files hold the scenario independent information. These again can be subdivided into:
 - a *Stock/activity database:* Information on the volume, stock, activity and emission per unit of activity per distinguished technology per country for the base year.
 - b *Technical measures:* Information on the technical emission reduction options, which can be implemented to reduce the emission per unit of activity of the distinguished technology per country. The technical measures are further distinguished into:
 - i) Technical improvements due to the implementation of *new stock*. New stock is introduced because of the replacement of existing stock and the expansion of the stock (these more or less reflect the autonomous efficiency improvement).
 - ii) Implementation of reduction options applying to the *existing stock* (capacity that is already in place in the base year).
- 2 **Scenario input:** Input data on growth of the activity levels per distinguished technology per country, implementation degrees of reduction options, energy prices, and discount rates.

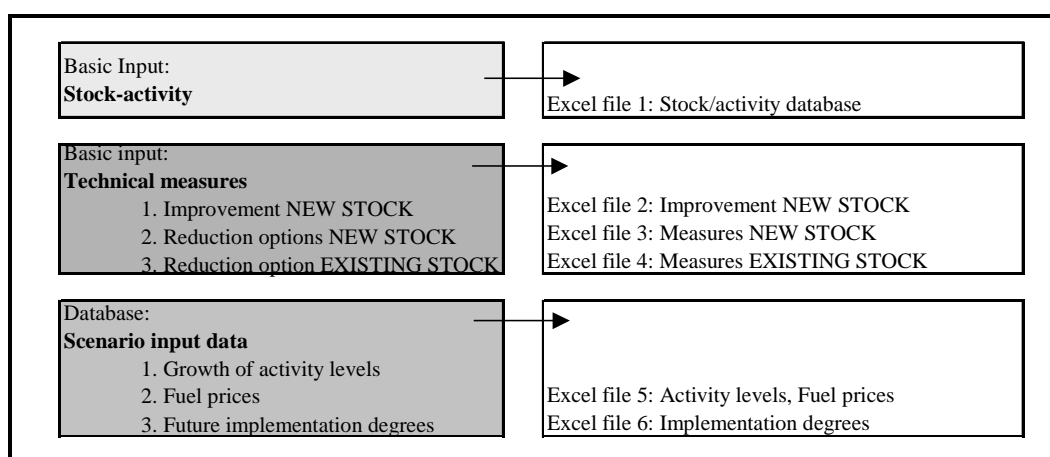


Figure 3: Input files of the GENESIS database

2.2 General format of the input files

The input data are stored in Excel spreadsheets. Five spreadsheet-formats are defined as already indicated in figure 1. General starting point for setting up the input files are:

- The technology level is the lowest level of detail and refers to a specific social activity that has significant impact on the emissions of air pollutants.
- All spreadsheet are structured in a similar way, i.e. each Excel file starts with a Default sheet filled with a set of default data per distinguished technology. Sheets per country with the distinguished technologies follow this sheet. These sheets are either filled with country specific data on the characteristics of the technologies (if available) or the default data are used (if no country specific data are available).
- The database distinguishes between changes in the characteristics of the EXISTING STOCK and the NEW STOCK. We think that it is important to make this distinction in order to get more insight into the effects of - more or less - autonomous technical improvement on the emission level through the introduction of new stock and the effect of reductions due to changes made to the existing stock.
- Figures in the database should be recognisable for the final users (i.e. express energy use and emissions per unit of activity level).
- Data gathering should be limited: i.e. a way must be found to work with default data instead of data on the country level.

2.3 BASIC INPUT: Stock/activity

The stock-activity part of the database characterises the technologies for the base year, i.e. the existing stock. These characteristics are the starting point for the scenario calculations. Figure 4 shows the structure of this 'Stock-activity' database. Each technology is principle distinguished by:

- *Stock* defined as the capacity of a technology to perform a certain task (e.g. the number of cars, installed amount of electricity generation capacity)
- *Activity* is defined as the frequency with which the stock is used (e.g. number of running hours or the number of kilometres driven by car).
- *Specific activity indicator* is equal to the stock * activity (e.g. kWh produced, produced tonnes of steel, passenger kilometres etc).
- Specific fuel/electricity/emission factors defined as the emissions, fuel demand or electricity demand per unit of specific activity indicator

This distinction is made because technical and non-technical measures can influence either the volume of the stock (e.g. a tax measure influence the number of which will be sold), the activity (e.g. road pricing influence the number of kilometres driven), or the specific activity indicators (e.g. the implementation of energy efficiency measures due to which less kWh need to be produced). It will not always be possible and useful to distinguish between these three levels for each technology (e.g. for the steel industry the specific activity indicator is produced tonnes of steel. It does not seem useful to collect figures on the stock and activity). In these cases the columns for stock and activity are by default set to '1'.

The **DEFAULT energy- and emission factors per technology** represents the situation in which none of the emission reduction measures included in the database have been implemented. This means that the default energy and emission factors are by definition equal to or higher than the country specific energy and emission factors. These defaults are referred to as the **reference technology** and emission reductions of measures applying to the existing stock all have to refer to the factors defined for the reference technology. For each sector it is very important to define the default situation very carefully so that it is clear where reductions of the options refer to.

EXCELL FILE 1	STOCK/ACTIVITY DATABASE		
SHEET TAB 1	DEFAULT: STOCK/ACTIVITY		
Column	Field	Unit	Description
1	Country code	[text]	In this sheet 'DEFAULT'
2	SNAP-code	[text]	
3	IPCC-sector	[text]	
4	Sector	[text]	
5	Subsector	[text]	
6	Technology =	[text]	Description of technology with addition_EX STOCK. The default factor used equals the characteristics referred to as the reference technology. See FILE_3 MEASURES EX STOCK
7	Base year	[number]	Base year for calculation (For Merlin probably 1998 or 2000)
8	Stock (capacity) - Unit	[text]	Description of the unit used to identify the stock of the technology (E.g MW, vehicles, houses)
9	Stock (capacity) - Volume	[number]	Volume of the installed stock of the technology in the baseyear (IN THIS SHEET BY DEFAULT 1)
10	Activity (load) - Unit	[text]	Description of annual activity of one unit of the stock of the technology (E.g. number of running hours, km/vehicle)
11	Activity (load) - Volume	[number]	Volume of the annual activity of per unit of the installed stock of the technology in the baseyear (IN THIS SHEET BY DEFAULT 1)
12	Specific activity indicator (SAI) - Unit	[text]	=Capacity*load (E.g kWh, number of km driven)
13	Specific activity indicator (SAI) - Volume	[number]	=Capacity*load (IN THIS SHEET BY DEFAULT 1)
14	Specific final fuel demand	[GJ_fuel / SAI]	Default final fuel demand per unit of the specific activity of the technology in the base year
15	Specific final electricity demand	[GJ_electricity/ SAI]	Electricity demand per unit of the specific activity of the reference technology in the base year
16	Specific heat demand	[GJ_heat/ SAI]	Heat demand per unit of the specific activity of the reference technology in the base year
17	Specific CO2-emissions	[kg_CO2-eq/ SAI]	Default CO2-emissions per unit of the specific activity of the reference technology in the base year
18	Specific CH4-emissions	[kg_CO2-eq/ SAI]	Default CH4-emissions per unit of the specific activity of the reference technology in the base year
19	Specific N2O-emissions	[kg_CO2-eq/ SAI]	Default N2O-emissions per unit of the specific activity of the reference technology in the base year
20	Specific HFC-emissions	[kg_CO2-eq/ SAI]	Default HFC-emissions per unit of the specific activity of the reference technology in the base year
21	Specific PFC-emissions	[kg_CO2-eq/ SAI]	Default PFC-emissions per unit of the specific activity of the reference technology in the base year
22	Specific SF6-emissions	[kg_CO2-eq/ SAI]	Default SF6-emissions per unit of the specific activity of the reference technology in the base year
23	Specific NOx-emissions	[kg_NOx/ SAI]	Default NOx-emissions per unit of the specific activity of the reference technology in the base year
24	Specific SO2-emissions	[kg_SO2/ SAI]	Default SO2-emissions per unit of the specific activity of the reference technology in the base year
25	Specific NH3-emissions	[kg_NH3/ SAI]	Default NH3-emissions per unit of the specific activity of the reference technology in the base year
26	Specific PM (2.5) -emissions	[kg PM (2.5) / SAI]	Default PM (2.5)-emissions per unit of the specific activity of the reference technology in the base year
27	Specific PM (10) -emissions	[kg PM (10) / SAI]	Default PM (10)-emissions per unit of the specific activity of the reference technology in the base year
28	Specific VOC-emissions	[kg VOC/ SAI]	Default VOC-emissions per unit of the specific activity of the reference technology in the base year
29	Specific Benzene-emissions	[kg Benzene/ SAI]	DefaultBenzene-emissions per unit of the specific activity of the reference technology in the base year
30	Specific CO-emissions	[kg CO/ SAI]	DefaultCO-emissions per unit of the specific activity of the reference technology in the base year
31	Specific Heavy metals-emissions	[kg HM/ SAI]	DefaultHM-emissions per unit of the specific activity of the reference technology in the base year
SHEET TAB 2	Country code		
Column	Field	Unit	Description
1	Country code	[text]	
2	SNAP-code	[text]	
3	IPCC-sector	[text]	
4	Sector	[text]	
5	Subsector	[text]	
6	Technology	[text]	Description of technology with addition_EX STOCK
7	Base year	[number]	Base year for calculation (For Merlin probably 1998 or 2000)
8	Stock (capacity) - Unit	[text]	Description of the unit used to identify the stock of the technology (E.g MW, vehicles, houses)
9	Stock (capacity) - Volume	[number]	Volume of the installed stock of the technology in the baseyear
10	Activity (load) - Unit	[text]	Description of annual activity of one unit of the stock of the technology (E.g. number of running hours, km/vehicle)
11	Activity (load) - Volume	[number]	Volume of the annual activity of per unit of the installed stock of the technology in the baseyear
12	Specific activity indicator (SAI) - Unit	[text]	=Capacity*load (E.g kWh, number of km driven)
13	Specific activity indicator (SAI) - Volume	[number]	=Capacity*load
14	Specific final fuel demand	[GJ_fuel/ SAI]	Final fuel demand per unit of the specific activity of the technology in the base year
15	Specific final electricity demand	[GJ_electricity/ SAI]	Electricity demand per unit of the specific activity of the technology in the base year
16	Specific heat demand	[GJ_heat/ SAI]	Heat demand per unit of the specific activity of the reference technology in the base year
17	Specific CO2-emissions	[kg_CO2-eq/ SAI]	CO2-emissions per unit of the specific activity of the technology in the base year
18	Specific CH4-emissions	[kg_CO2-eq/ SAI]	CH4-emissions per unit of the specific activity of the technology in the base year
19	Specific N2O-emissions	[kg_CO2-eq/ SAI]	N2O-emissions per unit of the specific activity of the technology in the base year
20	Specific HFC-emissions	[kg_CO2-eq/ SAI]	HFC-emissions per unit of the specific activity of the technology in the base year
21	Specific PFC-emissions	[kg_CO2-eq/ SAI]	PFC-emissions per unit of the specific activity of the technology in the base year
22	Specific SF6-emissions	[kg_CO2-eq/ SAI]	SF6-emissions per unit of the specific activity of the technology in the base year
23	Specific NOx-emissions	[kg_NOx/ SAI]	NOx-emissions per unit of the specific activity of the technology in the base year
24	Specific SO2-emissions	[kg_SO2/ SAI]	SO2-emissions per unit of the specific activity of the technology in the base year
25	Specific NH3-emissions	[kg_NH3/ SAI]	NH3-emissions per unit of the specific activity of the technology in the base year
26	Specific PM (2.5) -emissions	[kg PM (2.5) / SAI]	PM (2.5)-emissions per unit of the specific activity of the technology in the base year
27	Specific PM (10) -emissions	[kg PM (10) / SAI]	PM (10)-emissions per unit of the specific activity of the technology in the base year
28	Specific VOC-emissions	[kg VOC/ SAI]	VOC-emissions per unit of the specific activity of the technology in the base year
29	Specific Benzene-emissions	[kg Benzene/ SAI]	Benzene-emissions per unit of the specific activity of the technology in the base year
30	Specific CO-emissions	[kg CO/ SAI]	CO-emissions per unit of the specific activity of the technology in the base year
31	Specific Heavy metals-emissions	[kg HM/ SAI]	HM-emissions per unit of the specific activity of the technology in the base year

Figure 4 Structure file 'Stock/activity'

2.4 BASIC INPUT: Improvement new stock

The structure of the database on technical improvement of the new stock is given in Figure 5. The figures in this file more or less represent the autonomous development. For each distinguished technology three periods are included in the database representing the environmental performance and cost of technology implemented

- in the period between the base year and 2000 (future year 2000); this equals the best observed technology in the base year
- in the period between 2010 and 2010 (future year 2010); for the industry this equals the Best Observed Technology in the Brefs.
- in the period between 2020 and 2030 (future year 2020)

For some sectors the default data can probably be applied for all the countries. E.g. the electricity sector can probably be considered a global market meaning that new installed capacity has the same environmental characteristic and costs in all countries. For other sectors like the household country specific data have to be gathered.

