Fraunhofer

Energy-Using Product Group Analysis - Lot 5

Machine tools and related machinery

Task 4 Report – Assessment of Base Case

Sustainable Industrial Policy - Building on the Ecodesign Directive - Energy-using Product Group Analysis/2

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Executive Summary – Task 4

According to Task 1 the scope of the study selected nine base cases reflecting the following aspects:

- type of manufacturing,
- level of automation,
- type of machine tool according to DIN EN ISO 23125,
- metal forming machinery and machine tool according to EUROSTAT, NACE Rev. 2,
- PRODCOM,
- EPTA study,
- woodworking machine tools according to ISO 7984 and
- machine tool's definition according to CECIMO, VDW and other stakeholders.

The base cases have been extracted from these criteria in chapter 4.2. According to Task 2, Table 2-3 the overall stock of metal working machine tools presented a volume of €14.1 billion in 2009. Woodworking machine tools had a market volume of €2.5 billion in 2009, welding, soldering and brazing equipment a market volume of €2.0 billion. The future market share of these five categories is estimated to be roughly the same as in the past and present with a slight increase of numerically controlled machine tools accounting non-numerically controlled machine tools. Based on findings for the machine tools market the **Base Case (BC) assessments**, meant to be conscious abstractions of reality, cover one typical machinery of each of the following segments:

- **BC 1: numerically controlled machining centre,**
- **BC 2: numerically controlled deep drawing or bending machine tool,**
- **BC 3: laser cutting machine tool,**
- **BC 4: non-numerically controlled metal working drilling machine,**
- **BC 5: machine tool for woodworking: light stationary table saw,**
- **BC 6: machine tool for woodworking: horizontal panel saw,**

- **BC 7: machine tool for woodworking: throughfeed edge banding machine,**
- **BC 8: machine tool for woodworking: CNC machining centre, and**
- **BC 9: transportable welding equipment.**

This choice is based on the rationale, that the various levels of machine complexity should be addressed, different processes applied and the variety of materials processed.

The assessments confirm the relevancy of use phase energy consumption, but for some impact categories also the production of the machine tools matters.

The total energy consumption (primary energy) of **CNC metal working machining centres** (Base Case 1) is in the range of **410 PJ per year**, which is much more than for any of the other calculated Base Cases. Further relevant machine tools segments are welding equipment (46 PJ per year), industrial wood working machine tools (represented by horizontal panel saws, throughfeed edge banding machines, and CNC machining centres; 36 PJ per year) and CNC laser cutting machine tools (32 PJ per year). The **total energy consumption of all Base Cases is 645 PJ per year**, of which **60 kWh comprises electricity**, and the total aggregated **Greenhouse Gas emissions** amount to **28 million tonnes CO_2-equivalents**. The Base Cases cover the most relevant market segments of machine tools covered by this study, but not all such segments. Therefore, there is an underestimation of total impacts; however the order of magnitude is plausible.

4 Task 4 – Assessment of Base Case

For the environmental and economic assessment relevant machines constitute so-called Base Cases. On these Base Cases most of the environmental and Life Cycle Cost analyses will be built throughout the rest of the study. The Base Case is furthermore the point of reference for tasks 6 (improvement potential) and 7.2 (impact analysis). The Base Case is a conscious abstraction of reality. Having said that, the question if this abstraction leads to inadmissible conclusions for certain market segments will be addressed in the sensitivity and impact analysis.

The assessment methodology used for this analysis is the Excel MEEuP report, developed in 2005 by VHK to provide a standardised frameset for all product assessments in the Preparatory Studies / Product Group Analyses under the Ecodesign Framework Directive. The spreadsheets can be downloaded at http://www.ecomachinetools.eu/typo/reports.html.

4.1 Product-specific inputs

Product specific inputs vary broadly, depending on the type of machinery, actual application (i.e. workpieces to be processed) and use patterns. Hence, all data provided below can only represent exemplary settings, which to our best knowledge reflect typical conditions.

The product-specific inputs are structured in a way, which allows a direct correlation with Base Cases defined in 4.2. Consequently, product-specific inputs listed here reflect the classification systems of machine tools according to the product scope of this study and the previously drawn conclusion on product and market relevance of machine tools. The following classification systems are taken into account:

- Machine tools system
- Machine tools modules
- Application of machine tools
- Machine tools' complexity
- Manufacturing technology to be performed by machine tools
- CECIMO SRI approach of functional modules.

The machine tools system is sub-divided into workpiece system and tool system with clamping, handling and changing functions. The kinematic system realises all motions between workpiece and tool as well as all support motions. The energy system is regarded to transform the input energy in other energetic states for the manufacturing process. The information system serves the programming of all planned steps of manufacturing.

Related to this the module related approach of machine tools is defined as electrical system for control and mechanic purposes, control system, pneumatic system, hydraulic system, main and feed drives, handling system for tools and workpieces as well as consumables and waste materials.

The application related approach takes into account the application environment (e.g. workshop, industrial plant), number of shifts, embedding (e.g. single machine, automated production system), control system (e.g. mechanic, automated), energy system (e.g. switch-off, power data for sub-systems) and manufacturing method. The complexity related classification defines highly complex CNC, medium complex CNC and simple machine tools. The first are vertical, horizontal or combined horizontal and vertical machining centres. Moreover, lathes including turning centres, but excluding horizontal lathes, and numerically controlled bending, folding, straightening or flattening machines for working flat metal or other materials including presses are covered by this. The second group of machine tools are machine tools for working any material by removal of material, partly operated by laser or other light or photon beam processes as well as hydraulic presses for working metal and other formable material. Simple machine tools are non-numerically controlled machine tools and non-hydraulic and non-numerically controlled presses for working metal or other formable material.

The manufacturing technology related classification is dedicated to the machining purpose of the machine tool. Here, numerically controlled machining centre, numerically controlled deep drawing machine tool, welding equipment, machine tools for woodworking and non-numerically controlled drilling machine are to be found as representatives.

4.1.1 Production phase

The production phase covers the acquisition of the raw materials and the production and assembly processes to construct machine tools.

4.1.1.1 CNC milling and turning machine tools

4.1.1.1.1 Aggregated CECIMO data

CECIMO cordially provided on an aggregated, anonymised level the input data for the LCAs undertaken in preparation of the SRI proposal in 2009. Nine machine tools were taken into account for these assessments, representing a broad spectrum of metal working machine tools ranging from 5 tonnes to nearly 100 tonnes machinery weight. Table 4-1 displays for all nine machine tools the material distribution for each group of materials in kilograms.

Table 4-1: Itemized Bill-of-materials for CNC milling and turning machine tools - CECIMO assessments

Machine tool	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Weight in kg									
Aluminium parts	50,5	56	1500	2500	160	210	43	45	0
Cast iron parts	4250	92770	400	400	6137	6588	3167	3271	2075
Copper parts	4	15	0	0	0	0	112	133	140
Electric control cabinet	400	2000	1500	3500	1050	1300	0	0	800
Motor 0-10 kW	540	540	1264	2716	400	360	0	720	648
Motor 101-200 kW	0	0	0	0	0	0	660	0	0
Motor 11-100kW	114	192	0	0	0	116	132	132	0
Polycarbonate parts	30	240	0	0	0	0	0	0	0
Polypropylene parts	0	0	0	0	100	110	3	3	0
Resin-beton parts	0	0	0	0	1500	1500	0	0	0
Rubber parts	0	0	0	0	0	0	21	21	0
Stainless steel parts	0	0	6461	43520	180	180	0	0	0
Steel cast part alloyed	880	3400	500	800	3665	4531	1267	1318	3310
Window glass	0	0	0	0	0	0	3	3	0
Totals	**6270**	**99215**	**11628**	**53440**	**13198**	**14901**	**5415**	**5654**	**6982**

In Table 4-2 the data provided by CECIMO is listed as averaged data in the format of the MEEuP EcoReport.

Table 4-2: Aggregated Bill-of-materials for CNC milling and turning machine tools – averaged data based on CECIMO assessments

Nr	Product name	Date	Author
	averaged CNC milling and turning machine tools (basis: 9 machine tools)		**KSchi, based on CECIMO**

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Aluminium parts	507166,7	4-Non-ferro	27-Al diecast
2	Cast iron parts	13228666,7	3-Ferro	23-Cast iron
3	Copper parts	44888,9	4-Non-ferro	30-Cu tube/sheet
4	Electric control cabinet (total: 1.172.222,2 g)	172222,2	6-Electronics	98-controller board
5		400000,0	6-Electronics	44-big caps & coils
6		600000,0	3-Ferro	25-Stainless 18/8 coil
7	Motor 0-10 kW (total 798.666,7 g)	398666,7	4-Non-ferro	28-Cu winding wire
8		400000,0	3-Ferro	23-Cast iron
9	Motor 101-200 kW (total: 73.333,3 g)	35333,3	4-Non-ferro	28-Cu winding wire
10		38000,0	3-Ferro	23-Cast iron
11	Motor 11-100kW (total: 76.222,2 g)	36222,2	4-Non-ferro	28-Cu winding wire
12		40000,0	3-Ferro	23-Cast iron
13	Polycarbonate parts	30000,0	2-TecPlastics	12-PC
14	Polypropylene parts	24000,0	1-BlkPlastics	4-PP
15	Resin-beton parts	333333,3	7-Misc.	58-Concrete
16	Rubber parts	4666,7		
17	Stainless steel parts	5593444,4	3-Ferro	25-Stainless 18/8 coil
18	Steel cast part alloyed	2185766,7	3-Ferro	23-Cast iron
19	Window glass	666,7	7-Misc.	54-Glass for lamps

It is evident, that the material composition is dominated by cast iron parts, which represent 13.2 tonnes of the average machine tools weight, i.e. more than 50% of the total weight of nearly 25 tonnes. Stainless steel parts represent another 5.6 tonnes, alloyed steel cast parts 2.2 tonnes.