2.5 BASIC INPUT: Technical reduction options applied to the EXISTING stock

The structure of the database for reduction options applying to the existing stock is given in Figure 6. The data gathering for this part of the database is limited because only data have to be collected on the effect and cost of measures relative to a the DEFAULT reference technology. I.e. the technology representing the situation without the implementation of the reduction options in the database, which equals the default technology in the stock/activity database for the base year. Country specific characteristics that have to be gathered are the implementation degree in the base year and the share in sector.

EXCEL FILE 2 MEASURE DATABASE NEW STOCK			
SHEET TAB DEFAULT DATA: Technical Improvement NEW STOCK			
Column	Field	Unit	Description
1	Country code	[text]	In this sheet 'DEFAULT'
2	SNAP-code	[text]	
3	IPCC-sector	[text]	
4	Sector	[text]	
5	Subsector	[text]	
6	Technology	[text]	Description of technology with addition NEW STOCK
7	SAI	text	
8	Future year	[number]	For each technology the characteristic for three years are introduced 2010, 2020 and 2030. This means that each technology three rows have to be included.
9	Fixed costs	[Euro-2000/ SAI]	Investment (once only) expressed in Euro-2000 per unit of the activity level
10	Running costs	[Euro-2000/SAI]	Yearly running costs expressed in Euro-2000 per unit of the activity level
11	Lifetime	[years]	Technical lifetime of the new installed capacity
12	Specific final fuel demand	[GJ_fuel / SAI]	Default final fuel demand per unit of the specific activity of the technology in the base year
13	Specific final electricity demand	[GJ_electricity/ SAI]	Electricity demand per unit of the specific activity of the reference technology in the base year
14	Specific heat demand	[GJ_heat/ SAI]	Heat demand per unit of the specific activity of the reference technology in the base year
15	Specific CO2-emissions	[kg CO2-eq / SAI]	CO2-emissions per unit of the specific activity of the technology in 2010, 2020 or 2030
16	Specific CH4-emissions	[kg CO2-eq / SAI]	CH4-emissions per unit of the specific activity of the technology in 2010, 2020 or 2030
17	Specific N2O-emissions	[kg CO2-eq / SAI]	N2O-emissions per unit of the specific activity of the technology in 2010, 2020 or 2030
18	Specific HFC-emissions	[kg CO2-eq / SAI]	HFC-emissions per unit of the specific activity of the technology in 2010, 2020 or 2030
19	Specific PFC-emissions	[kg CO2-eq / SAI]	PFC-emissions per unit of the specific activity of the technology in 2010, 2020 or 2030
20	Specific SF6-emissions	[kg CO2-eq / SAI]	SF6-emissions per unit of the specific activity of the technology in 2010, 2020 or 2030
21	Specific NOx-emissions	[kg NOx / SAI]	NOx-emissions per unit of the specific activity of the technology in 2010, 2020 or 2030
22	Specific SO2-emissions	[kg SO2 / SAI]	SO2-emissions per unit of the specific activity of the technology in 2010, 2020 or 2030
23	Specific NH3-emissions	[kg NH3 / SAI]	NH3-emissions per unit of the specific activity of the technology in 2010, 2020 or 2030
24	Specific PM (2.5) -emissions	[kg PM (2.5) / SAI]	PM (2.5)-emissions per unit of the specific activity of the technology in 2010, 2020 or 2030
25	Specific PM (10) -emissions	[kg PM (10) / SAI]	PM (10)-emissions per unit of the specific activity of the technology in 2010, 2020 or 2030
26	Specific VOC-emissions	[kg VOC / SAI]	VOC-emissions per unit of the specific activity of the technology in 2010, 2020 or 2030
27	Specific Benzene-emissions	[kg Benzene / SAI]	Benzene-emissions per unit of the specific activity of the technology in 2010, 2020 or 2030
28	Specific CO-emissions	[kg CO / SAI]	CO-emissions per unit of the specific activity of the technology in 2010, 2020 or 2030
29	Specific Heavy metals-emissions	[kg HM / SAI]	HM-emissions per unit of the specific activity of the technology in 2010, 2020 or 2030
SHEET TAB			
Column	Field	Unit	Description
1	Country code	[text]	
2	SNAP-code	[text]	
3	IPCC-sector	[text]	
4	Sector	[text]	
5	Subsector	[text]	
6	Technology	[text]	Description of technology with addition NEW STOCK
7	SAI	text	
8	Future year	[number]	For each technology the characteristic for three years are introduced 2010, 2020 and 2030. This means that each technology three rows have to be included.
9	Fixed costs	[Euro-2000/ SAI]	Investment (once only) expressed in Euro-2000 per unit of the activity level
10	Running costs	[Euro-2000/SAI]	Additional yearly running costs expressed in Euro-2000 per unit of the activity level relative to the reference technology
11	Lifetime	[years]	Technical lifetime of the new installed capacity
12	Specific final fuel demand	[GJ_fuel / SAI]	Default final fuel demand per unit of the specific activity of the technology in the base year
13	Specific final electricity demand	[GJ_electricity/ SAI]	Electricity demand per unit of the specific activity of the reference technology in the base year
14	Specific heat demand	[GJ_heat/ SAI]	Heat demand per unit of the specific activity of the reference technology in the base year
15	Specific CO2-emissions	[kg CO2-eq / SAI]	CO2-emissions per unit of the specific activity of the technology in 2010, 2020 or 2030
16	Specific CH4-emissions	[kg CO2-eq / SAI]	CH4-emissions per unit of the specific activity of the technology in 2010, 2020 or 2030
17	Specific N2O-emissions	[kg CO2-eq / SAI]	N2O-emissions per unit of the specific activity of the technology in 2010, 2020 or 2030
18	Specific HFC-emissions	[kg CO2-eq / SAI]	HFC-emissions per unit of the specific activity of the technology in 2010, 2020 or 2030
19	Specific PFC-emissions	[kg CO2-eq / SAI]	PFC-emissions per unit of the specific activity of the technology in 2010, 2020 or 2030
20	Specific SF6-emissions	[kg CO2-eq / SAI]	SF6-emissions per unit of the specific activity of the technology in 2010, 2020 or 2030
21	Specific NOx-emissions	[kg NOx / SAI]	NOx-emissions per unit of the specific activity of the technology in 2010, 2020 or 2030
22	Specific SO2-emissions	[kg SO2 / SAI]	SO2-emissions per unit of the specific activity of the technology in 2010, 2020 or 2030
23	Specific NH3-emissions	[kg NH3 / SAI]	NH3-emissions per unit of the specific activity of the technology in 2010, 2020 or 2030
24	Specific PM (2.5) -emissions	[kg PM (2.5) / SAI]	PM (2.5)-emissions per unit of the specific activity of the technology in 2010, 2020 or 2030
25	Specific PM (10) -emissions	[kg PM (10) / SAI]	PM (10)-emissions per unit of the specific activity of the technology in 2010, 2020 or 2030
26	Specific VOC-emissions	[kg VOC / SAI]	VOC-emissions per unit of the specific activity of the technology in 2010, 2020 or 2030
27	Specific Benzene-emissions	[kg Benzene / SAI]	Benzene-emissions per unit of the specific activity of the technology in 2010, 2020 or 2030
28	Specific CO-emissions	[kg CO / SAI]	CO-emissions per unit of the specific activity of the technology in 2010, 2020 or 2030
29	Specific Heavy metals-emissions	[kg HM / SAI]	HM-emissions per unit of the specific activity of the technology in 2010, 2020 or 2030

Default data per technology
 Country specific data and if not available default data

Figure 5 Structure file 'Improvement NEW STOCK'

EXCELL FILE 3 MEASURE DATABASE_EX STOCK			
SHEET TAB DEFAULT DATA: Reduction options applying to EX STOCK			
Column	Field	Unit	Description
1	Country code	[text]	In this sheet DEFAULT
2	SNAP-code	[text]	
3	IPCC-sector	[text]	
4	Sector	[text]	
5	Subsector	[text]	
6	Technology =		Description of technology with addition _OLD STOCK. This is the reference technology for calculating the relative reductions per country (see text in footnote)
7	Reference technology	[text]	
8	SAI	text	
9	Name of the measure	[text]	Short name of the measure
10	Fixed costs	[Euro-2000/ SAI]	Additional investment (once only) expressed in Euro-2000 per unit of the activity level relative to the reference technology
11	Running costs	[Euro-2000/ SAI]	Additional yearly running costs expressed in Euro-2000 per unit of the activity level relative to the reference technology
12	Benefits	[Euro-2000/ SAI]	Yearly benefits due to the implementation of the emission reduction measures. NOTE: In case of measure saving on energy these benefits will be automatically calculated.
13	Lifetime	[years]	Technical lifetime of the measure
14	Share in technology	%	Share of the energy use or emission of the technology that is affected by the measure (IN THIS SHEET 100% BY DEFINITION)
15	Specific final fuel demand	[GJ fuel / SAI]	Specific final fuel demand per unit of the activity after implementation of the reduction option
16	Specific final electricity demand	[GJ_electricity/ SAI]	Specific electricity demand per unit of the activity after implementation of the reduction option
17	Specific heat demand	[GJ_heat/ SAI]	Heat demand per unit of the specific activity of the reference technology in the base year
18	Specific CO2-emissions	[kg CO2-eq / SAI]	Specific CO2 emissions per unit of the activity after implementation of the reduction option
19	Specific CH4-emissions	[kg CO2-eq / SAI]	Specific CH4 emissions per unit of the activity after implementation of the reduction option
20	Specific N2O-emissions	[kg CO2-eq / SAI]	Specific N2O emissions per unit of the activity after implementation of the reduction option
21	Specific HFC-emissions	[kg CO2-eq / SAI]	Specific HFC emissions per unit of the activity after implementation of the reduction option
22	Specific PFC-emissions	[kg CO2-eq / SAI]	Specific PFC emissions per unit of the activity after implementation of the reduction option
23	Specific SF6-emissions	[kg CO2-eq / SAI]	Specific SF6 emissions per unit of the activity after implementation of the reduction option
24	Specific NOx-emissions	[kg NOx / SAI]	Specific NH3 emissions per unit of the activity after implementation of the reduction option
25	Specific SO2-emissions	[kg SO2 / SAI]	Specific PM (2.5) emissions per unit of the activity after implementation of the reduction option
26	Specific NH3-emissions	[kg NH3 / SAI]	Specific PM (10) emissions per unit of the activity after implementation of the reduction option
27	Specific PM (2.5) -emissions	[kg PM (2.5) / SAI]	Specific VOC emissions per unit of the activity after implementation of the reduction option
28	Specific PM (10) -emissions	[kg PM (10) / SAI]	Specific Benzene emissions per unit of the activity after implementation of the reduction option
29	Specific VOC-emissions	[kg VOC / SAI]	Specific CO emissions per unit of the activity after implementation of the reduction option
30	Specific Benzene-emissions	[kg Benzene / SAI]	Specific HM emissions per unit of the activity after implementation of the reduction option
31	Base year	[number]	Base year of calculation (For Merlin probably 1998, for Sect. Targets it was 1990)
32	Base year implementation degree	%	Share of the activity level in the baseyear were the measure is implemented (IN THIS SHEET 0% BY DEFINITION)
33	Remarks	[code]	A=also affect the activity level
SHEET TAB Country code			
Column	Future year	[number]	Description
1	Country code	[text]	
2	SNAP-code	[text]	
3	IPCC-sector	[text]	
4	Sector	[text]	
5	Subsector	[text]	
6	Technology	[text]	Description of technology with addition _OLD STOCK
7	SAI	text	
8	Name of the measure	[text]	Short name of the measure
9	Fixed costs	[Euro-2000/ SAI]	Additional investment (once only) expressed in Euro-2000 per SAI relative to the reference technology
10	Running costs	[Euro-2000/ SAI]	Additional yearly running costs expressed in Euro-2000 per SAI relative to the reference technology
11	Benefits	[Euro-2000/ SAI]	Yearly benefits due to the implementation of the emission reduction measures. NOTE: In case of measure saving on energy these benefits will be automatically calculated.
12	Lifetime	[years]	Technical lifetime of the measure
13	Share in technology	%	Share of the energy use or emission of the technology that is affected by the measure
14	Specific final fuel demand	[kg CO2-eq / SAI]	Specific final fuel demand per unit of the activity after implementation of the reduction option
15	Specific final electricity demand	[kg CO2-eq / SAI]	Specific electricity demand per unit of the activity after implementation of the reduction option
16	Specific heat demand	[GJ_heat/ SAI]	Heat demand per unit of the specific activity of the reference technology in the base year
17	Specific CO2-emissions	[kg CO2-eq / SAI]	Specific CO2 emissions per unit of the activity after implementation of the reduction option
18	Specific CH4-emissions	[kg CO2-eq / SAI]	Specific CH4 emissions per unit of the activity after implementation of the reduction option
19	Specific N2O-emissions	[kg CO2-eq / SAI]	Specific N2O emissions per unit of the activity after implementation of the reduction option
20	Specific HFC-emissions	[kg CO2-eq / SAI]	Specific HFC emissions per unit of the activity after implementation of the reduction option
21	Specific PFC-emissions	[kg NOx / SAI]	Specific PFC emissions per unit of the activity after implementation of the reduction option
22	Specific SF6-emissions	[kg SO2 / SAI]	Specific SF6 emissions per unit of the activity after implementation of the reduction option
23	Specific NOx-emissions	[kg NH3 / SAI]	Specific NH3 emissions per unit of the activity after implementation of the reduction option
24	Specific SO2-emissions	[kg PM (2.5) / SAI]	Specific PM (2.5) emissions per unit of the activity after implementation of the reduction option
25	Specific NH3-emissions	[kg PM (10) / SAI]	Specific PM (10) emissions per unit of the activity after implementation of the reduction option
26	Specific PM (2.5) -emissions	[kg VOC / SAI]	Specific VOC emissions per unit of the activity after implementation of the reduction option
27	Specific PM (10) -emissions	[kg Benzene / SAI]	Specific Benzene emissions per unit of the activity after implementation of the reduction option

Figure 6 Structure file 'Reduction options applying to EXISTING STOCK'

2.6 Scenario input

The scenario input data has to be entered is given in Figure 7. The main input data are:

- Growth figure for the volume of the activity levels of the different technologies.
- Annual pace of demolition of the existing capacity
- Fuel prices and discount rates
- Implementation degree for the measures applying to the existing stock

EXCELL FILE 4		SCENARIO INPUT DATA: ACTIVITY LEVELS	
SHEET TAB 1		DEFAULT DATA: Growth figures activity levels	
Column	Field	Unit	Description
1	Country code	[text]	In this sheet DEFAULT
2	SNAP-code	[text]	
3	IPCC-sector	[text]	
4	Sector	[tekst]	
5	Subsector	[tekst]	
6	Technology	[tekst]	Description of technology either with addition _OLD STOCK or _NEW STOCK
7	SAI	[text]	
8	Baseyear	[number]	
9	Future year 1st period	[number]	
10	Growth activity level_ Technology 1st period	[%]	Annual growth of the activity level of the technology relative to the baseyear in the period baseyear - 2010. NOTE: If volume of activity level in baseyear is 0, and growth is expected for future year, assume for calculation reasons that volume in baseyear is equal to 1
11	Future year 2nd period	[number]	
12	Growth activity level_ Technology 2nd period	[%]	Annual growth of the activity level of the technology in the period 2010 - 2020
13	Future year 3rd period	[number]	
14	Growth activity level_ Technology 3rd period	[%]	Annual growth of the activity level of the technology in the period 2020 - 2030
15	Pace of demolition of existing capacity	[%]/year	Annual pace of demolition of the existing capacity
16	Fuel price_ 2010	[Euro/GJ]	
17	Fuel price_ 2020	[Euro/GJ]	
18	Fuel price_ 2030	[Euro/GJ]	
19	Electricity price_ 2010	[Euro/kWh]	
20	Electricity price_ 2020	[Euro/kWh]	
21	Electricity price_ 2030	[Euro/kWh]	
SHEET TAB 2...X		Country code	
Column	Field	Unit	Description
1	Country code	[text]	
2	SNAP-code	[text]	
3	IPCC-sector	[text]	
4	Sector	[tekst]	
5	Subsector	[tekst]	
6	Technology	[tekst]	
7	SAI	[text]	
8	Baseyear	[number]	
9	Future year 1st period	[number]	
10	Growth activity level_ Technology 1st period	[%]	
11	Future year 2nd period	[number]	
12	Growth activity level_ Technology 2nd period	[%]	
13	Future year 3rd period	[number]	
14	Growth activity level_ Technology 3rd period	[%]	
15	Pace of demolition of existing capacity	[%]/year	
16	Fuel price_ 2010	[Euro/GJ]	
17	Fuel price_ 2020	[Euro/GJ]	
18	Fuel price_ 2030	[Euro/GJ]	
19	Electricity price_ 2010	[Euro/kWh]	
20	Electricity price_ 2020	[Euro/kWh]	
21	Electricity price_ 2030	[Euro/kWh]	

Default data per technology
 Country specific data and if not available default data
 **) For the activity level of the NEW STOCK in the different future years a formula will be applied to calculate the share of new capacity with characteristics of 2000, 2010 and 2020 in the different years

EXCELL FILE 6		SCENARIO INPUT DATA: IMPLEMENTATION DEGREES	
SHEET TAB 1		DEFAULT DATA: Implementation degrees per reduction options**)	
Column	Field	Unit	Description
1	Country code	[text]	In this sheet DEFAULT
2	SNAP-code	[text]	
3	IPCC-sector	[text]	
4	Sector	[text]	
5	Subsector	[text]	
6	Technology	[text]	Description of technology with addition _OLD STOCK
7	Code of measure	[text]	Code of two letters and three digits. Letters referring to the sector.
8	Name of the measure	[text]	Short name of the measure
9	Base year implementation degree	%	Share of the activity level in the baseyear were the measure is implemented
10	Implementation degree (2010)	%	Share of the the activity level in 2010 were the measure can be implemented (DEFAULT IMPL. DEGREE 2010 = IMPL. DEGREE BASEYEAR= 0% BY DEFINITION)
11	Implementation degree (2020)	%	Share of the the activity level in 2020 were the measure can be implemented (DEFAULT IMPL. DEGREE 2020 = IMPL. DEGREE BASEYEAR = 0% BY DEFINITION)
12	Implementation degree (2030)	%	Share of the the activity level in 2030 were the measure can be implemented (DEFAULT IMPL. DEGREE 2030 = IMPL. DEGREE BASEYEAR = 0% BY DEFINITION)
SHEET TAB 2...X		Country code	
Column	Field	Unit	Description
1	Country code	[text]	
2	SNAP-code	[text]	
3	IPCC-sector	[text]	
4	Sector	[text]	
5	Subsector	[text]	
6	Technology	[text]	Description of technology with addition _OLD STOCK
7	Code of measure	[text]	Code of two letters and three digits. Letters referring to the sector.
8	Name of the measure	[text]	Short name of the measure
9	Base year implementation degree	%	Share of the activity level in the baseyear were the measure is implemented
10	Implementation degree (2010)	%	Share of the the activity level in 2010 were the measure can be implemented (DEFAULT IMPL. DEGREE 2010 = IMPL. DEGREE BASEYEAR)
11	Implementation degree (2020)	%	Share of the the activity level in 2020 were the measure can be implemented (DEFAULT IMPL. DEGREE 2020 = IMPL. DEGREE BASEYEAR)
12	Implementation degree (2030)	%	Share of the the activity level in 2030 were the measure can be implemented (DEFAULT IMPL. DEGREE 2030 = IMPL. DEGREE BASEYEAR)

Default data per technology
 Country specific data and if not available default data

Figure 7 File Structure 'Scenario input data'

3 Calculation rules

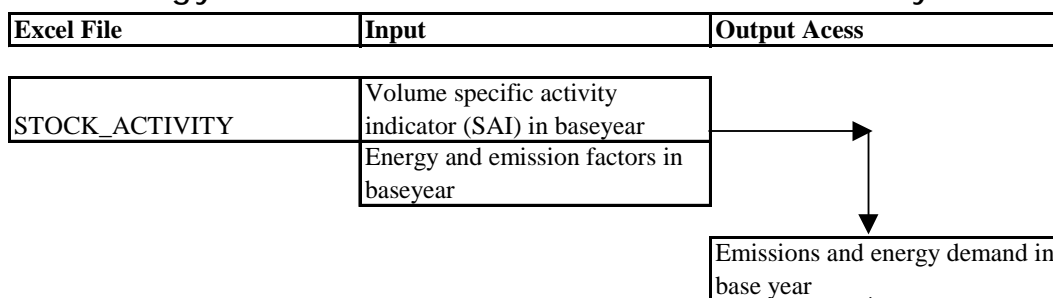
3.1 Introduction²

Scenario calculation will be executed using Access. Therefore Access links are made to the five input files. Point of departure for design of the calculator:

- Scenario calculations are performed for one future year at a time; i.e. either 2010, 2020 or 2030
- Scenario calculations can in principle (given their are no hardware limitations) be performed for all sectors in one run.

This chapter describes the calculation rules applied to reach the scenario results and the assumptions made with the design of these rules. Each chapter starts with a description of the dataflows to perform the calculations.

3.2 Energy demand and emissions in the base year

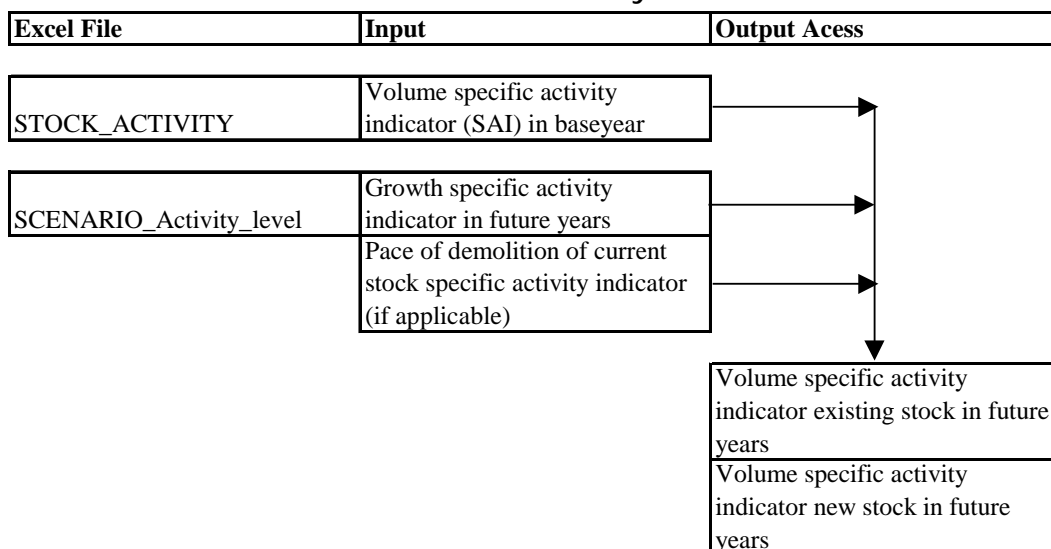


For one specific technology the energy demand and/or emissions in the baseyear equal:

$$Em(b) = Ef_b * Act_b$$

² For a manual on how to use the calculator see Manual Calculator

3.3 Future volume of the activity levels



For one specific technology the future volume of the activity level is split into different age categories. Each age categories has it's own activity level is a specific future year.

Activity level of the existing stock in future year X

$$Act_ex(x) = Act_b * (1 - dem * (x - b))$$

If $lt_new < 0$ then $Act_ex(x) = Act_b * (1 + gr)^{future\ year - b}$

If $(1 - dem * (x - b)) < 0$ then $Act_ex(x) = 0$

If $gr < - dem$ then $Act_ex(x) = Act_b * (1 + gr)^{future\ year - b}$

Activity level of the new stock implemented in the period between the base year and 2010 in future year X (New from 2000)

$$Act_nw_2000(x) = (Act_b * (1 + gr_{B-2010})^{2010-b} - Act_ex(2010)) * (1 - \frac{x - 2000 - lt_new}{lt_new})$$

If $x = b$ or $lt_new < 0$ then $Act_nw_2000 = 0^3$

If $gr < - dem$ then $Act_nw_2000 = 0$

If $x - 2000 < lt_new$ then $Act_b * (1 + gr_{B-2010})^{(2010-B)} - Act_ex(2010)$

If $x - 2000 > 2 * lt_new$ then $Act_nw_2000 = 0$

Activity level of the NEW stock implemented in the period between 2010 and 2020 in future year X (New from 2010)

³ This condition is included in order to be able to model the future development of technologies/sectors that are not modelled through means of a vintage approach.

$$Act_nw_2010(x) = (Act_b * (1 + gr_{B_2010})^{2010-b} * (1 + gr_{2010_2020})^{2020-2010} - Act_ex(2020) - Act_nw_2000(2010)) * (1 - \frac{x - 2010 - lt_new}{lt_new})$$

If $x < 2010$ or $lt_new=0$ then $Act_nw_2010 = 0$

If $gr < - dem$ then $Act_nw_2010 = 0$

If $x-2010 < lt_new$ then $Act_b * (1 + gr_{B_2010})^{(2010-B)} * (1 + gr_{2010-2020})^{(2020-2010)} - Act_ex(2010) - Act_nw_2000(2010)$