4.1.1.1.2 CNC 4-axis multifunctional milling centre

Complementary to the data provided by CECIMO a machine tools manufacturer provided separately and independently data for a CNC machining centre supposed to represent typical machine tools in the segment of very complex high-value metal working machinery.

The 4-axis multifunctional milling centre is equipped with multi-functionality for milling, turning and hobbing in all axes simultaneously. The working space is 700 x 90 x 800 mm^3. The machine tool is equipped with hydraulic system for clamping purposes and cooling equipment for the main spindle. Moreover, central component lubrication is part of the milling centre. Main drive and feed drives are provided with energy recovery system[1].

The most used material for the system is cast iron and steel with 24.3 t of an overall weight of 25.8 t excluding the iron based material of the electrical motors. Non-ferrous metal is taken into account with 0.87 t, mainly resulting from copper parts of the power electronics and the electrical motors. Plastic and rubber materials result in a weight of 70 kg. The Bill-of-materials in Table 4-3 is nearly the same as the average BOM according to the CECIMO assessments as documented in chapter 4.1.1.1.1. 15% of sheet metal is estimated as scrap during manufacturing.

Table 4-3: Bill-of-materials for the CNC 4-axis multifunctional milling centre

Nr	Product name	Date	Author
	Hor. M/C - 500x500 pallet, 4 Axis, ATC 150, Multifunctional		

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Aluminium parts	40000,0	4-Non-ferro	27-Al diecast
2	Cast iron parts	16000000,0		23-Cast iron
3	Steel parts	5500000,0	3-Ferro	22-St tube/profile
4		2800000,0	3-Ferro	21-St sheet galv.
5	Copper parts	80000,0	4-Non-ferro	31-CuZn38 cast
6	Electrical Cabinet	158000,0	4-Non-ferro	28-Cu winding wire
7		80000,0	4-Non-ferro	31-CuZn38 cast
8		138000,0	4-Non-ferro	28-Cu winding wire
9	Motor 0-10 kW	138000,0	4-Non-ferro	28-Cu winding wire
10		260000,0	3-Ferro	24-Ferrite
11		125000,0	4-Non-ferro	27-Al diecast
12	Motor 11-100 kW	110000,0	4-Non-ferro	28-Cu winding wire
13		120000,0	3-Ferro	22-St tube/profile
14		90000,0	3-Ferro	24-Ferrite

1 Note, that for the later Base Case assessment this sophisticated option of energy recovery is not taken into account for the majority of the installed stock of CNC machining centres

15	Polycarbonate parts	12000,0	2-TecPlastics	**12-PC**
16	Polypropylen parts	30000,0	1-BlkPlastics	**4-PP**
17	Rubber parts	28000,0		
18	Stainless steel parts	50000,0	3-Ferro	**25-Stainless 18/8 coil**
19	Window glass	16000,0	7-Misc.	**54-Glass for lamps**

The main production processes to produce CNC machine tools are typical metal working processes (drilling, cutting, bending etc.) performed on other metal working machine tools and the following assembly processes. Plastic parts are typically manufactured with injection moulding machines, electronics are assembled with standard technologies, surfaces of the machine housing are typically colour coated (powder coating or similar). Although the production process of machine tools is very complex, actually standard manufacturing processes are used in their majority, hence the standard production processes implemented in the MEEuP EcoReport template are likely to reflect properly the real production processes to manufacture a machine tool. Furthermore, as the production processes of machine tools are largely performed by metal working machine tools, this Product Group Study directly tackles the production processes of machine tools and related machinery themselves.

4.1.1.2 CNC laser cutting machine

Compact CNC CO_2-laser cutting machines for working metal sheets of up to 15 mm mild steel or 6 mm aluminium come with a machinery weight of roughly 10 tonnes. Laser power of such machines is in the range of 2 kW. More universal laser cutting machines for up to 20 mm mild steel and 8 mm Aluminium (for a working range of 3000 mm in the X axis and 1500 mm in the Y axis, maximum laser power 3 – 5 kW typically) weigh in the range of 12 tonnes, whereas laser cutting machines for oversize formats could exceed 15 t of total machinery weight.

Production of these laser cutting machines and material composition is very similar to other types of CNC metal working machine tools. Specific components used in laser cutting machines are

- HF generator / laser source
- chiller system
- extraction system

However, these components do not change much of the overall material composition. Hence, as a typical material composition the CECIMO data for 9 metal working machine tools as stated above can be scaled for a total machinery weight of 12 tonnes[2].

Table 4-4: Aggregated Bill-of-materials for a (generic) CNC Laser cutting machine tool

Nr	Product name	Date	Author
	Generic CNC Laser cutting machine tool		**KSchi**

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Aluminium parts	250000,0	4-Non-ferro	27-Al diecast
2	Cast iron parts	6600000,0	3-Ferro	23-Cast iron
3	Copper parts	22000,0	4-Non-ferro	30-Cu tube/sheet
4	Electric control cabinet	170000,0	6-Electronics	98-controller board
5		200000,0	6-Electronics	44-big caps & coils
6		300000,0	3-Ferro	25-Stainless 18/8 coil
7	Motor 0-10 kW	190000,0	4-Non-ferro	28-Cu winding wire
8		200000,0	3-Ferro	23-Cast iron
9	Motor 101-200 kW		4-Non-ferro	28-Cu winding wire
10			3-Ferro	23-Cast iron
11	Motor 11-100kW		4-Non-ferro	28-Cu winding wire
12			3-Ferro	23-Cast iron
13	Polycarbonate parts	15000,0	2-TecPlastics	12-PC
14	Polypropylen parts	12000,0	1-BlkPlastics	4-PP
15	Resin-beton parts	160000,0	7-Misc.	58-Concrete
16	Rubber parts	2000,0		
17	Stainless steel parts	2790000,0	3-Ferro	25-Stainless 18/8 coil
18	Steel cast part alloyed	1090000,0	3-Ferro	23-Cast iron
19	Window glass	300,0	7-Misc.	54-Glass for lamps

2 Following adaptations applied: no motors > 10 kW, controller boards weight remains unchanged, rounded figures

4.1.1.3 Hydraulic Press Brake

A press brake is a machine tool for bending sheet metal or plate material. A typical bill-of-materials for a hydraulic press brake is as listed in Table 4-5. The BOM and allocation to modules and material categories has been cordially provided by Marta Lopes de Oliveira and Ana Reis, Universidade do Porto.

The allocation per module follows the assembly structure of the press brake manufacturer and hence slightly deviates from the modular structure as defined in Task 1. The main structural modules are:

- Structural components
- Laser safety assembly
- Common components (in between different machine models)
- Table assembly
- Bumping system assembly
- Hydraulic system assembly
- Lateral guards assembly

The specification of the press brake under study is as follows:

- Commercially available hydraulic press-brake, standard construction as of 2006
- Maximum bending capacity: 110 t
- Maximum bending length: 3 m
- Main motor rated at 7.5 kW

Table 4-5: Aggregated Bill-of-materials for a Hydraulic Press Brake

Nr	Product name	Date	Author
	CNC Bending machine tool	**Dec, 2011**	**KSchi**

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	STRUCTURAL COMPONENTS			
2	Steel	6224490,0	3-Ferro	**22-St tube/profile**
3	LASER SAFETY ASSEMBLY			
4	Steel	10360,0	3-Ferro	**22-St tube/profile**
5	Stainless steel	1020,0	3-Ferro	**25-Stainless 18/8 coil**
6	Aluminium	6920,0	4-Non-ferro	**26-Al sheet/extrusion**
7	COMMON COMPONENTS			
8	Steel	569210,0	3-Ferro	**22-St tube/profile**
9	Stainless steel	1620,0	3-Ferro	**25-Stainless 18/8 coil**
10	TABLE ASSEMBLY			
11	Steel	285770,0	3-Ferro	**22-St tube/profile**
12	BUMPING SYSTEM ASSEMBLY			
13	Steel	431330,0	3-Ferro	**22-St tube/profile**
14	Galvanized steel	1920,0	3-Ferro	**21-St sheet galv.**
15	Stainless steel	15040,0	3-Ferro	**25-Stainless 18/8 coil**
16	Aluminium	13390,0	4-Non-ferro	**26-Al sheet/extrusion**
17	Plastics	280,0	2-TecPlastics	**11-PA 6**
18	HYDRAULIC SYSTEM ASSEMBLY			
19	Steel	92920,0	3-Ferro	**22-St tube/profile**
20	Cast iron	97700,0	3-Ferro	**23-Cast iron**
21	Aluminium	520,0	4-Non-ferro	**26-Al sheet/extrusion**
22	LATERAL GUARDS ASSEMBLY			
23	Steel	110070,0	3-Ferro	**22-St tube/profile**
24	Composites	9410,0	2-TecPlastics	**18-E-glass fibre**

The main production processes to produce press brakes are typical metal working processes (drilling, cutting, bending etc.) performed on other metal working machine tools and the following assembly processes.

4.1.1.4 Non-numerical controlled metal working machine tools

Main parts of non-numerical controlled machine tools are also metal parts, typically steel, for machinery frame, guides and bearings. Motors and potentially power electronics represent an important but minor weight share.

Engine and feed shaft lathes are the most used machines in the metal working industry. Typical components:

- Headstock,
- main spindle (drive),
- machine base / frame,
- tool slide,
- tailstock,
- cabinet

Total weight of a typical manually controlled machine tool: 1.000 kg.