If $x-2010 > 2 * lt_new$ then $Act_nw_2010 = 0$

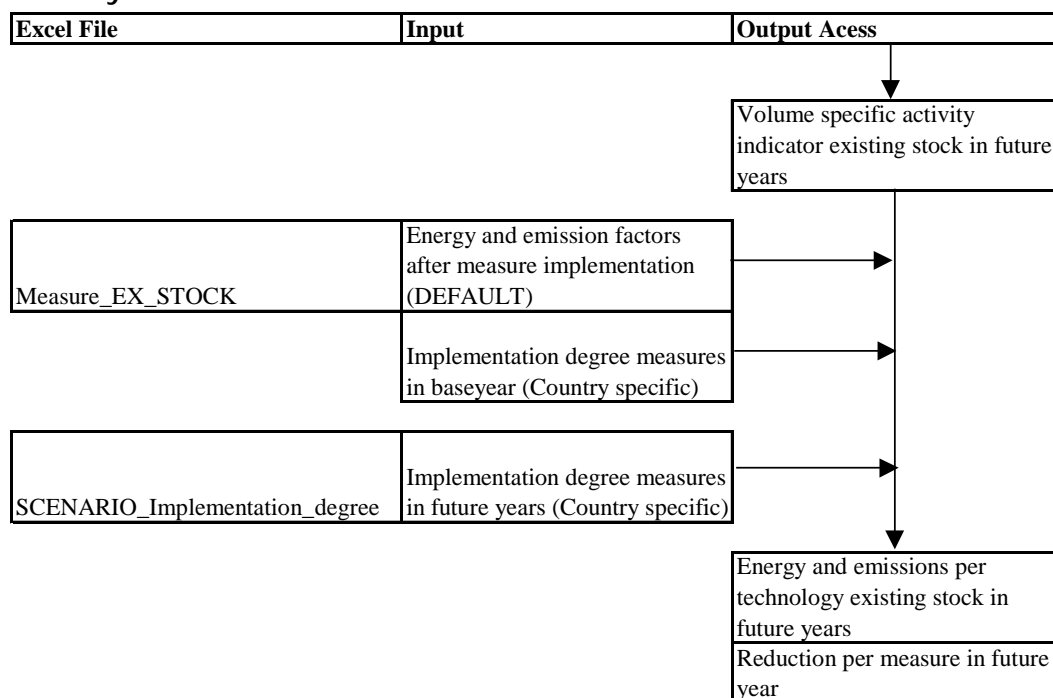
Activity level of the NEW stock implemented in the period between 2020 and 2030 in future year X (New from 2020)

$$Act_nw_2020(x) = (Act_b * (1 + gr_{B_2010})^{2010-b} * (1 + gr_{2010_2020})^{2020-2010} * (1 + gr_{2020_2030})^{2030-2020} - Act_ex(2030) - Act_nw_2000(2030) - Act_nw_2010(2030))$$

If $x < 2020$ or $lt_new=0$ Then $Act_nw_2020 = 0$

If $gr < - dem$ then $Act_nw_2020 = 0$

3.4 Energy use and emissions existing stock in future years



When calculating the new emission factors for the existing stock, i.e. after implementation of reduction options we have to encounter two problems in our structure:

1. 'Order problem': usually there is a logic order for implementing measures this means that the measures in the database are mutually dependent.
2. 'Default' versus country specific data: we want to make use of default data as much as possible.

3.4.1 Emissions calculations: Existing Stock on the measure level

The emission factor (default) after implementation of measure m is the emission factor before implementation minus the potential reduction (equal to share of technology t time's reduction factor)

$$Ef_after_def(x) = Ef_def(b) * (1 - S_def * Red)$$

The already obtained reduction in country c depends on the implementation of the measure in the base year, the share in sector and the reduction that can be obtained by the measure. The emission factor $Efc(old)$ without measure m in country c would have been:

$$Ef_c(old) = \frac{Ef_c(b)}{(1 - S_c * I_c(b) * Red)}$$

$Ef_after_c(x)$ is than the emission factor without any implementation minus the reduction obtained by implementation degree in future year

$$Ef_after_c(x) = Ef_c(old) * (1 - S_c * I_c(x) * Red)$$

The *absolute reduction potential per measure* applied to a technology for a specific country in year x then equals:

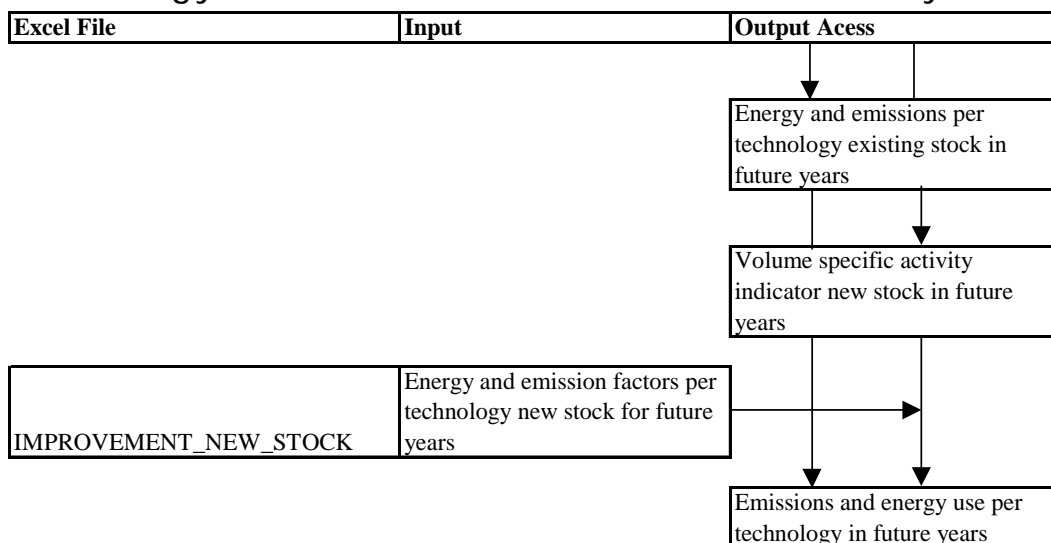
$$Red_c(x) = [Ef_c(old) - Ef_after_c(x)] * Act_ex(x)$$

3.4.2 Emission calculation: Existing Stock on the technology level

For one specific technology the energy demand and/or emission of the existing stock in future year x after implementation of n emission reductions or energy efficiency measures equals:

$$Ef_ex(x) = [Ef_c(b) - \sum_{m=1}^n Ef_c(b) - Ef_after_c(x)] * Act_ex(x)$$

3.5 Energy demand and emissions for a future year



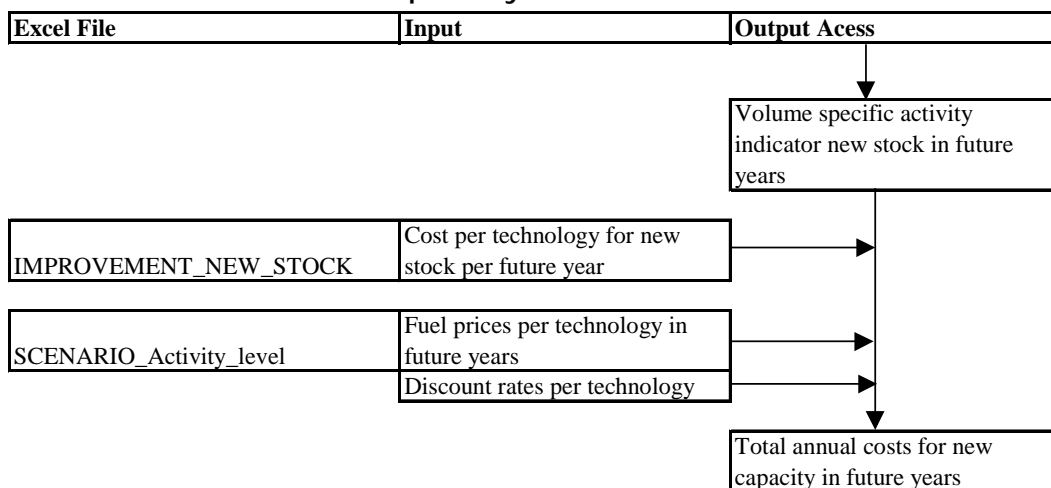
For one specific technology the energy demand and/or emissions in future year X equal:

$$Em(x) = Ef_ex(x) * Act_ex(x) + Ef_nw_2000(x) * Act_nw_2000(x) + Ef_nw_2010(x) * Act_nw_2010(x) + Ef_nw_2020(x) * Act_nw_2020(x)$$

If Ef_nw_2000 and Ef_nw_2010 and Ef_nw_2020 are not present then

$$Em(x) = Ef_ex(x) * Act_tot(x)$$

3.6 Costs for new capacity



For one specific technology the annual fixed costs for New capacity in future year X equal:

$$Fixed_nw(x) = Fixed_nw_2000(x) * Act_nw_2000(x) + Fixed_nw_2010(x) * Act_nw_2010(x) + Fixed_nw_2020(x) * Act_nw_2020(x)$$

The *total annual costs for a measure m* applying for one technology for a specific country equals in future year x

$$Tot_cost_ex_c(x) = Tot_spec_cost_ex_c(x) * S_c * Act_ex(x) * [I_c(b) - I_c(x)] - Red_fuel_c * FP_c(x) - Red_elec_c * EP_c(x)$$

3.8 Exceptions

Measures that do not fit in the above structure are modelled in the following way:

(1) Fuel switch with oil and coal fired power plants measures. As no energy is saved through this measures no benefits from less energy use can be calculated with the help of the before mentioned formulas. There is however a benefit (can also be negative benefits) due to the switch to another energy carrier because there is a price difference between the two energy carries. The problem is solved by calculating these benefits manually in the benefits column, i.e. by linking it manually to the Scenario_activity_levels file and the Stock_activity_file.

4 Preparation of input data per sector

4.1 Sector: Energy sector

4.1.1 Subsector Electricity and power generation, Issues: Energy and GHG gases

Stock activity data

- Volume of the specific activity indicator per technology (in this case MWh_e or MWh_{th} produced) are gained from IEA⁴ and EUROSTAT⁵ Statistics.
- Specific energy and emission factors (e.g. GJ fuel per MWh and kg CO₂ per MWh) were calculated with the help of the IEA and EUROSTAT Statistics and the standard emission factors from UNFCCC⁶. More specification.....
- The calculated specific energy and emissions factors were compared with data on the 'environmental' performance of the technologies, as we know from other literature sources. It showed that not for all countries and technologies the calculated specific energy and emission factors give a good representation of the 'environmental performance' of the technology (Sources...).
- For those countries where the calculated specific energy and emission factors do not give a good representation of the 'environmental performance' of the technology we replaced the calculated specific energy and emission factors with the data we know from literature. All other data stayed the same.
- Data on renewable (MoV??)

Improvement new stock

Data on energy and environmental performance were gained from the different sources like ATLAS⁷ study etc. Data on the ATLAS study represented the situation in 2010, specific assumption for other years were.....

Measures existing stock

Data were mainly gained from other studies from Ecofys⁸. More detail on data gained from

⁴ IEA (2000a) Electricity information (2000). IEA/OECD. Paris

⁵ EUROSTAT (2001). Confidential data on CHP (received by e-mail)

⁶ UNFCCC (United Nations Framework Convention on Climate Change): Data on Greenhouse gas emissions (<http://www.unfccc.de/resource/index.html>). Bonn, 2000

⁷ ATLAS, 1997: Energy Technology - The next steps. Summary findings of the ATLAS project, ETSU/DG XVII. Thermie, December 1997

⁸ Hendriks, C.; De Beer, J.; De Jager, D.; Blok, K.: Economic Evaluation of Sector Targets for Climate Change. Economic Evaluation of Emission Reduction of Greenhouse Gases in the Energy Supply Sector in the EU- Bottom up Analysis. Ecofys, Utrecht.

Specific assumption for CEEC

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4.1.2 Subsector: CHP, Issues: Energy and GHG gases

Stock activity data

.....

Improvement new stock

....

Measures existing stock

...

Specific assumption for CEEC

....

4.2 Sector: Industry

4.2.1 Subsector: Energy transformation, Technology: Refineries, Issues: Energy and GHG gases

There is no such thing as “an average refinery in Europe”. Refineries differ in size, complexity, the types of processes they operate, the quality of the crude oil that is processed and the types of products produced. Therefore, energy demand, CO₂ emissions, types of (retrofit) measures applicable and costs differ dramatically between countries and sites [(BREF, 2001), (CONCAWE, 1999)].

Besides this it is extremely difficult to find good data on refineries, as data are confidential. The best database available is property of Solomon and treated commercially. Figures in this chapter must be seen as rough estimates for Europe and can only be used in a macro modelling exercise.