Table 4-6: Aggregated Bill-of-materials for a manually controlled engine and feed shaft lathe

Nr	Product name	Date	Author
	manually controlled lathe		**DuB**

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Aluminium parts	0,0		
2	Cast iron parts	741021,0		23-Cast iron
3	Steel parts	110000,0	3-Ferro	22-St tube/profile
4		110000,0	3-Ferro	21-St sheet galv.
5	Copper parts	3100,0	4-Non-ferro	31-CuZn38 cast
6	Electrical Cabinet	6130,0	4-Non-ferro	28-Cu winding wire
7		3104,0	4-Non-ferro	31-CuZn38 cast
8		5355,0	4-Non-ferro	28-Cu winding wire
9	Motor 0-10 kW	5355,0	4-Non-ferro	28-Cu winding wire
10		10090,0	3-Ferro	24-Ferrite
11		4850,0	4-Non-ferro	27-Al diecast
12	Motor 11-100 kW	0,0		

13		0,0		
14		0,0		
15	Polycarbonate parts	0,0		
16	Polypropylen parts	500,0	1-BlkPlastics	**4-PP**
17	Rubber parts	500,0		
18	Stainless steel parts	0,0		
19	Window glass	0,0		**54-Glass for lamps**

Just as with CNC-machine tools the main production processes to produce non-NC machine tools are on the one hand typical metal working processes (drilling, cutting, bending etc.) performed on other metal working machine tools and on the other hand the assembly processes.

4.1.1.5 Wood working machine tools: Light stationary table saw

Light stationary tools for wood working are typically in the range of 10 – 50 kg. Main parts are the chassis or base part (typically made of cast iron parts or steel sheets), manually operated adjustment parts, the saw table, which might be made of CNC machined aluminium or steel, and motor, gear, drive axis with protective covers.

An exemplary Bill-of-materials is displayed in Table 4-8. This bill of materials is compiled based on spare parts lists and explosion drawings of a table saw; the weight per component has been estimated. The total weight of the table saw is approximately 27 kg. The specification is as listed in Table 4-7.

Table 4-7: Parameters - Exemplary Table Saw

Parameter	
Dimensions: Depth x length x height	73 x 78 x 34 cm
Table size	641 x 737 mm
No-load speed	3.650 rpm
Motor rating	1.800 W
Price	Approx. 1.000 Euro

With these characteristics, this exemplary table saw is above average in terms of power rating and price of light stationary woodworking tools.

Table 4-8: Aggregated Bill-of-materials for a Table Saw

Nr	Product name	Date	Author
	Light Stationary Wood Working Equipment / Table Saw		Kschi

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	MOTOR and GEAR DRIVE			
2	Motor Housing	1000,0	3-Ferro	23-Cast iron
3	Field	500,0	3-Ferro	21-St sheet galv.
4		500,0	4-Non-ferro	28-Cu winding wire
5	Armature	200,0	3-Ferro	22-St tube/profile
6		300,0	4-Non-ferro	28-Cu winding wire
7	Cover	200,0	3-Ferro	23-Cast iron
8	Gear Housing	400,0	3-Ferro	23-Cast iron
9	Screws, springs, nuts etc.	20,0	4-Non-ferro	31-CuZn38 cast
10	Gear Cover	60,0	3-Ferro	23-Cast iron
11	Rubber ring	5,0	7-Misc.	
12	Ball bearings	20,0	3-Ferro	22-St tube/profile
13	Threaded Rod	30,0	3-Ferro	22-St tube/profile
14	Protective Cover	20,0	3-Ferro	25-Stainless 18/8 coil
15				
16				
17	CHASSIS / BASE			
18	Housing	10000,0	3-Ferro	23-Cast iron
19	Container	500,0	3-Ferro	21-St sheet galv.
20	Guard plates	300,0	3-Ferro	21-St sheet galv.
21	Front Panel	200,0	3-Ferro	21-St sheet galv.
22	Power supply cord	400,0	1-BlkPlastics	8-PVC
23		400,0	4-Non-ferro	29-Cu wire
24	Switch Housing	50,0	1-BlkPlastics	10-ABS
25	Hand wheel assembly	300,0	3-Ferro	23-Cast iron
26	Slide	50,0	3-Ferro	23-Cast iron
27	On-off switch	20,0	1-BlkPlastics	10-ABS
28		10,0	4-Non-ferro	29-Cu wire
29		10,0	3-Ferro	21-St sheet galv.
30	Coil	10,0	4-Non-ferro	29-Cu wire
31	Screws, springs, nuts etc.	40,0	4-Non-ferro	31-CuZn38 cast
32	Threaded bushing	20,0	3-Ferro	22-St tube/profile
33				
34	STRUCTURAL COMPONENTS			
35	Holding Plate	400,0	3-Ferro	21-St sheet galv.
36	Flap Guards	100,0	2-TecPlastics	13-PMMA

37	Cover Plates	50,0	3-Ferro	**21-St sheet galv.**
38	Screws, springs, nuts etc.	30,0	4-Non-ferro	**31-CuZn38 cast**
39	Riving Knife	10,0	3-Ferro	**25-Stainless 18/8 coil**
40	Guard Holder	10,0	3-Ferro	**23-Cast iron**
41	Shaft and Guiding Bolts	20,0	3-Ferro	**22-St tube/profile**
42				
43	TABLE			
44	Table Plates	9000	4-Non-ferro	**27-Al diecast**
45	Profile Rails	1000	4-Non-ferro	**26-Al sheet/extrusion**
46	End stop	200	4-Non-ferro	**26-Al sheet/extrusion**
47	Housing	20	1-BlkPlastics	**10-ABS**
48	Clamping Plates	10	3-Ferro	**21-St sheet galv.**
49	Mounting Rails	20	3-Ferro	**25-Stainless 18/8 coil**
50	Clamp Handle	50	3-Ferro	**23-Cast iron**
51	Screws, rings etc.	20	4-Non-ferro	**31-CuZn38 cast**
52	End stop	200	3-Ferro	**23-Cast iron**
53	Clamp handle end stop	50	3-Ferro	**23-Cast iron**
54	Insert	200	3-Ferro	**21-St sheet galv.**
55	Rod	15	3-Ferro	**22-St tube/profile**
56	Guide bar	30	3-Ferro	**22-St tube/profile**

For smaller wood working machine tools also motors with a smaller power rating are used than for large machinery. An evaluation of product catalogues for wood working machinery (not only table saws but also mid-range machinery up to 1 ton in machinery weight) unveils the motor sizes typically used in such machines (Figure 4-1).

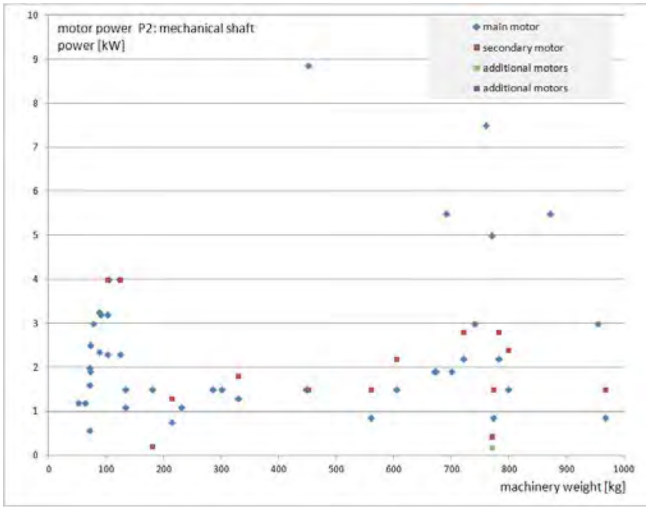

Figure 4-1: Output motor power (mechanical shaft power) of main and auxiliary motors in small and mid-range wood working machine tools

It is evident that even among smaller machines there are only very few motors used with a mechanical shaft power of less than 1 kW, meaning an even higher rated input power.

4.1.1.6 Wood working machine tools: Horizontal panel saw

An averaged bill-of-materials for a horizontal panel saw is as listed in Table 4-9. This bill-of-materials is derived from general insights in construction and modules of horizontal panel saws, checked against plausibility on the basis of typical machinery weights and composition of other large industrial equipment. Consequently the data does not represent any real machinery and has to be understood as an approximation. Data on the control computer is derived from the EuP Lot 3 study on computers, laptops and monitors, as standard PCs are typically use for this kind of machinery.

Table 4-9: Aggregated Bill-of-materials for a Horizontal panel saw

Nr	Product name		Date	Author
	Horizontal panel saw			**Pwi**

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Machine table			
2	epoxy panels	100000,0	2-TecPlastics	**14-Epoxy**
3	steel sheets	1100000,0	3-Ferro	**22-St tube/profile**
4				
5	Feed table			
6	steel sheets	1200000,0	3-Ferro	**22-St tube/profile**
7				
8	Horizontal Beam			
9	steel sheets	150000,0	3-Ferro	**22-St tube/profile**
10				
11	Saw Carriage			
12	steel sheets	150000,0	3-Ferro	**22-St tube/profile**
13				
14	Motor 0-10 kW			
15		56500,0	4-Non-ferro	**28-Cu winding wire**
16		106400,0	3-Ferro	**24-Ferrite**
17		37100,0	4-Non-ferro	**27-Al diecast**
18				
19	Pneumatic system			
20		40000,0	3-Ferro	**23-Cast iron**

21		10000,0	3-Ferro	**22-St tube/profile**
22				
23	PC			
24	LDPE	246,0	1-BlkPlastics	**1-LDPE**
25	ABS	381,0	1-BlkPlastics	**10-ABS**
26	PA 6	138,0	2-TecPlastics	**11-PA 6**
27	PC	264,0	2-TecPlastics	**12-PC**
28	Epoxy	98,0	2-TecPlastics	**14-Epoxy**
29	Flex PUR	2,0	2-TecPlastics	**16-Flex PUR**
30	Steel sheets galv.	6312,0	3-Ferro	**21-St sheet galv.**
31	Steel tube/profile	107,0	3-Ferro	**22-St tube/profile**
32	Cast iron	483,0	3-Ferro	**23-Cast iron**
33	Stainless 18/8 coil	10,0	3-Ferro	**25-Stainless 18/8 coil**
34	Al sheets	315,0	4-Non-ferro	**26-Al sheet/extrusion**
35	Al diecast	15,0	4-Non-ferro	**27-Al diecast**
36	Cu winding wire	257,0	4-Non-ferro	**28-Cu winding wire**
37	Cu wire	334,0	4-Non-ferro	**29-Cu wire**
38	Cu tube/sheet	67,0	4-Non-ferro	**30-Cu tube/sheet**
39	Powder coating	2,0	5-Coating	**39-powder coating**
40	Big caps & coil	483,0	6-Electronics	**44-big caps & coils**
41	Slots / ext. Ports	310,0	6-Electronics	**45-slots / ext. ports**
42	Integrate Circuits, 5% Si, 1% Au	69,0	6-Electronics	**46-IC's avg., 5% Si, Au**
43	Integrate Circuits, 1% Si	96,0	6-Electronics	**47-IC's avg., 1% Si**
44	SMD & LEDs avg	194,0	6-Electronics	**48-SMD/ LED's avg.**
45	PWB 1/2 lay 3,75kg/m2	78,0	6-Electronics	**49-PWB 1/2 lay 3.75kg/m2**
46	PWB 6 lay 4,5kg/m2	163,0	6-Electronics	**50-PWB 6 lay 4.5 kg/m2**
47	Solder SbAg4Cu0,5	48,0	6-Electronics	**52-Solder SnAg4Cu0.5**
48	Cardboard	2287,0	7-Misc.	**56-Cardboard**
49				
50	LCD			
51	LDPE	164	1-BlkPlastics	**1-LDPE**
52	EPS	279	1-BlkPlastics	**6-EPS**
53	PVC	43	1-BlkPlastics	**8-PVC**
54	ABS	679	1-BlkPlastics	**8-PVC**
55	PA 6	422	2-TecPlastics	**11-PA 6**
56	PC	385	2-TecPlastics	**12-PC**
57	PMMA	153	2-TecPlastics	**13-PMMA**
58	E-glass fibre	120	2-TecPlastics	**18-E-glass fibre**
59	Aramid fibre	6,5	2-TecPlastics	**19-Aramid fibre**
60	Steel sheet galvanized	1854	3-Ferro	**21-St sheet galv.**
61	Al sheet/extrusion	39	4-Non-ferro	**26-Al sheet/extrusion**
62	Cu wire	190	4-Non-ferro	**29-Cu wire**
63	Powder coating	1	5-Coating	**39-powder coating**
64	LCD Screen m2 (viewable screen size)	91	6-Electronics	**42-LCD per m2 scrn**

65	Big caps & coils	41	6-Electronics	**44-big caps & coils**
66	Slots /ext. Ports	37	6-Electronics	**45-slots / ext. ports**
67	Integrate Circuits, 5% Si, 1% Au	13	6-Electronics	**46-IC's avg., 5% Si, Au**
68	Integrate Circuits, 1% Si	20	6-Electronics	**47-IC's avg., 1% Si**
69	Solder SbAg4Cu0,5	11	6-Electronics	**52-Solder SnAg4Cu0.5**
70	SMD & LEDs avg	11	6-Electronics	**48-SMD/ LED's avg.**
71	PWB 1/2 lay 3,75kg/m2	30	6-Electronics	**49-PWB 1/2 lay 3.75kg/m2**
72	PWB 6 lay 4,5kg/m2	20	6-Electronics	**50-PWB 6 lay 4.5 kg/m2**
73	Glass for Lamps	26	7-Misc.	**54-Glass for lamps**
74	Cardboard	650	7-Misc.	**56-Cardboard**
75	Office paper	55	7-Misc.	**57-Office paper**
76	Misc glass	308	7-Misc.	
77	Cast iron	1165	3-Ferro	**23-Cast iron**
78				
79	Housing	30427,5	3-Ferro	**21-St sheet galv.**
80				
81	Chassis	1000000	3-Ferro	**21-St sheet galv.**
82		1000000	3-Ferro	**21-St sheet galv.**

4.1.1.7 Wood working machine tools: Throughfeed edge banding machine

An averaged bill-of-materials for a throughfeed edge banding machine is as listed in Table 4-10.

This bill-of-materials is derived from general insights in construction and modules of throughfeed edge banding machines, checked against plausibility on the basis of typical machinery weights and composition of other large industrial equipment. Consequently the data does not represent any real machinery and has to be understood as an approximation. Data on the control computer is derived from the EuP Lot 3 study on computers, laptops and monitors, as standard PCs are typically use for this kind of machinery.

Table 4-10: Aggregated Bill-of-materials for a Throughfeed edge banding machine

Nr	Product name	Date	Author
	Throughfeed edge banding machine		**Pwi**

Pos nr	MATERIALS Extraction & Production Description of component	Weight in g	Category Click &select	Material or Process select Category first !
1	Motors 0-10 kW			
2		79800,0	3-Ferro	**24-Ferrite**
3		42300,0	4-Non-ferro	**28-Cu winding wire**
4		27900,0	4-Non-ferro	**27-Al diecast**
5				
6	Cables	10000,0	4-Non-ferro	**29-Cu wire**
7				
8	Pipes	10000,0	3-Ferro	**22-St tube/profile**
9				
10	Cast steel parts	630000,0	3-Ferro	**23-Cast iron**
11				
12	PC			
13	LDPE	246,0	1-BlkPlastics	**1-LDPE**
14	ABS	381,0	1-BlkPlastics	**10-ABS**
15	PA 6	138,0	2-TecPlastics	**11-PA 6**
16	PC	264,0	2-TecPlastics	**12-PC**
17	Epoxy	98,0	2-TecPlastics	**14-Epoxy**
18	Flex PUR	2,0	2-TecPlastics	**16-Flex PUR**
19	Steel sheets galvanized	6312,0	3-Ferro	**21-St sheet galv.**
20	Steel tube/profile	107,0	3-Ferro	**22-St tube/profile**
21	Cast iron	483,0	3-Ferro	**23-Cast iron**
22	Stainless 18/8 coil	10,0	3-Ferro	**25-Stainless 18/8 coil**
23	Al sheet/extrussion	315,0	4-Non-ferro	**26-Al sheet/extrusion**
24	Al diecast	15,0	4-Non-ferro	**27-Al diecast**
25	Cu winding wire	257,0	4-Non-ferro	**28-Cu winding wire**
26	Cu wire	334,0	4-Non-ferro	**29-Cu wire**
27	Cu tube/sheet	67,0	4-Non-ferro	**30-Cu tube/sheet**
28	Powder coating	2,0	5-Coating	**39-powder coating**
29	Big caps & coils	483,0	6-Electronics	**44-big caps & coils**
30	Slots/ext. Port	310,0	6-Electronics	**45-slots / ext. ports**
31	Integrated Circuits, 5% Silicon, Au	69,0	6-Electronics	**46-IC's avg., 5% Si, Au**
32	Integrated Circuits, 1% Silicon	96,0	6-Electronics	**47-IC's avg., 1% Si**
33	SMD & LEDs avg	194,0	6-Electronics	**48-SMD/ LED's avg.**

34	PWB 1/2 lay 3,75kg/m2	78,0	6-Electronics	**49-PWB 1/2 lay 3.75kg/m2**
35	PWB 6 lay 4,5kg/m2	163,0	6-Electronics	**50-PWB 6 lay 4.5 kg/m2**
36	Solder SbAg4Cu0,5	48,0	6-Electronics	**52-Solder SnAg4Cu0.5**
37	Cardboard	2287,0	7-Misc.	**56-Cardboard**
38				
42	LCD			
43	LDPE	164	1-BlkPlastics	**1-LDPE**
44	EPS	279	1-BlkPlastics	**6-EPS**
45	PVC	43	1-BlkPlastics	**8-PVC**
46	ABS	679	1-BlkPlastics	**8-PVC**
47	PA 6	422	2-TecPlastics	**11-PA 6**
48	PC	385	2-TecPlastics	**12-PC**
49	PMMA	153	2-TecPlastics	**13-PMMA**
50	E-glass fibre	120	2-TecPlastics	**18-E-glass fibre**
51	Aramid fibre	6,5	2-TecPlastics	**19-Aramid fibre**
52	Steel sheet galvanized	1854	3-Ferro	**21-St sheet galv.**
53	Al sheet/extrusion	39	4-Non-ferro	**26-Al sheet/extrusion**
54	Cu wire	190	4-Non-ferro	**29-Cu wire**
55	Powder coating	1	5-Coating	**39-powder coating**
56	LCD Screen m2 (viewable screen size)	91	6-Electronics	**42-LCD per m2 scrn**
57	Big caps & coils	41	6-Electronics	**44-big caps & coils**
58	Slots /ext. Ports	37	6-Electronics	**45-slots / ext. ports**
59	Integrate Circuits, 5% Si, 1% Au	13	6-Electronics	**46-IC's avg., 5% Si, Au**
60	Integrate Circuits, 1% Si	20	6-Electronics	**47-IC's avg., 1% Si**
61	Solder SbAg4Cu0,5	11	6-Electronics	**52-Solder SnAg4Cu0.5**
62	SMD & LEDs avg	11	6-Electronics	**48-SMD/ LED's avg.**
63	PWB 1/2 lay 3,75kg/m2	30	6-Electronics	**49-PWB 1/2 lay 3.75kg/m2**
64	PWB 6 lay 4,5kg/m2	20	6-Electronics	**50-PWB 6 lay 4.5 kg/m2**
65	Glass for Lamps	26	7-Misc.	**54-Glass for lamps**
66	Cardboard	650	7-Misc.	**56-Cardboard**
67	Office paper	55	7-Misc.	**57-Office paper**
68	Misc glass	308	7-Misc.	
69	Cast iron	1165	3-Ferro	**23-Cast iron**
70				
71	Housing	30427,5	3-Ferro	**21-St sheet galv.**
72				
73	Chassis			
74	steel sheet	700000	3-Ferro	**21-St sheet galv.**
75	steel sheet	700000	3-Ferro	**21-St sheet galv.**
76	PMMA	20000	2-TecPlastics	**13-PMMA**
77	Al	150000	4-Non-ferro	**26-Al sheet/extrusion**

78	Cables	20000	4-Non-ferro	**29-Cu wire**
79	tubes	10000	3-Ferro	**22-St tube/profile**
80	Motors 0-10 kW			
81		26600	3-Ferro	**24-Ferrite**
82		14100	4-Non-ferro	**28-Cu winding wire**
83		9300	4-Non-ferro	**27-Al diecast**

4.1.1.8 Wood working machine tools: CNC machining centre

An averaged bill-of-materials for a CNC machining centre is as listed in **Table 4-11**.