The essential function of an oil refinery unit is to produce hydrocarbon based products and intermediates from crude oil or other hydrocarbon feedstock. In order to produce different products, a number of successive process steps are carried out in different installations. The most important processes at a refinery are; distillation (atmospheric, vacuum or high pressure), aromatic extraction, dewaxing, desalting, de-asphalting and gas separation. Some processes that bring about chemical conversions are isomerisation, alkylation, reforming, catalytic cracking, hydrocracking and petroleum coking. Furthermore,

each refinery has its own utilities (steam and power supply) and general facilities (water, air, hydrogen, cooling systems wastewater treatment etc.). Important products are: fuels (LPG, gasoline, kerosene, light and heavy fuel oils) petrochemical feedstock (naphta, ethylene, propylene, benzene, and toluene) and other products (bitumen, petroleum coke, and sulphur). These lists are by no means complete and show the complexity of the processes taking place at refineries and the diversity of the products produced [(BREF, 2001), (IEA 1999)].

The complexity of the refineries in Europe has increased the last 10 years and is still increasing as a result of a demand for higher yields of light fuels and more diversity in products. Refineries are expected to increase both in capacity and in complexity the next 10 years. The increase in capacity is mainly covered by expanding and retrofitting existing plants; no new plants will be built in Europe the next 10 to 20 years [ECN, 1999].

Stock activity data

.....

Improvement new stock

No complete new production technologies are expected to be implemented in Europe in the next 10 to 20 years. Furthermore the increase in demand for refinery products will be covered by expansion of existing plants and no new capacity is expected. The refineries are therefore not included in the worksheet 'Improvement new stock'.

Measures existing stock

Code	Measure database	Description
Ref-1	Reflux overhead vapour recompression (distillation)	The energy efficiency of the crude distillation unit can be improved by pumping reflux from the overhead condenser to lower points in the column. In this way the heat transfer temperatures are higher and a higher fraction of the heat energy can be recovered by preheating the feed. Savings amount to 0.15 GJ/tonne crude oil.
Ref-2	Power recovery	Some processes in a refinery are carried out at elevated pressure, e.g. cracking processes. The subsequent fractionation of cracking products takes place at a much lower pressure. Hence, after the completion of the cracking reaction the pressure needs to be reduced. The energy of the pressurised gas can be recovered by using a power recovery turbine. Energy savings are estimated at 0.01 GJ /tonne for a power recovery unit at a hydrocracker and 0.05 GJ when installed at a fluid catalytic cracker.
Ref-3	Improved catalysts at catalytic reforming	Higher active and selective catalysts can increase the

Code	Measure database	Description
	and cracking	yield of processes based on catalytic conversions, e.g. in the catalytic reformer and the cracker. Savings of 0.5 GJ/tonne have been reported (WEC, 1995)
Ref-4 Ref-5	Miscellaneous I and II (low and high cost tranche)	Other measures are: better process management, more efficient hydrogen production, intermediate reboilers and condensers, air preheaters, application of vacuum pumps.

Specific assumption for CEEC

....

4.2.2 Subsector: Paper and pulp, Issues: Energy and GHG gases

Paper is produced from two main materials: primary wood pulp and waste paper (recycling). Wood pulp is made from fibres in wood. Two main processes can be distinguished: chemical pulping (also called Kraft pulping) and (thermo-) mechanical pulping, of which chemical pulping makes out the largest part of total pulp production

Chemical pulping relies on sulphur and sodium compounds to dissolve the lignin. However, nowadays sulphur free processes are also available. Chemical pulping requires a high energy input but pulp plants are also steam and electricity producers by burning wood, bark and chemicals. Although the heat demand of chemical pulp mills can be in the order of 10-14 GJ/tonne of pulp, the excess heat is about 5 GJ/tonne pulp [BREF-PP, 2000] Usually this heat is used in the integrated paper mill. The electricity consumption is 400-750 kWh/tonne. All this electricity is in practice generated in the recovery station. In fact, there is an overproduction of electricity in the pulp mill [BREF-PP, 2000].

The specific energy consumption varies per pulping process and depends to a large extent on the quality demands set on the pulp by the end product. EC [BREF-PP, 2001] reports on an electricity consumption that ranges from 1100-2300 kWh/tonne of pulp for ground wood processes. Heat produced during the process may be recovered as hot water (maximum 30% of electricity input) or as steam (maximum 20% at pressurised processes). The electricity consumption for refining processes is higher, ranging from 1600-3600 kWh/tonne of pulp. However, the recoverable energy may be as high as 65% of the electricity input. Heat is required only during the start-up phase.

Stock activity data

- Specific energy demand per country.....
- Production figures....

- CO₂-emissions factors for the fuel mix used per sector (kg CO₂/GJ) were calculated from IEA Statistics.....

Improvement new stock

- The assumption is that no complete new technologies are expected to come on the market for the production of paper and pulp [BREF, 2001].
- The assumption is that existing technologies for production of pulp and paper will become more efficient up to the year 2030. New installed capacity in 2010 will have an average efficiency equalling the best-observed in 1998. In 2020 new capacity is on average 10% more efficient than in 2010 and in 2030 another 10% more efficient.

Measures existing stock

Retrofit improvement options for the paper and pulp industry [(LBNL, 2000), (Icarus, 2001), (de Beer et al 2001)]

Code	Measure database	Description
Ind-13 Ind-17 Ind-21 Ind-22	Miscellaneous I (Low cost tranche) and Miscellaneous II (High cost tranche)	Different measures leading to different energy savings depending on investment (high and low cost tranche) in the mechanical pulp industry and the paper industry.
Ind-14	Super pressurised groundwood	Grinding under elevated pressure (4.5 bar) can halve the energy demand for pressurised ground wood (PGW) pulp. Valmet-Tampella has developed a process called Pressure Ground Wood-Super process. As a result, higher temperatures can be achieved without boiling, softening the lignin. The strength properties of the produced pulp are close to those of TMP-pulp. According to Valmet-Tampella pulp produced in this process can replace TMP-pulp. The electricity consumption for this process is 1100-1300 kWh/tonne of pulp, which is about 600 kWh/tonne less than for TMP. ⁹
Ind-15	Heat recovery in thermal mechanical pulping	The heat produced in the process of thermo-mechanical pulping can be recovered as low-pressure steam in an evaporator reboiler system. The steam generated can be used in the pulping process itself or in paper making in case of an integrated mill. Heat recovery systems can be expected to save between 3.2 to 5.5 GJ/tonne of pulp. We will calculate with an average value of 4.4 GJ/tonne. Electricity demand will increase by 0.5 GJ/tonne.
Ind-16	Refiner improvements	The electricity demand for refining can be reduced by several options: refiner control strategies, conical instead of disk refiners and decreasing the consistency of pulping to 30% from 50%. An estimate is total sav-

⁹ According to CEPI this energy saving is far too high; savings of about 5% have been achieved in test runs, according to CEPI.

Code	Measure database	Description
		ings for the US industry at 11% of the electricity demand for pulping. If we make the same assumption for the EU the saving would be about 0.35 GJ _e /tonne of pulp.
Ind-18	Pressing to higher consistency, e.g. by extended nip press (paper making)	Removal of water in the pressing section is far less energy-intensive than in the drying section. Therefore, an increase in the fibre concentration after the pressing section can result in a reduction of the energy demand of the drying section. This can be achieved by using an extended nip press (or long nip press). With an extended nip press the fibre concentration after the pressing section can be increased to 53-55% compared to 42-48% for conventional pressing. On average an increase of 4% seems possible. Each percent increase results in a 4% saving on the steam demand of the pressing section. Since 90% of the heat demand of a paper mill is for the drying section, a maximum saving of 0.8 GJ/tonne results. Because this measure cannot be applied equally to all paper grades we use a saving of 0.5 GJ/tonne. The electricity demand will increase by about 0.05 GJ/tonne of paper due to increased used of vacuum and driving power.
Ind-19	Improved drying, e.g. condensing belt drying	The production speed of paper machines is limited by the drying rate of the conventional drying section. A combination of pressing and drying can increase the drying rate and simultaneously reduce the energy consumption. Condensing belt drying is developed by Valmet-Tampella in Finland. The first commercial units are already in operation, albeit at a small scale. It results in improved sheet properties and easy operation at high speeds. Energy can be saved because heat can be recovered easier than with conventional drying. Saving on the heat demand is estimated to be on the order of 0.5-1.0 GJ/tonne paper. Impulse drying involves pressing the paper between one very hot rotating roll (150-500°C) and a static concave-shaped press with a very short contact time. Sheet dryness can be increased to 55-78%, depending on the type of paper. Impulse drying is still not commercial, despite international R&D efforts. It is also not clear whether impulse drying will result in an energy saving. Therefore, this technology is not expected to be implemented before 2010.
Ind-20	Reduced air requirements, e.g. by humidity control in paper machine drying hoods	In most paper mills the drying section is covered with a closed hood. By better insulation of the hood condensation of water vapour shall occur at a higher temperature reducing the amount of ventilation air required. An average dew point increase of 4°C was possible in The Netherlands in 1990, resulting in a reduction of the heat demand of 0.3 GJ/tonne of paper.

Specific assumption for CEEC

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4.2.3 Subsector: Iron and steel, Issues: Energy and GHG gases

In 1990 all EU countries had steel production facilities. Germany, Italy, France and the United Kingdom, account for nearly three-quarters of the total EU production (approximately 150 million tonnes). Integrated steel plants based on blast furnaces and basic oxygen furnaces (BOF), accounted for 70% of the crude steel production, the balance being produced in electric arc furnaces (EAF)¹⁰. Only in Eastern Europe some steel is made in the obsolete Open Hearth Furnace. Whereas in 1990 steel making in Luxembourg was completely based on the BOF-route, since August 1997 it is 100% EAF-based. Between 1994 en 1997 three EAF plants were built and the sinter plants, blast furnaces and BOFs were decommissioned. It is expected that also in other countries a shift from primary to secondary steel making routes will take place (scrap-based production).

Stock activity data

- Specific energy demand per country.....
- Production figures....
- CO₂-emissions factors for the fuel mix used per sector (kg CO₂/GJ) were calculated from IEA Statistics.....

Improvement new stock

Assumption is that plants with a Smelt Reduction Unit (SRP) will gradually replace BOF plants (primary steel) (not before 2010). Plants with Direct Reduction technology (DRP) will gradually replace Electric Arc plants (secondary steel). One could look at these new technologies as retrofit shift options, but since it is not likely that existing plants will be retrofitted with these new technologies (although technically speaking it is possible), DRP and SRP are considered as new technologies in the database (see also section 3.2).

Measures existing stock

Code	Measure database	Description
Ind-1	Injection of pulverised coal and plastics waste in blast furnaces	Injection of fuel, particularly pulverised coal, into the blast furnace to replace part of the coke is already a common measure in many countries. The maximum injection rate still has to be determined but is estimated at 280-300 kg of pulverised coal per tonne of pig iron. Experiments with such a high injection rate at the Dutch iron and steel plant (Hoogovens) turned out to be a failure [De Jong, 1999]. The highest injection rate achieved so far is 225 kg/tonne pig iron, amongst others at Hoogovens. This means that about 40-45% of the energy and feedstock required by the blast furnace is injected in the

¹⁰ OHF = Open Hearth Furnace, BOF = Basic Oxygen Furnace, BF = Blast Furnace, EAF = Electric Arc Furnace, DRP = Direct Reduction Plant, SRP = Smelt Reduction Plant.