Wood working machinery labelled as CNC machining centres starts from lower weights than metal working "machining centres", i.e. in the range of few tonnes. Typical groove machines for workshop use are in the weight range of 2-3 tonnes. Industrial sawing machines span a wide range from few hundred kilograms to several tonnes.

For structural parts of wood working machinery steel parts are common, which dominate the overall machinery weight. Electronics, window glass, motors and plastic and rubber parts are of secondary importance. Integrated chip and dust extracting systems require fans, and vacuum systems.

Table 4-11: Aggregated Bill-of-materials for a CNC machining centre

Nr	Product name		Date	Author
	CNC machining center			**Pwi**
Pos nr	**MATERIALS Extraction & Production Description of component**	**Weight in g**	**Category** Click &select	**Material or Process** select Category first !
1	Aluminium parts	167489,2	4-Non-ferro	**27-Al diecast**
2	Cast iron parts	4368699,6	3-Ferro	**23-Cast iron**
3	Copper parts	14824,3	4-Non-ferro	**30-Cu tube/sheet**
4	Electric control cabinet (total: 1.172.222,2 g)	56875,5	6-Electronics	**98-controller board**
5		132098,0	6-Electronics	**44-big caps & coils**
6		198146,9	3-Ferro	**25-Stainless 18/8 coil**
7	Motor 0-10 kW (total 798.666,7 g)	131657,6	4-Non-ferro	**28-Cu winding wire**
8		132098,0	3-Ferro	**23-Cast iron**
9	Motor 101-200 kW (total: 73.333,3 g)	11668,7	4-Non-ferro	**28-Cu winding wire**
10		12549,3	3-Ferro	**23-Cast iron**
11	Motor 11-100kW (total: 76.222,2	11962,2	4-Non-ferro	**28-Cu winding wire**
12		13209,8	3-Ferro	**23-Cast iron**
13	Polycarbonate parts	9907,3	2-TecPlastics	**12-PC**

14	Polypropylen parts	7925,9	1-BlkPlastics	**4-PP**
15	Resin-beton parts	110081,6	7-Misc.	**58-Concrete**
16	Rubber parts	1541,1		
17	Stainless steel parts	1847206,5	3-Ferro	**25-Stainless 18/8 coil**
18	Steel cast part alloyed	721838,3	3-Ferro	**23-Cast iron**
19	Window glass	220,2	7-Misc.	**54-Glass for lamps**
20				
21	PC			
22	LDPE	246,0	1-BlkPlastics	**1-LDPE**
23	ABS	381,0	1-BlkPlastics	**10-ABS**
24	PA 6	138,0	2-TecPlastics	**11-PA 6**
25	PC	264,0	2-TecPlastics	**12-PC**
26	Epoxy	98,0	2-TecPlastics	**14-Epoxy**
27	Flex PUR	2,0	2-TecPlastics	**16-Flex PUR**
28	Steel sheets galv.	6312,0	3-Ferro	**21-St sheet galv.**
29	Steel tube/profile	107,0	3-Ferro	**22-St tube/profile**
30	Cast iron	483,0	3-Ferro	**23-Cast iron**
31	Stainless 18/8 coil	10,0	3-Ferro	**25-Stainless 18/8 coil**
32	Al sheets	315,0	4-Non-ferro	**26-Al sheet/extrusion**
33	Al diecast	15,0	4-Non-ferro	**27-Al diecast**
34	Cu winding wire	257,0	4-Non-ferro	**28-Cu winding wire**
35	Cu wire	334,0	4-Non-ferro	**29-Cu wire**
36	Cu tube/sheet	67,0	4-Non-ferro	**30-Cu tube/sheet**
37	Powder coating	2,0	5-Coating	**39-powder coating**
38	Big caps & coil	483,0	6-Electronics	**44-big caps & coils**
39	Slots / ext. Ports	310,0	6-Electronics	**45-slots / ext. ports**
40	Integrated Circuits, 5% Si, 1% Au	69,0	6-Electronics	**46-IC's avg., 5% Si, Au**
41	Integrated Circuits, 1% Si	96,0	6-Electronics	**47-IC's avg., 1% Si**
42	SMD & LEDs avg	194,0	6-Electronics	**48-SMD/ LED's avg.**
43	PWB 1/2 lay 3,75kg/m2	78,0	6-Electronics	**49-PWB 1/2 lay 3.75kg/m2**
44	PWB 6 lay 4,5kg/m2	163,0	6-Electronics	**50-PWB 6 lay 4.5 kg/m2**
45	Solder SbAg4Cu0,5	48,0	6-Electronics	**52-Solder SnAg4Cu0.5**
46	Cardboard	2287,0	7-Misc.	**56-Cardboard**
47				
48	LCD			
49	LDPE	164	1-BlkPlastics	**1-LDPE**
50	EPS	279	1-BlkPlastics	**6-EPS**
51	PVC	43	1-BlkPlastics	**8-PVC**
52	ABS	679	1-BlkPlastics	**8-PVC**
53	PA 6	422	2-TecPlastics	**11-PA 6**
54	PC	385	2-TecPlastics	**12-PC**
55	PMMA	153	2-TecPlastics	**13-PMMA**
56	E-glass fibre	120	2-TecPlastics	**18-E-glass fibre**
57	Aramid fibre	6,5	2-TecPlastics	**19-Aramid fibre**

58	Steel sheet galvanized	1854	3-Ferro	**21-St sheet galv.**
59	Al sheet/extrusion	39	4-Non-ferro	**26-Al sheet/extrusion**
60	Cu wire	190	4-Non-ferro	**29-Cu wire**
61	Powder coating	1	5-Coating	**39-powder coating**
62	LCD Screen m2 (viewable screen size)	91	6-Electronics	**42-LCD per m2 scrn**
63	Big caps & coils	41	6-Electronics	**44-big caps & coils**
64	Slots /ext. Ports	37	6-Electronics	**45-slots / ext. ports**
65	Integrate Circuits, 5% Si, 1% Au	13	6-Electronics	**46-IC's avg., 5% Si, Au**
66	Integrate Circuits, 1% Si	20	6-Electronics	**47-IC's avg., 1% Si**
67	Solder SbAg4Cu0,5	11	6-Electronics	**52-Solder SnAg4Cu0.5**
68	SMD & LEDs avg	11,0	6-Electronics	**48-SMD/ LED's avg.**
69	PWB 1/2 lay 3,75kg/m2	30,0	6-Electronics	**49-PWB 1/2 lay 3.75kg/m2**
70	PWB 6 lay 4,5kg/m2	20,0	6-Electronics	**50-PWB 6 lay 4.5 kg/m2**
71	Glass for Lamps	26	7-Misc.	**54-Glass for lamps**
72	Cardboard	650	7-Misc.	**56-Cardboard**
73	Office paper	55	7-Misc.	**57-Office paper**
74	Misc glass	308	7-Misc.	
75	Cast iron	1165	3-Ferro	**23-Cast iron**
76				
77	Housing	30427,5	3-Ferro	**21-St sheet galv.**

The main production processes to produce wood working machine tools are typical metal working processes (drilling, cutting, bending etc.) and the following assembly processes. The minor share of plastic parts are typically manufactured with injection moulding machines, electronics are assembled with standard technologies, surfaces of the machine housing are typically colour coated (powder coating or similar). Standard manufacturing processes are used in the majority of cases, hence the standard production processes implemented in the MEEuP EcoReport template are likely to reflect properly the real production processes to manufacture wood working machinery. Furthermore, as the production processes of wood working machinery are largely performed by metal working machine tools, this Product Group Study directly tackles the relevant production processes.

4.1.1.9 Welding equipment

A major part of typical transportable welding equipment is the power source, i.e. related transformer or power electronics / inverter and housing parts of the power source. Every piece of equipment comes with a control panel of its own. Torch, gas supply and welding wire feed are further essential components.

Smaller units start from roughly 7 kg in weight. Typical transportable arc welding power sources are in the range of 40 – 150 kg roughly. Transportable plasma cutting equipment including power source, burner and cables are in the range of 10 – 30 kg per unit. Stated weights refer to current product models, former generations with power sources based on larger, less efficient transformers were heavier and larger regarding the electrical part, and thus also the housing.