Code	Measure database	Description
		form of pulverised coal, the remainder being mainly coke.
Ind-2	Heat recovery from sinter cooler air	The recovered heat can be used to preheat raw material or combustion air or to produce steam. Sinter plant heat recovery has been applied in several integrated mills worldwide. Energy savings are estimated at 0.55 GJ/tonne sinter; the electricity demand increases by 1.5 kWh/tonne sinter. These data are based on a retrofitted system at Hoogovens, the Netherlands. [
Ind-3	Recovery from energy in process gases from the blast furnace and the basic oxygen furnace	Process gases contain energy in the form of heat, chemicals and pressure. Various options are available to recover these forms of energy. The total amount of energy that can be recovered from BF and BOF is 0.9-1.4 GJ/tonne of liquid steel. The recovered electricity is expressed as saved fuel (efficiency 40%) assuming that most electricity is generated on site. The potential savings for each country are assumed to be dependent on the 1990 efficiency. If the SEC is higher than 25 GJ/tonne it is assumed that the 1990 penetration of the technologies is 0%, if the SEC is lower than 25 GJ/tonne the 1990 penetration is assumed to be 10%. The size and age of the furnaces limit the maximum penetration. Older furnaces work under a pressure that is too low for pressure recovery. Since most furnaces in Europe are older than 25 years it is assumed that the maximum penetration is 20%.
Ind-4	Application of continuous casting	In 1998 the penetration of continuous casting was 83.3% worldwide. Penetration in Western European countries is even higher. Continuous casting is a mature technology and is in general exploited to its maximum in Western Europe. In Eastern Europe there still is potential for this measure.
Ind-5	Efficient recovery of low-temperature heat	An integrated steel plant has a number of high-temperature processes. Several techniques are available to recover the heat that would otherwise be lost. We estimate the total saving of low-temperature heat recovery at 0.5-1.0 GJ/tonne crude steel, excluding the potential of techniques that were dealt with separately.
Ind-6	Increase scrap input in primary steel making	The maximal input of scrap met in experiments at Hoogovens (De Jong 1999) was 30%. Savings of 3,6 GJ fuel/tonne steel are achieved [Icarus, 2001].
Ind-7	Scrap preheating in electric arc furnaces	Preheating of the scrap before being charged into the furnace by use of the hot off-gases of the furnace is a way to save on the power demand for melting. However, extra energy is required to treat the off-

Code	Measure database	Description
		<p>gases and the balance is not always positive. Two technologies are in use: the Finger Shaft Furnace and Conroll. Scrap preheating in the Finger Shaft Furnace is achieved by holding the scrap in a bucket above the furnace. Cooled fingers in the form of a grab at the bottom of the bucket hold the scrap in place. When the preheating stage is finished the grab is released and the scrap is loaded into the melt. In the Conroll process scrap is preheated in a long tunnel with counter current off-gases and auxiliary burners. The scrap is fed continuously into the furnace. With both systems a saving of about 80 kWh/tonne liquid steel can be achieved. Both systems have already been applied to numerous furnaces in USA, Europe and Japan. An additional fuel consumption of 0.2 GJ/tls is required [De Beer et al., 1998].</p>
Ind-8	Oxygen and fuel injection in the electric arc furnace	<p>Injection of oxygen and fuel can improve the energy efficiency of an electric arc furnace in the following ways:</p> <ul style="list-style-type: none"> - Post combustion - Foamy slag practise - Oxy fuel burners <p>Overall a saving of 80 kWh/ton liquid steel on electricity demand is assumed. The fuel demand will increase by 0.24 GJ/tls.</p>
Ind-9	Improved process control in mini mills;	<p>Artificial intelligence techniques, e.g. fuzzy logic's or neural networks, can be applied to optimise the energy input. Especially with the complex heating schemes that are used in modern ultra high power (UHP) furnaces this type of control systems is necessary. The savings depend on the raw material input, the type of furnace and the furnace operation. In line with we assume that savings of 30 kWh/tcs are possible on average. Other advantages of automated controls are an increased productivity and lower electrode consumption. The capital costs are estimated at €0.95/tonne steel (€9/GJ saved annually). We assume that the savings that could be achieved by systems available in 1990 were small compared to the currently available systems. [</p>
Ind-10	Thin slab casting	<p>Thin slab casting allows casting of thinner slabs (40-125 mm) than with continuous casting (150-300 mm). Less energy is required to reheat the slabs before rolling. Thin slab casters were originally designed for minimills, but are now being constructed or planned by some integrated steel manufacturers. IISI [1998a] reports the following data for the energy consumption of an actual thin slab caster (CSP-technology): 250 MJ of electricity/tonne and 350 MJ fuel/tonne. Continuous casting, reheating and hot rolling use about 4 GJ of fuel and 0.6 GJ of electricity per tonne of slabs. Thus, assuming</p>

Code	Measure database	Description
		that 40% of the steel production is on average in the form of slabs, the savings amount to 1.5 GJ of fuel and 0.15 GJ of electricity per tonne steel.
Ind-11 Ind-12	Miscellaneous measures (low and high cost tranche)	A large number of other measures are available that can be taken in the iron and steel industry. The fuel savings in the low cost range (average costs €15/GJ saved annually) total to 1.0 GJ/tonne steel and the electricity savings to 0.1 GJ/tonne steel. In the high cost range (average costs €50/GJ saved annually) the potential saving on electricity demand is 0.05 GJ/tonne steel. The savings on fuel demand in this range amount to 1.0 GJ/tonne steel.

Specific assumption for CEEC

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4.2.4 Subsector: Non-ferro, Technology: Aluminium, Issues: Energy and GHG gases

In 1998, 22 million tonnes of primary aluminium were produced world wide, of which the largest part (almost 30%) in North America and approximately 16% in Western Europe. The secondary production amounted 7,4 million tonnes, of which 46% in Northern America and over 30% in Western Europe. There are over 200 primary smelters located in 46 countries with a capacity of 25 million tonnes. The smallest in size is rated at just several thousand tonnes per year and the largest rated in the order of 850.000 tonnes per year (located in Russia).

Primary aluminium is produced in the Hall-Héroult process by passing a direct current through a bath with alumina dissolved in a molten cryolite electrode. Different cells are available: Centre Worked Prebake (CWPB), Side Worked Prebake (SWPB) and, the state-of-the-art cell, the Point Feed Prebake (PFPB). In CWPB cells, alumina is fed along the longitudinal centre line in the reactor bed whereas in SWPB cells, alumina is fed along the sides of the cells. There are two ways of alumina feed; bar feed and point feed. Point feed systems offer more precise process control of alumina concentration, allowing higher current efficiencies, lower energy consumption and lower emissions compared to conventional bar feeders [ICF, 1999].

In the Soderberg cell a single monolithic carbon anode is used, that is formed directly in the cell. Electrical connectors can be placed horizontally in the cell (HSS Horizontal Stud Soderberg) or vertically (VSS Vertical Stud Soderberg). The anodes used in the process are consumed at a rate of 0,45 kg/tonne aluminium.

The electricity use varies from 46,8 GJ/tonne for more state-of-the-art plants to 60 GJ/tonne for old Russian smelters. The theoretical minimum is 23 GJ/tonne aluminium,

so there is still room for improvement. In total, on average, the production of aluminium demands 17.8 GJ fuel per tonne and 52 GJ electricity per tonne (including anodes). The CO₂ emissions are not only energy related but also process related.

Secondary aluminium uses only 5 to 10% of the energy demand for primary production because it involves remelting of the metal instead of the electrochemical reduction process. An important aspect of secondary aluminium production are the necessary pre-treatment steps to make post consumer waste applicable as input in the smelter. There are technological developments concerning the pre-treatment steps, some of which might lead to energy savings, but these developments have not been included.

Stock activity data

- Specific energy demand per country.....
- Production figures....
- CO₂-emissions factors for the fuel mix used per sector (kg CO₂/GJ) were calculated from IEA Statistics.....

Improvement new stock

According to [Gielen, van Dril, 1997] the potential for additional electricity savings are 5 to 10%. No major technological breakthroughs are expected the next 25 years. In this study no new technologies have been defined for production of primary or secondary aluminium. The existing technologies are expected to become more energy efficient.

Measures existing stock

Code	Measure database	Description
Ind-23	Retrofit existing Hall-Héroult process	A portfolio of options to retrofit existing cells is available, e.g. alumina point-feeding, process computer control, conversion from wet to dry anodes (Soderberg cells only) and improvements to bath chemistry, anode design, busbar design and cathode shell composition and design [ICF, 1999]. An existing SWPB smelter being converted to PFPB can achieve at most a saving of 1 MWh/tonne depending on the starting point. A VSS smelter being retrofitted can also save about 1 MWh/tonne and a VSS smelter being rebuilt to PFPB can save 2 – 2.5 MWh/tonne. On an EU scale most of the smelters are already today operating PFPB technology and the smelters available for retrofitting are only about a third of the total operating EU smelters [Nordheim, 2000]. An average saving of 1 MWh/tonne for 33% of the capacity is assumed.
Ind-24	Inert anodes	Inert anodes are non-carbon anodes that are not consumed in the electrolytic process. Inert anodes are not yet commercially available, but field-testing is currently underway [ICF,

Code	Measure database	Description
		1999]. Considering the potential savings, a direct replacement will not give any energy savings; this will require a total rebuilding of today's cell design, using a bipolar design. It is too optimistic to expect any saving already by 2010.
Ind-25	Wettable cathode	The wettable cathode is made of an inert material and allows reduction of the gap between anode and cathode [ICF, 1999]. Application of the wettable cathode can result in a reduction of the SEC, an increase of the current efficiency and an increase of the cell's stability. The wettable cathode has been field-tested and is undergoing materials failure analysis. Commercial designs are expected in the next 10-20 years. In combination with a drained cathode this could give energy savings of 0.2-0.3 MWh/tonne at any given plant, representing a saving of up to 2% on today consumption.

Specific assumption for CEEC

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4.2.5 Subsector: Non-metallic minerals, Issues: Energy and GHG gases

Cement is considered one of the most important building materials around the world. Cement is an inorganic, non-metallic substance with hydraulic binding properties. In the common cement types, e.g. Portland, the hardening is mainly due to the formation of calcium silicate hydrates. The main raw material for cement is clinker (made from calcium carbonate, silicon dioxide, aluminium oxide and iron (III) oxide). These compounds react during a heating process. There are numerous different cement types, due to the use of different sources for calcium and different additives to regulate properties. The most important sources for calcium are limestone, blast furnace slag and fly ash.

Four production steps are distinguished in the description of the production of cement:

- Quarrying and mining: mining of the raw materials.
- Preparing raw materials: Mixing/homogenising, grinding and preheating (drying) produces the *raw meal*.
- Burning of raw meal to form cement clinker in the kiln: The components of the raw meal react at high temperatures (900-1500 °C) in the rotary kiln, to give clinker.
- Finish grinding of clinker and mixing with additives: After cooling the clinker is ground together with additives.

Continuous production of clinker started with the use of shaft kilns around 1880, followed by the introduction of the dry rotary kiln. The wet process, fed by slurry, was introduced to achieve better homogenisation of the kiln feed, easier operation, less dust,

and more uniform cement quality. In 1928 the Lepol, or semi-dry, process was introduced, reducing moisture content of the material entering the kiln, reducing fuel consumption. Improved raw meal homogenisation systems and dust collection equipment improved the product quality of the dry process. The introduction of a dry kiln with material (suspension) preheating reduced the energy costs compared to the commercially used processes in the 1950's. The latest technology development was the introduction of the precalciner in the 1970's; reducing energy needs further, while boosting productivity when rebuilding existing kilns. Table 1 shows the specific fuel demand for different types of cement kilns.

Table 1 Actual specific fuel demand for different types of cement kilns.
[BREF-Cement, 2000].

Kiln type	Specific fuel use (GJ/tonne clinker)
Dry process, multi-stage cyclone preheater and precalciner kiln	About 3.0
Dry rotary kiln equipped with cyclone preheater	3.1-4.2
Semi-dry/semi-wet process (Lepol-klin)	3.3-4.5
Dry process long kiln	up to 5.0
Wet process long kiln	5.0-6.0
(Shaft kiln)	(3.1-4.2)

Electricity is mainly required for raw and finish grinding and the exhaust fans. Total specific electricity production is in the order of 90-130 kWh/tonne cement (0.3-0.5 GJ/tonne). [BREF-Cement, 2000].

Stock activity data

- Specific energy demand per country.....
- Production figures....
- CO₂-emissions factors for the fuel mix used per sector (kg CO₂/GJ) were calculated from IEA Statistics.....

Improvement new stock

- Assumption is that no complete new technologies are expected to come into the market for the production of cement and/or clinker.
- The assumption is that existing technologies for production of cement will become more efficient up to the year 2030. New installed capacity in 2010 will have efficiencies on average equalling the best-observed in 1998. In 2020 new capacity is on average 10% more energy efficient than in 2010 and in 2030 another 10% more efficient.

Measures existing stock

Code	Measure database	Description
Ind-26	Use of waste derived fuels	Waste processing in the cement industries is technical and economical feasible and current practise. Waste as alternative fuel is increasingly used in cement plants. Waste may

Code	Measure database	Description
		<p>reduce CO₂ emissions by 0.1 to 0.5 kg/kg cement produced compared to current used production techniques using fossil fuels [BREF-cement, 2000]. The use of waste generates no additional emissions, although care should be taken for high volatile elements as mercury, thallium, cadmium and chlorine.¹¹ On the other hand, the use of waste does not impair clear environmental advantages, besides the reduction of substituted fossil fuels. In 2000 10-15% of the total fuel consumption in the EU was in the form of alternative fuels and the rate is constantly increasing [Hjorth, 2000]. The future possibility of using waste differs from country to country. The barriers are availability of suitable waste, lack of infrastructure to collect useful waste, legislation, public concern and competition with incinerators. Since waste can be used as combustible in a variety of installations such as incinerators with or without energy generation, power plants and cement kilns, it seems very complicated to establish the avoided CO₂ emissions of one of the installations.</p>
Ind-27	Reduce clinker content of cement	<p>Clinker production is the most energy-intensive step in cement production. Moreover, on average about 50% of the direct CO₂ emissions of cement production is the non-fuel related process emission from clinker production. Substantial CO₂ emission reduction can be obtained by reducing the amount of clinker required, i.e. reducing energy use and process emissions. One option to reduce clinker use is by substituting clinker by industrial by-products such as coal fly ash, blast furnace slag or pozzolanic materials (e.g. volcanic material).</p>
Ind-28	Application of multi-stage preheaters and pre-calciners	<p>An existing preheater kiln may be converted to a multi-stage preheater precalciner kiln by adding a precalciner and, when possible and extra cyclone. The addition of a precalciner will generally increase the capacity of the plant. For new plants the specific fuel consumption can be lowered; this is not automatically the case in retrofit situation [HJORTH, 2000].</p>
Ind-29	Optimisation of heat recovery of clinker cooler	<p>The clinker cooler cools clinker from 1200 °C down to 100 °C. The most common cooler designs are of the rotary,</p>

¹¹ The emissions of conventional air pollutants (including mercury, thallium, cadmium and chlorine) have been regulated under the new Waste Incineration Directive (2000/76/EC) dated 4 December 2000.