Table 4-12: Parameters - Exemplary MIG/MAG Welding Equipment

Parameters		
Mains voltage	**3 x 230 V / 400 V**	
Welding current range	**10 – 340 A**	
Welding current at: 10 min/40° C	**35 % d.c.**	**340 A**
	60 % d.c.	**260 A**
	100 % d.c.	**200 A**
Open-circuit voltage	**45 V**	
Operating voltage	**14.5 – 31.0 V**	
N° of switching steps	**2 x 7**	
Protection level	**IP 23**	
Primary continuous power (100 % d.c.):	**6.2 kVA**	
efficiency	**76,8 % @ 200 A**	
price	**approx. 2.700,- Euro**[3]	

Table 4-13: Aggregated Bill-of-materials for a MIG/MAG Welding Equipment

Nr	Product name	Date	Author
	MIG/MAG-Welding Equipment		**KSchi**

Pos nr	**MATERIALS Extraction & Production Description of component**	**Weight in g**	**Category Click &select**	**Material or Process select Category first !**
1	**Cover**			
2	handle tube Vario Synergic	2300,0	3-Ferro	**21-St sheet galv.**
3	Grip accom. left red	141,0	3-Ferro	**21-St sheet galv.**
4	Grip accom. right red	141,0	3-Ferro	**21-St sheet galv.**
5	BOTTLE CHAIN	110,0	3-Ferro	**21-St sheet galv.**
6	CHAIN ASSEMBLY	14,0	3-Ferro	**21-St sheet galv.**
7	Side panel right	5600,0	3-Ferro	**21-St sheet galv.**

3 compared to PRODCOM unit value of 1.188 Euro for NACE Code 27903154, which covers an estimated stock of 1,27 million units

8	Sidepanel left top	12000,0	3-Ferro	**21-St sheet galv.**
9	Cover red	4500,0	3-Ferro	**21-St sheet galv.**
10	Sidepanel left red	4500,0	3-Ferro	**21-St sheet galv.**
11		30,0	5-Coating	**39-powder coating**
12				
13	**Chassis**			
14	PICK-UP WHEEL BLACK	1000,0	3-Ferro	**22-St tube/profile**
15	Bottom black	15000,0	3-Ferro	**21-St sheet galv.**
16	Rear panel bl	12000,0	3-Ferro	**21-St sheet galv.**
17	Bottle holder SW	600,0	3-Ferro	**21-St sheet galv.**
18	WHEEL STEEL 180 GL 45 20 (2 Stk)	2080,0	3-Ferro	**22-St tube/profile**
19	Motor plate 42V	1000,0	3-Ferro	**21-St sheet galv.**
20	front panel print	12000,0	3-Ferro	**21-St sheet galv.**
21	TUMBLER GEAR D=16O (2 Stk)	2000,0	3-Ferro	**22-St tube/profile**
22	STAR LOCK D= 2O (2 Stk)	20,0	3-Ferro	**22-St tube/profile**
23	CURRENT SOCKET/5O-7O MM2/6OOA (3 Stk)	255,0	1-BlkPlastics	**8-PVC**
24		300,0	4-Non-ferro	**29-Cu wire**
25	SOCKET-CONTACT	3,0	3-Ferro	**22-St tube/profile**
26	MAINS-CABLE	740,0	4-Non-ferro	**29-Cu wire**
27		740,0	1-BlkPlastics	**8-PVC**
28	ROCKER SWITCH	9,0	4-Non-ferro	**29-Cu wire**
29		9,0	1-BlkPlastics	**6-EPS**
30	TERMINAL STRIP 9pin	3,5	1-BlkPlastics	**8-PVC**
31		3,5	4-Non-ferro	**26-Al sheet/extrusion**
32	TURNING KNOB D=23 RED/BLA./RED	8,0	1-BlkPlastics	**10-ABS**
33		5,0	3-Ferro	**22-St tube/profile**
34	Decel.device kit D=300	390,0	3-Ferro	**23-Cast iron**
35	Nut for brake	28,0	4-Non-ferro	**31-CuZn38 cast**
36	MOUNTING SPRING FOR PLUG	3,0	3-Ferro	**25-Stainless 18/8 coil**
37	INSULATION F.BUSHING STRIP	5,0	1-BlkPlastics	**6-EPS**
38	AXLE	800,0	3-Ferro	**22-St tube/profile**
42	TRACTION RELEASE	18,0	1-BlkPlastics	**8-PVC**
43	RESISTOR	27,0	6-Electronics	**44-big caps & coils**
44	Frame device Industry red	12000	3-Ferro	**21-St sheet galv.**
45	Remote control cable 10-pin/20m	1750	4-Non-ferro	**29-Cu wire**
46		1750	1-BlkPlastics	**8-PVC**
47	Adaptor wire coil	630	3-Ferro	**23-Cast iron**
48	Isolation wire coil	410	3-Ferro	**23-Cast iron**
49				
50	Electronics			

51	Divider printed	12000	3-Ferro	**21-St sheet galv.**
52	CONTROL TRANSF. 440/460/500V	3200	6-Electronics	**44-big caps & coils**
53	PC-BOARD	29	6-Electronics	**98-controller board**
54	PC-Board	400	6-Electronics	**98-controller board**
55	PC-Board	450	6-Electronics	**98-controller board**
56	PC-Board	50	6-Electronics	**98-controller board**
57	FUSE HOLDER 6.3/5X20	50	3-Ferro	**23-Cast iron**
58	FUSE-CAP	1	3-Ferro	**23-Cast iron**
59	FUSE HOLDER	4	3-Ferro	**23-Cast iron**
60	FUSE	3	3-Ferro	**23-Cast iron**
61	FILTER-GLASS GREEN (2 Stk)	12	7-Misc.	**54-Glass for lamps**
62	ROT.SWITCH W.LINCHPIN (6 Stk)	3	4-Non-ferro	**29-Cu wire**
63		3	1-BlkPlastics	**8-PVC**
64	DISTANCE 9,5	1	3-Ferro	**23-Cast iron**
65	PROTECTION CIRCUIT EMV 500V	800	4-Non-ferro	**29-Cu wire**
66		800	1-BlkPlastics	**6-EPS**
67	CONTACTOR	800	4-Non-ferro	**29-Cu wire**
68	Current bolt 90mm²	250	4-Non-ferro	**31-CuZn38 cast**
69	TURNING KNOB D=23 RED/BLA./RED (2 Stk)	26	1-BlkPlastics	**6-EPS**
70	FUSE 1A/25O V	3	3-Ferro	**23-Cast iron**
71	GAS SOLENOiD VALVE	131	3-Ferro	**22-St tube/profile**
72				
73	Transformer assembly			
74	SWITCH KNOB BLACK (2 Stk)	25	1-BlkPlastics	**6-EPS**
75	RECTIFIER	1500	4-Non-ferro	**28-Cu winding wire**
76	Transformer 230/400V50Hz	15000	6-Electronics	**44-big caps & coils**
77	Output choke	7000	6-Electronics	**44-big caps & coils**
78	CAM-SWITCH	400	4-Non-ferro	**26-Al sheet/extrusion**
79		100	1-BlkPlastics	**8-PVC**
80	Contact cam	500	4-Non-ferro	**26-Al sheet/extrusion**
81	THERMAL CIRCUIT BREAKER	1	4-Non-ferro	**29-Cu wire**
82		1	1-BlkPlastics	**8-PVC**
83		1	4-Non-ferro	**26-Al sheet/extrusion**
84	THERMAL CIRCUIT BREAKER	4	1-BlkPlastics	**8-PVC**
85		4	4-Non-ferro	**29-Cu wire**
86	THERMAL CIRCUIT BREAKER	5	1-BlkPlastics	**8-PVC**
87		5	4-Non-ferro	**29-Cu wire**
88	FAN W.BLADE	1430	1-BlkPlastics	**7-HI-PS**
89	SHUNT VST	27	3-Ferro	**21-St sheet galv.**
90	PC-BOARD (2 Stk)	58	6-Electronics	**98-controller board**

4.1.1.10 Other machine tools and related machinery

Other machine tools and related machinery covers such a huge spectrum, that a statement regarding the production and material composition has to remain on a very general level:

- Total weight is from few kilograms to several tonnes
- Frames and housing parts, and thus the total machinery weight, are dominated by steel and other iron based materials
- Electrical and electronics parts are relevant (although not in terms of total weight) for all electricity powered and in particular automated machinery
- Motors are used in all kind of machinery, i.e. the typical composition of motors across all power ranges constitutes a share of the total machinery composition

Metal working machine tools are broadly used for machinery building and the related manufacturing processes of machinery parts and components.

4.1.2 Distribution phase

Industrial machinery is typically directly shipped from the manufacturer to the customer, either in parts to be assembled at the final destination or as a whole. Within Europe (and as the majority of machine tools operating in Europe actually comes from European manufacturers) ground transport by truck is the typical way of delivering machinery to the customer.

The MEEuP standard settings are based on final assembly, delivery distribution centre(s) and warehouses by intra-EU trucking / rail and for an import share of 10% sea-freight and EU trucking/rail. Set distances are 1,000 km intra-EU trucking/rail and for the imported share an additional 12,000 km sea-freight. In addition, final delivery to whole-seller or central retail warehouse in medium-sized truck, transport distance 500 km, is the standard entry. The latter and the impacts of distribution centres and warehouses as such are not relevant for typical machine tools, and therefore – taking 1,000 km intra-EU transport as a realistic figure for machinery – MEEuP is likely to overestimate the distribution impacts calculated.

4.1.2.1 CNC milling and turning machine tools

The 4-axis multifunctional milling centre in section 0 specified needs for packaging and distribution, mainly plastics, wood and sheet metal. The material has a minor level of re-use. The most of it is further used in countries with waste treatment systems. The packaged volume of a unit is 72 m^3. Table 4-14 shows the entries to be made in the MEEuP EcoReport. Same entries regarding weight class and installation are to be made for the following types of machine tools.

Table 4-14: Distribution attributes of the CNC 4-axis multifunctional milling centre

Pos nr	DISTRIBUTION (incl. Final Assembly) Description		Answer	Category index (fixed)	
208	Is it an ICT or Consumer Electronics product <15 kg ?		NO	59	0
209	Is it an installed appliance (e.g. boiler)?		YES	60	1
				62	0
210	Volume of packaged final product in m^3	in m3	72	63	1

4.1.2.2 CNC laser cutting machine

The packaged final volume for a typical generic laser cutting machine tool, as outlined in 4.1.1.2, is 80 m^3.

4.1.2.3 Hydraulic Press Brake

The packaged final volume for the hydraulic press brake specified in 4.1.1.2 is 19.66 m^3.

4.1.2.4 Non-numerical controlled metal working machine tools

The packaged final volume for typical non-numerical controlled metal working machine tools is assumed to be in the range from 1-2 m^3 for smaller units up to maximum 20 m^3. Larger machinery is unlikely to be non-numerical controlled.

4.1.2.5 Wood working machine tools: Table saw

Light stationary wood working tools are assumed to start from roughly 0.2 m^3 packaged volume. Larger stationary, but less complex units are in the range of 1-2 m^3.

4.1.2.6 Wood working machine tools: Horizontal panel saw

Horizontal panel saws are shipped disassembled as they require larger tables for panel handling, and therefore feature a less compact design. Disassembled shipping allows an optimised use of any cargo capacity. For horizontal panel saws with a cutting length in the range of 3000 to 5000 mm the estimated shipped volume is in the range of 10 to 20 m^3. 14 m^3 can be considered a sound approximation.

4.1.2.7 Wood working machine tools: Throughfeed edge banding machine

Throughfeed edge bending machines are typically of a nearly cuboid shape, plus smaller feeding and auxiliary units and components. Typical machinery dimensions can be considered a sound approximation to calculate the shipping volume. Depending on the functionality and number of modules integrated in a throughfeed edge banding machine the shipping volume varies, but for a machinery length of roughly 6000 mm a sound approximation of packaged volume is 18 m^3.

4.1.2.8 Wood working machine tools: CNC machining centre

Wood working CNC machining centres are of a packaged size of several tens of cubic meters.

4.1.2.9 Welding equipment

Smaller transportable units start from 0.02 m^3 packaged volume. The typical wheeled arc welding equipment comes at roughly 0.3 m^3 packaged volume.

4.1.2.10 Other machine tools and related machinery

The broad variety of machinery comes with a broad spectrum of “packaged volume”, in particular if whole production lines are addressed, such as in the paper and printing industry. Typical values cannot be stated besides the fact that small handheld units are excluded from the scope and stationary units are likely to start at 0.02 m^3 packaged volume.

4.1.3 Use phase

The **tools** used for machining can be considered as a “consumable”. Tools are a very important component of the machine tool and the environmental impact related to tool production itself could be relevant: Rajemi et al.[4] investigated optimum turning conditions based on minimum energy considerations, taking into account also the embodied energy of the tools. As tool wear and thus tool lifetime depends on machining velocity, high throughput means a shorter tool lifetime in terms of processing cycles per tool. Rajemi et al. found out, that in terms of total energy consumption a reduced processing velocity despite the longer processing times might result in a lower total energy consumption[5]. This aspect is a question of how setting process parameters right, not of the machine design as such. Tools are made of particularly durable materials, such as specific steel alloys, frequently underwent specific hardening processes or are surface coated. The assessment of tool production will be taken into account in the later analysis where relevant.

Hydraulic oil is an essential auxiliary material for most machine tools. Hydraulic oil is not a consumable in the closer sense compared to others (e. g. lube oil) because it is used in a closed system for power transmission. However, it has to be replaced regularly and thus will be listed under “consumables” in the MEEuP assessments. As the MEEuP EcoReport does not provide a dataset for hydraulic oil, the MEEuP assessment has to be complemented by literature data. McManus et al.[6] published Life Cycle Assessment data for hydraulic oil, but for mobile systems, such as agriculture vehicles. As an approximation this data will be used in this study. The calculated impacts per 1 kg mineral oil are listed in the table below. As the impact categories used deviate from the impact categories of MEEuP the right coulmn lists the corresponding categories. There is a considerable overlap of the categories, but not a full match.

Table 4-15: Production related life cycle impacts of mineral oil production

Impact of 1 kg mineral oil production for hydraulics			MEEuP equivalents
Greenhouse gases	Kilograms CO2 equivalent	3.56	Global Warming Potential (GWP)
Ozone-depleting gases	Kilograms CFC-11 equivalent	$8.90 * 10^{-12}$	None, category considered irrelevant for EuPs

4 Rajemi, M.F.; Mativenga, P.T.; Aramcharoen, A.: Sustainable machining: selection of optimum turning conditions based on minimum energy considerations, Journal of Cleaner Production 18 (2010), p. 1059-1065

5 CECIMO stated disagreement with this finding by Rajemi et al. and provided comprehensive data to verify this aspect. Data provided by CECIMO is cited in Task 5 (discussion on productivity) extensively.

6 McManus, M. C.; Hammond, G.P.; Burrows, C.R.: Life-Cycle Assessment of Mineral and Rapeseed Oil in Mobile Hydraulic Systems, Journal of Industrial Ecology, Volume 7, Issue 3-4, Article first published online: 8 Feb 2008

Impact of 1 kg mineral oil production for hydraulics			MEEuP equivalents
Acidification	Kilograms SO equivalent	0.00383	Acidification (AD)
Eutrophication	Kilograms PO equivalent	0.000378	Eutrophication (EUP)
Heavy metals	Kilograms Pb equivalent	$5.02 * 10^{-7}$	Not transferrable to Ni and Hg equivalents
Carcinogens	Kilograms B(a)P equivalent	$1.62 * 10^{-12}$	none
Winter smog	Kilograms SPM equivalent	0.0018	none
Summer smog	Kilograms C2H4 equivalent	$1.61 * 10^{-8}$	Approximation: Volatile Organic Compounds (VOC)
Energy	Megajoules LHV equivalent	5.94	Approximation: Total Energy
Solid waste	Kilograms	0.00519	Approximation: Waste, non-hazardous, landfill

Although leakages of hydraulic oil might happen, there is no evidence, that such leakages pose a major environmental problem for machine tools.

Cooling lubricants are an important auxiliary for metal working machine tools and serve several purposes, lubricating tool and workpiece, cooling both and enhancing the removal of chips from the processing area. Under certain conditions harzardous substances might be released. Reducing the exposition requires thorough controlling and maintenance of emulsions / solutions and system components. On site measures by industrial safety authorities indicate as of 2006 that the abatement systems frequently are not effective enough and substantial emissions are released back to the working environment[7].

Cooling lubricants despite being recovered and cycled typically within a manufacturing plant constitute – besides cut-offs of any kind - the most relevant waste generated at metal working processes. Those cooling lubricants stated as consumption in the use phase per Base Case below are understood to be net consumption (i.e. already internally recycled several times), and leave the process finally either as an emission, filtered in the abatement unit or as industrial waste (either separated as waste emulsions / solutions or attached as residue on metal chips, which are then processed in metals recycling).

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[7] Pfeiffer, W.: Absaugen und Abscheiden von Kühlschmierstoffemissionen an geschlossenen Werkzeugmaschinen – Einführung, BGIA-Report 9/2006, Absaugen und Abscheiden von Kühlschmierstoffemissionen, Zusammenfassung der Vorträge anlässlich einer Fachveranstaltung am 11. Mai 2006 in Bonn

The assessments in this Task 4 cover the actual consumption of cooling lubricants (as well as of lubrication oil and hydraulic oil where relevant), but do not cover work place exposition and waste generation and disposal.

Further consumables of machine tools are **grease** for bearings and gears, and **air** for the pneumatic system. Pressurized air is assessed under the aspect energy consumption.

Furthermore, typical consumables depend on the type of machinery and are stated below.

The UK Manufacturing Technologies Association (MTA) stated metal working machine tool power ratings for major machine tool categories[8], see Table 4-16.

Table 4-16: Machine tool power ratings (source: MTA)

Machine Tool Category	Power (kW)		
	Minimum	Typical	Maximum
By laser, ultrasonic and the like	0.1	1.5	4
Machining centres	2	23	45
Lathes	1	11	75
Drilling, boring or milling; threading or tapping	0.25	23	30
Deburring, sharpening, grinding (finishing metal)	0.25	15	50
Planing, sawing, cutting-off (cutting metal)	0.25	2.2	50
Bending, folding and straightening	1.5	5	50
Shearing, punching and notching	1.5	5	30
Forging or die-stamping machines and hammers; hydraulic presses and presses	5	20	180
Sintered metal carbides or cermets, without removing material	1.5	5	50

The huge min-max range for all machine tools categories (factor 20 to 200) again shows the fact, that machine tools span a huge range of machinery sizes and technical performance. Any assumption about average power consumption therefore is a critical factor in the overall assessments.

4.1.3.1 CNC 4-axis multifunctional milling centre

Consumables for metal working machine tools are

8 SKM Enviros: Estimating the Energy Saving Potential from Small Motors and Machine Tools, Report on Machine Tools Research & Modelling, 11 July 2011, p.20

- Hydraulic oil
- Lubricant oil
- Cooling lubricants

Water is a consumable either for water-miscible cooling lubricants, or (very occassionally) for cooling of machinery parts.