Code	Measure database	Description
		<p>planetary (or satellite) and grate type. All coolers heat the secondary air for the kiln combustion process and sometimes also tertiary air for the precalciner [Alsop and Post, 1995]. Grate coolers are the modern variant and are suitable for large-scale kilns (up to 10,000 tpd). Grate coolers use electric fans and excess air. Rotary coolers (used for approximately 5% of the world clinker capacity for plants up to 2000-4500 tpd), and planetary coolers (used for 10% of the world capacity for plants up to 3000-4000 tpd) do not need cooler fans and use little excess air, resulting in relatively lower heat losses[Buzzi and Sassone, 1993; Vleuten, 1994]. Improving heat recovery efficiency in the cooler results in fuel savings, but may also influence product quality and emission levels. Heat recovery can be improved through reduction of excess air volume [Alsop and Post, 1995], control of clinker bed depth and new grates. Control of cooling air distribution over the grate may result in lower clinker temperatures and high air temperatures. In the EU-12, over 70% of the clinker coolers were grate coolers, the rest being mainly planetary coolers [CowiConsult, 1992].</p>
Ind-30	Electricity savings	<p>The demand for electricity can be reduced by various measures:</p> <ul style="list-style-type: none"> - Use roller mills for grinding raw materials instead of ball mills (saving 7 kWh/tonne clinker) [Martin et al, 1999] . - Efficient grinding technologies, high-pressure mills (saving 16-19 kWh/tonne [Hendriks et al, 1999]). - High-efficiency classifiers resulting in a sharper separation reducing overgrinding (saving 1.7-2.3 kWh/tonne) [Hendriks et al, 1999]) . - High-efficiency motors and drives and adjustable speed drives (saving 10-15 kWh/tonne) [Martin et al, 1999]).

Specific assumption for CEEC

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4.2.6 Subsector: Fossil fuel extraction Issues: Gas extraction, gas distribution, oil extraction and solid fuels

[Include short description of the technologies included]

Stock activity data

- Used datasources: CRF of UNFCCC; [EC, 2000; BP-Amoco 1999; Esso 1999; Coal information 1995 and 1996; EC 1998] (see SO)
- Assumptions:
 - Numbers of activity and EFs are taken from CRF. When not available data is taken from other sources (as reported in SO)
 - When no data were available a default number for EF was taken
- Calculations performed to get right input data : When Mtcoal is mentioned multiplied by 26e6 GJ/Mt.

Improvement new stock

This option is not used for this subsector.

Measures existing stock

- Used datasources: all data and measures were taken from Sectoral Objectives (Ecofys....)¹²
- Assumptions: calculations performed to get right input data:
 - cost data was only available in euro/tCH₄-avoided. To come to euro/activity[GJ] the costs data was multiplied by EF and Emission reduction percentage.
 - For the EF fixed numbers were chosen (so not the country specific numbers). Assumed was that countries with a low EF already had implemented measures to reduce emissions. Using fixed EF results in same costs per country. If country specific EF was used, this would imply that countries with high EF will have lower costs.
- Implementation degree:
 - Coal production: EU countries SO numbers; other countries: countries with lower EF than the EF used for calculating the costs have an implementation in 1998 higher than 0%. (if EF is higher than nothing happens).
 - Oil and Gas: countries with lower EF than the EF used for calculating the costs have an implementation in 1998 higher than 0%. (if EF is higher than nothing happens).

Specific assumption for CEEC

¹² Aanpak olie en gas omrekening naar euro/GJ doorzet

Bekend:

- Kosten per euro/tCH₄(vermeden): [C]
- Aandeel emissie in subsector [%Es]
- Totale emissie sector [T]
 - Vermenigvuldigen met elkaar geeft emissie in subsector [ES] = [%Es] * [T]
 - Doorzet energie in GJ [E]
 - Delen op elkaar geeft emissiefactor in subsector [EFs] = [ES] / [E]

Kosten per tCH₄ [C] delen door emissiefactor [C] / [EFs] geeft kosten per GJ doorzet [K]

Om tot een betere toekenning te komen zou je gas moeten verdelen in

- productie
- consumptie (met gegeven welke deel met distributie)

Aandeel in emissie is landspecifiek

No specific assumptions for CEEC

4.3 Sector: Households

4.3.1 Subsector: Households, Issues: Energy and GHG gases

Stock activity data

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Improvement new stock

The cost of a newly built house in 2000 is about 100.000 Euro [housing statistics in several Western European countries]. It is assumed that these costs are equally divided over the fixed investment costs and fixed O&M costs [Misset, 1998]. The running costs are about 2% of the total fixed costs [Association own house, 1999]. It is assumed that these cost consist of 55% material and 45% labour costs for new buildings [Elsevier, 2002]¹³.

Furthermore it is assumed that the costs in the years 2010, 2020 and 2030 are comparable with the costs in 2000 (frozen scenario). New buildings have already a much lower energy demand for space heating than buildings of the existing stock. It expected that this trend will continue in the future. These reductions are based on improvements of the insulation building standards [Eurima, 1999] [Novem, 2002].

Measures existing stock

The sectoral objective study serves as basis for the cost of the measures. This study is thoroughly reviewed by experts in the fields (glass manufacturers, insulation branch and heat pump experts) [Sectoral objectives, 2001]. The division between fixed investment cost and fixed O&M costs is based on several Dutch sources [Consumentenbond, 1999] [Novem, 2001]. The running costs for maintenance of heat pumps and condensing boilers are mainly for labour (90%) [expert estimate, Ecofys]. The maximum implementation is in general assumed to be 100% with the exceptions of the measure heat pumps and condensing boilers. For these measures the maximum implementation degree is assumed to be 60%, due to technical barriers and excluding houses with district heating.

Code	Measure database	Description
Hou-1	Retrofit houses: improving building shell: wall insulation	Heat losses of existing poorly insulated houses can be reduced through insulation. Particularly retrofit wall insulation can save substantial quantities of energy since the heat loss per unit of wall surface can be reduced substantially.

¹³ We used among other expert guesses, because according to [BCIS, June 2002] the survey about average European building costs (including distinction between material and labour costs) stopped 12 years ago.

Code	Measure database	Description
Hou-2	Retrofit houses: improving building shell: roof insulation	Roof insulation is cheaper and simpler to implement than wall insulation. The energy saving depends on both the roof type and the heat demand of the room beneath the roof (low heat demand results in low energy saving, high heat demand results in high energy saving).
Hou-3	Retrofit houses: improving building shell: windows, double glass	<p>Another important insulation measure is the replacement of single windows or double pane windows by highly insulated windows.</p> <p>Double pane: U-value 3 W/m²K (U-value – heat transmission coefficient. The lower this value is, the smaller is the heat loss. Including losses through frame).</p> <p>Major assumptions:</p> <ul style="list-style-type: none"> • replace single pane by double pane • average window space 21 m² per dwelling <p>Saving and cost figures:</p> <ul style="list-style-type: none"> • about 791 MJ/m² window insulation • about 97 Euro/m² window insulation
Hou-4	Retrofit houses: improving building shell: windows, HR ⁺⁺ , best practice	<p>Argon-filled low e-window: U-value 1,5 W/m²K</p> <p>Major assumptions:</p> <ul style="list-style-type: none"> • replace single pane by HR⁺⁺ pane • average window space 21 m² per dwelling • calculation additional to double glass to avoid double counting <p>Saving and cost figures:</p> <ul style="list-style-type: none"> • about 1108 MJ/m² window insulation, • additional saving 317 MJ/m² window insulation • about 116.4 Euro/m² window insulation, • additional cost 19.4 Euro/m² window insulation
Hou-5	Retrofit houses: improving building shell: windows, super window	<p>Super windows: U-value glass 1 W/m²K.</p> <p>Major assumptions:</p> <ul style="list-style-type: none"> • replace single pane by superwindow • average window space 21 m² per dwelling • calculation additional to HR⁺⁺ to avoid double counting <p>Saving and cost figures:</p> <ul style="list-style-type: none"> • about 1200 MJ/m² window insulation, • additional saving 92 MJ/m² window insulation • about 175 Euro/m² window insulation, • additional cost 58.6 Euro/m² window insulation
Hou-6	Advanced heating systems: heat	A heat pump transports heat of a low temperature level to a

Code	Measure database	Description
	pumps	high temperature level. Heat is extracted from the environment (soil, air, ground water, exhaust air from dwelling, sewage) upgraded using a compressor and delivered to either a radiator or warm air heating system. An indication of the energy saving per dwelling is 75% (final energy) and 30% to 50% (primary energy).
Hou-7	Advanced heating systems: condensing boilers	A considerable amount of the fossil fuel combustion products consists of water vapour. Condensing boilers use a heat exchanger to condense the water vapour and extract the heat. Hence, the latent heat of the water vapour is made use of and the efficiency of the boiler is improved.
Hou-8	Cold appliances: Best Practice	This measure consists of reducing the average level of energy consumption to the best practice level in 1999. It is assumed that 65% of the total stock will be replaced by best practice equipment.
Hou-9	Very energy efficient refrigerators and freezers	In case new techniques are used, such as vacuum insulation, energy savings by 80% can be achieved compared to the average energy consumption in 1995 [Boardman et al, 1997a; Boardman et al, 1997b]. It is assumed that 5% of the total stock will be replaced by equipment with such a high efficiency.
Hou-10	New residential houses: Best Practice (this measures apply to New houses)	<p>So-called superinsulated prototype dwellings have been built over the last 15 years in both Europe and North America. Their energy requirement for space heating is typically about 30-50 kWh/m², this is about 40% lower than the average standard for new buildings. This is mainly achieved by the following measures:</p> <ul style="list-style-type: none"> • Highly insulated building shell (U-value floor and external walls 0.20 W/m²K, roof 0.15 W/m²K). • Argon filled low-e windows • Ventilation rates are reduced to average air exchange rates of 0.3 per hour using demand-orientated ventilation systems. (Air quality benefit is higher than that provided by uncontrolled infiltration of the same average magnitude: when the building is fully occupied, ventilation provides more than the average per hour rate and vice versa) [Krause et al., 1998]. <p>A recent project of the WWF in the Netherlands shows that it is already possible to realise low energy dwellings (about 30</p>

Code	Measure database	Description
		kWh/m ²) on a commercial basis.
Hou-11	New residential houses: Zero Energy (this measures apply to New houses)	The advances in component technology (e.g. superwindows, vacuum insulation) combined with improved design tools will allow to realise dwellings with no or a very low space heating requirement (0-15 kWh/m ²). Here, space heating related energy use is more or less limited to the electricity demand for operating ventilation systems and controls (few hundred kWh in a well-designed system). An example of recent demonstration project is: townhouses in Darmstadt-Kranichstein in Germany with a space-heating requirement of 10-15 kWh/m ² . The field experience suggests that present building technology alone would allow the construction of completely passive-solar dwellings in Southern Europe [Krause et al., 1998].

Specific assumption for CEEC

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4.4 Sector: Services

4.4.1 Subsector: Services, Issues: Energy and GHG emissions

Stock activity data

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Improvement new stock

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Measures existing stock

Code	Measure database	Description
Serv-1	Retrofit services buildings: improving building shell: wall insulation	In poorly insulated or uninsulated buildings there are enormous heat losses through the building envelope. One measure with great effect is wall insulation. The impact of the application of wall insulation depends very much on the age distribution profile of buildings, the renovation level etc. Only little information is available on these aspects which decisively influence the energy use of the services sector. The results of the measures assumed for the domestic sector are translated

Code	Measure database	Description
		to the services sector by correcting for the relative lower heat losses through walls in the services sector and taking into account other characteristics.
Serv-2	Retrofit services buildings: improving building shell: roof insulation	Another measure to reduce heat losses of the building shell is roof insulation.
Serv-3	Retrofit services buildings: improving building shell: windows, double glass	<p>The replacement of single pane windows by double pane windows, Ar-filled low-e windows or superwindows represents a considerable energy saving potential.</p> <p>Double pane: U-value 3 W/m²K (U-value – heat transmission coefficient. The lower this value is, the smaller is the heat loss. Including losses through frame).</p> <p>Major assumptions:</p> <ul style="list-style-type: none"> • replace single pane by double pane • window space / gross floor space ratio is 0.2 (based on reference office building) <p>Saving and cost figures:</p> <ul style="list-style-type: none"> • about 791 MJ/m² window insulation • about 97 Euro/m² window insulation
Serv-4	Retrofit services buildings: improving building shell: windows, HR ⁺⁺ , best practice	<p>Argon-filled low e-window: U-value 1,5 W/m²K</p> <p>Major assumptions:</p> <ul style="list-style-type: none"> • replace single pane by HR⁺⁺ pane • window space / gross floor space ratio is 0.2 • calculation additional to double glass to avoid double counting <p>Saving and cost figures:</p> <p>about 1108 MJ/m² window insulation,</p> <ul style="list-style-type: none"> • additional saving 317 MJ/m² window insulation • about 116.4 Euro/m² window insulation, • additional cost 19.4 Euro/m² window insulation
Serv-5	Retrofit services buildings: improving building shell: windows, superwindows	<p>Superwindows: U-value glass 1 W/m²K.</p> <p>Major assumptions:</p> <ul style="list-style-type: none"> • replace single pane by superwindow • window space / gross floor space ratio is 0.2 (based on reference office building) • calculation additional to HR⁺⁺ to avoid double counting <p>Saving and cost figures:</p> <ul style="list-style-type: none"> • about 1200 MJ/m² window insulation, • additional saving 92 MJ/m² window insulation • about 175 Euro/m² window insulation,

Code	Measure database	Description
		<ul style="list-style-type: none"> • additional cost 58.6 Euro/m² window insulation
Serv-6	Efficient space cooling equipment	<p>There are generally two ways for energy conservation in this area: reducing the need for cooling and by improving the efficiency of the cooling system. The demand for air conditioning can be reduced and sometimes eliminated by using natural shading in building design, natural shading by planting trees, improvement of ventilation and by efficiency improvement of other office equipment. The efficiency of the air conditioning system itself can be improved by improving the efficiency of the chiller, improved heat exchange, improved controls, switching to systems using a heat pump, adequate system design and improved maintenance [Levine, 1995]. Important are also the increased use of heat exchangers and economiser, which switch the air conditioning system to the use of outdoor air when the outdoor temperature is low enough to cool the building. The technical energy saving potential comes up to 40% based on most efficient models on the market [Levine, 1995]. Other important developments are storage of thermal energy in building mass ('night ventilation') and seasonal storage of thermal energy (for cooling and heating). Utilising the thermal storage capacity can cut cooling energy demand by 30-70% [Bevington and Rosenfeld, 1990].</p>
Serv-7	Building Energy Management Systems (BEMS): space heating and cooling	<p>Building energy management systems (BEMSs) automatically regulate the operation of all energy demands (heating, cooling, transport, lighting and equipment). The BEMS saves energy and water demands by producing accurate and proper comfort levels depending on climate conditions. They are especially realising energy conservation by switching off energy-services when rooms are not occupied. Particularly for the services sector, where many offices are empty for over 75% of the time, this is an essential source of energy saving. The introducing of BEMSs has been widely trailed and monitored in the public building sector (among others through the CADDET programme).</p> <p>Saving and cost figures:</p> <ul style="list-style-type: none"> • It is estimated that savings in the range up to 20% in space heating energy consumption could be realised if wider use of BEMSs were made in the public and services sectors [Ashford, 1998].

Code	Measure database	Description
		<ul style="list-style-type: none"> <li data-bbox="802 293 1086 315">• additional cost negligible
Serv-8	New services buildings: Energy efficiency level 1 (this measures apply to New buildings)	The energy intensity of space heating in new buildings is already lower than in existing buildings. A typical current energy demand for space heating of service buildings in the moderate climate zone is around 320 MJ/m ² . In many European countries buildings have been realised with very low heating requirement: e.g. in France, Spain, and the United Kingdom services offices have been built using around 200 MJ/m ² or less for heating. Based on this information it is assumed that it is possible to bring the average energy use for space heating of new services building in 2010 down to a level of 30% of average 1995 buildings (about 100 MJ/m ²). This can be achieved by applying good insulated building shell, heat recovery systems and energy efficient heating systems (heat pumps). 50% of the new buildings have 30% lower energy use for space heating compared to the autonomous development in 2010 (from 200 MJ/m ² to 140 MJ/m ²)
Serv-9	New services buildings: Energy efficiency level 2 (this measures apply to New buildings)	10% of the new buildings have 50% lower energy use (100MJ/m ²).

Specific assumption for CEEC

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5 Validation of input data

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Abbreviations

Act_b	Volume of the activity level of the Existing Stock for one technology in the base year
Act_ex	Volume of the activity level of the Existing Stock for one technology in a future year x
Act_nw_2000	Volume of the activity level of the New Stock for one technology in a future year x that has been implemented in the period between the baseyear and 2010
Act_nw_2010	Volume of the activity level of the New Stock for one technology in a future year x that has been implemented in the period between 2010 and 2020
Act_nw_2020	Volume of the activity level of the New Stock for one technology in a future year x that has been implemented in the period between 2020 and 2030
Ann	Annuity factor
b	Baseyear [number]
c	Abbreviation for a specific country e.g. AUT, NLD etc
dem	Annual pace of demolition of the existing stock, i.e. stock available in the base year [%]
Eelec	Specific electricity demand for one technology [GJ/SAI]
Ef_after_c	Specific emission or energy factor for one technology in a future year after implementation of one specific measure for a specific country c [kg or GJ/SAI]
Ef_after_def	Specific emission or energy factor for one technology in a future year after implementation of one specific measure for the default situation [kg or GJ/SAI]
Ef_c(b)	Specific emission or energy factor for one technology in the baseyear for a specific country c [kg or GJ/SAI]
Ef_c(old)	Specific emission or energy factor for one technology <u>before</u> implementation of one specific measure for a specific country c [kg or GJ/SAI]
Ef_def(b)	Specific emission or energy factor for one technology in the baseyear for the default situation [kg or GJ/SAI]
Ef_ex	Specific emission or energy factor for the existing stock for one technology in a future year x after implementation of emissions reduction or energy efficiency measures [kg or GJ/SAI]
Ef_new_2000	Specific emission or energy factor for the stock implemented in the period between the baseyear and 2010 [kg or GJ/SAI]
Ef_new_2010	Specific emission or energy factor for the stock implemented in the period 2010 and 2020 [kg or GJ/SAI]
Ef_new_2020	Specific emission or energy factor for the stock implemented in the period 2020 and 2030 [kg or GJ/SAI]
Eel	Specific electricity demand for one technology [GJ/SAI]
Efuel	Specific fuel demand for one technology [GJ/SAI]
Em	Total emissions or energy use in a specific year (either the baseyear of a specific future year) for one technology [kg]
En_cost_nw	Annual energy cost for the new capacity for one technology in a future year [Euro]

EP	Electricity price for one technology in a future year for a specific country [Euro/GJ]
Fixed_nw	Annual fixed cost for the new capacity for one technology in a future year [Euro]
Fixed_nw_200	Specific fixed cost for the new capacity for one technology in a future year implemented in the period 2020-2030 [Euro/SAI]
Fixed_nw_2000	Specific fixed cost for the new capacity for one technology in a future year implemented in the period between the baseyear and 2010 [Euro/SAI]
Fixed_nw_2010	Specific fixed cost for the new capacity for one technology in a future year implemented in the period 2010-2020 [Euro/SAI]
FP	Fuel price for one technology in a future year for a specific country [Euro/GJ]
gr _{2010_2020}	Annual growth rate of the volume of the activity level for one technology in the period 2010 and 2020 [%]
gr _{2020_2030}	Annual growth of the volume of the activity level for one technology in the period 2020 and 2030 [%]
gr _{B,2010}	Annual growth of the volume of the activity level for one technology in the period between the baseyear and 2010 [%]
I_c(b)	Implementation of a measure in the baseyear (%).
I_c(x)	Implementation of a measure in the a future year (%).
lt_new	Lifetime of the new stock [years]
Red	Specific emission reduction or energy efficiency improvement of a measure [%]
Run_nw	Annual running cost for the new capacity for one technology in a future year [Euro]
Run_nw_2020	Specific running cost for the new capacity for one technology in a future year implemented in the period 2020-2030 [Euro/SAI]
Run_nw_2000	Specific running cost for the new capacity for one technology in a future year implemented in the period between the baseyear and 2010 [Euro/SAI]
Run_nw_2010	Specific running cost for the new capacity for one technology in a future year implemented in the period 2010-2020 [Euro/SAI]
S_c	Share in sector for a specific country [%]
S_def	Share in sector for the default situation [%]
Tot_costs_ex	Total annual cost for the reduction measures applying to the existing capacity for one technology in a future year [Euro]
Tot_cost_nw	Total annual cost for the new capacity for one technology in a future year [Euro]
x	Future year [number]

Manual Calculator

Preparing input files

Copy data to the input files that are used by the Access database. Note

- the names of the input files should never be changed
- all cells should be filled out with numbers (so don't leave cells blank)

Input File in directory: S:\proj\M7\M763 MERLIN\CALCULATOR	Copy data from the following files and worksheets as values to the input files
STOCK_ACTIVITY.xls	[Sector name]STOCK_ACTIVITY.xls Copy all data from different country worksheets and the default worksheet as values to corresponding worksheets of the input files NOTE: Make sure that the header of your default sheet only holds the title, i.e. the (possible) row with numbers of units must be removed.
IMPROVEMENT_NEW_STOCK.xls	[Sector name]IMPROVEMENT_NEW_STOCK.xls Copy all data from different country worksheets as values to the corresponding worksheets of the input files (do not copy the default sheet) NOTE: Make sure that all technologies/sectors listed in the STOCK_ACTIVITY file are also included in the IMPROVEMENT_NEW_STOCK file. If for a certain sector or technology you <u>don't</u> want to work with a <u>vintage approach</u> you have to include (at least) 0 in the column lifetime. Then the calculator doesn't use the vintage approach but simply puts a growth factor on the level of the existing stock in 1998 to calculate the level of the activity level in a future year.
MEASURES_EX_STOCK.xls	[Sector name]MEASURES_EX_STOCK.xls Copy all data from different country worksheets and the default worksheet as values to corresponding worksheets of the input files NOTE: Make sure that the header of your default sheet only holds the title, i.e. the (possible) row with numbers of units must be removed.
SCENARIO_Activity_Levels.xls	[Sector name]SCENARIO_Activity_Levels.xls Copy all data from different country worksheets and the

Input File in directory: S:\proj\M7\M763 MERLIN\CALCULATOR	Copy data from the following files and worksheets as values to the input files
	discount rate sheet as values to the corresponding worksheets of the input files (do not copy the default sheet) NOTE: <ol style="list-style-type: none"> 1. Make sure that the header of your discount rates sheet only holds the title, i.e. the (possible) row with numbers of units must be removed. 2. For sectors/technologies where no vintage approach is applied no figure needs to be included in the column "demolishing rate".
SCENARIO_Implementation_degrees.xls	[Sector name]SCENARIO_Implementation_degrees.xls Copy all data from different country worksheets as values to the corresponding worksheets of the input files (do not copy the default sheet)

Preparing input data for the calculations

The following steps have to be taken:

1. Open the input file: S:\proj\M7\M763 MERLIN\CALCULATOR\SCENARIO_Activity_Levels.xls. Go to worksheet: parameters: Select for which future year scenario calculations have to be performed. Save the file.
2. Open the file S:\proj\M7\M763 MERLIN\CALCULATOR\MERLIN.mdb
3. Refreshing links with input files: Tools > Add ins > Linked Table Manager > Select All > Ok > Ok > Close
4. Import tables: Go to tab Macros: Run Macro: mcrImportSummaryMeasuresExStock
5. Set tables for calculations: Go to tab Queries: Run query: s_qrSCENARIO_Calculator_FILE_Emissions_NEW_maketblversion (answer yes to all questions)

Preparing results by running queries

- Queries must be run in order to obtain results. The results of the different queries can be analysed best by exporting them to Excel. On the Menu bar go to Tools > Office Links > Analyse it with MS Excel.
- In Excel the results can be best analysed by preparing Pivot Tables. On the Menu bar go to Data > Pivot Table Report.

Run Query to get:

1. Emission in the baseyear: s_qrEmissionInBaseYear: holds the emissions and the activity level per country per technology for the baseyear.
2. Future volume of the activity levels for the year chosen: s_qrSCENARIO_Calculator_FILE_1: This query present the resulting activity levels per technology per country for the year chosen (Note: only for the chosen year the

columns provide useful figures). Shown are the total volume per technology and the split for existing and new.

3. Emissions and energy use for the year chosen: s_grEmission. This query provides for the chosen year energy use and emissions per technology per country (i.e. emission of new and existing stock)
4. Emission reduction Existing stock per measure per technology per country for year chosen: s_grEmissionReductionPerMeasurePerCountry
5. Total annual costs for new capacity installed in the period between the baseyear and the year chosen: s_grTotal_Cost_Nw. (These costs can e.g. be calculated for a BAU scenario and in a second step for a scenario with a lot of renewables. The difference in total cost between the BAU scenario and the 'renewables' scenario divided by the difference in emissions between these two scenarios determine the cost effectiveness of this strategy.

Analysing results

The results can most easily be analysed in Excell.

1. In main menu Access choose: Tools > Office Links > Analyse it with MS Excel
2. In main menu Excell choose: Data > Pivot Table Report