The product life cycle of the milling centre specified in 4.1.1.1.2 is set with 12 years, according to the analysis for machining centres provided in Task 2. The input power for the “real machine tool”, which served as the background for this base case, is 25 kW during full operation. Being equipped with sophisticated energy recovery[9], an abstraction is required for a theoretical machine tool without this feature, which means higher power consumption in the range of approximately 30 kW during full operation[10]. In standby-mode power of 1.5 kW is consumed for latch mode of CNC control and power electronics (thyristor). Automated standby-mode switch-on is time scalable by the customer from five minutes to several hours. Usually, the time span for automated sleep is half an hour up to two hours. No electrical power is consumed during off-mode. The mode distribution is estimated for shifts of six days a week with 16.5 hours each including set-up, maintenance and repair. The operational availability is estimated for 4,400 hours/year as pure machining time with additional 750 hours/year for set-up works such as tool and work-piece change, cleaning, change of auxiliary materials as well as other maintenance and repair operations. The total switch-off is estimated with 3,600 hours/year. The operational time of 4,400 hours per year is confirmed by data provided by the UK Manufacturing Technologies Association (MTA)[11].

Water consumption for process lubrication emulsion totals in 18 m^3. A ratio of 6% to 7% lubrication oil in the range of 0.11 m^3 to 0.13 m^3 is mixed with it. The life cycle of the emulsion is strongly user-dependent and is estimated for a maximum of two years. Lube oil (“Auxiliary Material 2”) with an amount of 0.1 m^3/year and hydraulic oil (“Auxil-

9 Main drive and feed drives are equipped with energy recovery modules for transforming kinetic energy in electrical energy during drive braking. The technology to be used for this is a controlled VAC drive. Moreover, using thermo sensors the transient heat fields are estimated for compensating thermally induced dislocations of the drives.

10 For comparison, MTA stated a minimum of 2 kW, a maximum of 45 kW and a typical value of 23 kW power rating for “machining centres”

11 SKM Enviros: Estimating the Energy Saving Potential from Small Motors and Machine Tools, Report on Machine Tools Research & Modelling, 11 July 2011, p.20

iary Material 3") with an amount of 0.025 m^3/year[12], both approximated with densities of 0.9 g/cm^3, and cooling fluid with an amount of 0.11 m^3/year are also to be used ("Auxiliary Material 1", approximated with a density of 1 g/cm^3)[13].

Throughout the use phase of metal working machine tools cooling lubricants waste has to be disposed off and can be recycled:

- Cooling lubricant oils: Secondary oil refinary for drilling, cutting, and grinding oil, or incineration
- Cooling lubricant emulsions: Emulsion cracking, recycling of the oil phase in a secondary oil refinary or thermal recycling
- Cooling lubricant solutions: Separation hindered, recycling critical
- Waste of sythetic cooling lubricants should not be mixed with mineral oil based ones as it hinders recycling

Hydraulic oil, being used in closed systems, can be recovered even much better, once it has to be replaced.

However, controlled disposal of cooling lubricants waste and other oil wastes in an industrial environment can be assumed as common practice.

Throughout the use phase cooling lubricant mist is generated and might pollute the working environment, but occupational safety regulations apply, which limit the impact on workers. There are large scale emissions of cooling lubricants and oils during nor-

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12 information provided by one machine tools manufacturer in the course of base case compilation indicated a consumption of 100 l hydraulic oil per year, whereas VDMA Fluid Power / Power Transmission submitted a stakeholder comment, estimating a consumption of less than 25 liters/year and CECIMO similarly calculated with a consumption of 400 l hydraulic oil in 20 years (assumption)

13 VDMA Fluid Power / Power Transmission submitted a stakeholder comment, estimating a consumption of less than 10 liters/year cooling fluid and less than 25 liters/year hydraulic oil. The total consumption of cooling lubricants in the EU-27 is roughly 100.000 t (see 2.4.3.1), of which the majority is used in metal working. Assuming a consumption of 110 kg per year extrapolated to the total stock of CNC machine tools of 850.000 units in the EU-27 (which overestimates the consumption, as these 850.000 units do not include only machining centres but also less complex CNC machine tools) results in a total annual consumption of 93.500 t, which is pretty close to the EU-27 totals and thus seems to be plausible. CECIMO estimated in their LCA study a con-sumption of 4.000 kg coolant lubricant in 20 years for CNC machine tools, which equals 200 kg per year, which is even more than our estimate based on the information provided by one machine tools manufacturer in the course of base case compilation

mal operation of machine tools and regulation applies to minimize the impact of hazardous incidents.

Consequently the environmental impacts of cooling lubricants and oils throughout the use phase of a machine tool can be considered minor as long as state-of-the-art waste management practice is followed.

The efforts for maintenance, repair and service regard service travel of 500 kilometres per year for CNC machine tools. The service centres are situated in a maximum range of 200 kilometres to the customers. The spare part weight of 1% of the product weight is 260 kilograms. The percentage is fixed by the MEEuP template. The re-use of product parts and assemblies is to be taken into account for the estimation of spare part weight.

Table 4-17: Use phase entries for a CNC 4-axis multifunctional milling centre

Pos nr	USE PHASE Description		unit	Subtotals
211	Product Life in years	12	years	
	Electricity			
212	On-mode: Consumption per hour, cycle, setting, etc.	30	kWh	131610
213	On-mode: No. Of hours, cycles, settings, etc. / year	4387	#	
214	Standby-mode: Consumption per hour	1,5	kWh	1131
215	Standby-mode: No. Of hours / year	754	#	
216	Off-mode: Consumption per hour	0	kWh	0
217	Off-mode: No. Of hours / year	3619	#	
	TOTAL over Product Life	1592,89	MWh (=000 kWh)	65
	Consumables (excl, spare parts)			material
221	Water	18	m^3/year	83-Water per m3
222	Auxilliary material 1 (Click & select)	110	kg/ year	85-None
223	Auxilliary material 2 (Click & select)	90	kg/ year	85-None
224	Auxilliary material 3 (Click & select)	22,5	kg/ year	85-None
	Maintenance, Repairs, Service			
225	No. of km over Product-Life	6000	km / Product Life	86
226	Spare parts (fixed, 1% of product materials & manuf.)	257750	g	

4.1.3.2 CNC laser cutting machine

Consumables for laser cutting machines are

- Water (for cooling mainly the laser unit, de-ionised; to be replaced regularly also in integrated, closed chiller systems)
- Cutting gases, such as air, oxygen, nitrogen, or argon, typically few m³/h[14]
- Laser gas (where applicable): CO_2, Nitrogen, ArF, KrF, XeCl, XeF, Ar, or Kr, consumption of typically few litres per hour[15] (high purity required)
- Lubrication oil for bearings
- Hydraulic oil

Oliveira et al.[16] investigated the power consumption of various laser-based technologies for metal cutting. It has to be noted, that CO_2 lasers are the most common ones, but fibre-lasers are gaining market shares and under many conditions those fibre-lasers are less energy consuming. However, both technologies present advantages for specific production conditions with respect to metal type and sheet thickness: CO_2 lasers are more efficient for thick sheets, and are said to result also in a better cut quality, whereas fibre lasers can process a broader range of metals beyond iron-based metals and aluminium, namely copper and copper alloys in particular. As the laser requires cooling, the machine tool might come with an integrated cooling system, or alternatively it has to be connected to a central chiller system. Consequently power consumption of laser cutting machine tools includes

- Electricity
- Cooling load

Main power consuming units of a laser cutting machine are:

- Laser source
- Chiller

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14 Duflou, J.R.; Kellens, K.; Dewulf, W.: Unit process impact assessment for discrete part manufacturing: A state of the art, CIRP Journal of Manufacturing Science and Technology 4 (2011) 129-135; analysed scenario: 13,6 m³/h N_2

15 Linde: LASERLINE®. Die perfekte Lösung für eine perfekte Gasversorgung, http://www.linde-gase.de/produkte/down/katalog_laserline.pdf

16 Oliveira, M.; Santos, J.P.; Almeida, F.G., Reis, A.; Pereira, J.P.; Rocha, A.B.: Impact of Laser-based Technologies in the Energy-Consumption of Metal Cutters: Comparison between commercially available Systems, Key Engineering Materials (Volume 473), Volume Sheet Metal 2011

- Control unit (feeding positioning motors and drives, remaining electronic controls)
- Exhaustion system

Key characteristics of laser cutting systems investigated by Oliveira et al are listed in Table 4-18. It is evident, that a major share of the energy consumption is attributed to the laser unit, which is adjusted with respect to power output and thus consumption to material and sheet thickness. Particularly for the 4.5 kW CO_2 laser there is a broad range from 18.5 kW for thin sheets to 70 kW for thicker ones.

Table 4-18: Key characteristics of exemplary CNC laser cutting machines

Laser type	CO2 laser	CO2 laser	Fibre laser
Laser power [kW]	2,5	4,5	2,0
Chiller cooling capacity [kW]	43,1	86,2	9,29
Laser unit stand-by power consumption [kW]	4,8	5,8	
Laser unit off mode power consumption [kW]		Considered negligible	
Laser unit working mode power consumption [kW] for various sheet thicknesses	18,5 / 34,0 / 40,0	18,5 / 70,0	max. 8,5
control unit stand-by power consumption [kW]	1,0	1,0	1,0 (assumption)
control unit working mode power consumption [kW]	5,8	5,8	5,8 (assumption)
chiller unit stand-by power consumption [kW]	6,8 (average)	30,0 (average)	6
chiller unit working mode power consumption [kW]	15,5	30,0 – 35,0	6
exhaustion system working mode power consumption [kW]	4 – 5,5	4 – 5,5	4 – 5,5
exhaustion system stand-by mode power consumption [kW]	Close to 0	Close to 0	Close to 0

Those facilities analysed by Oliveira et al. featured time shares in the various modes as follows:

- Working mode: 45-55%
- Standby mode: 35-50%
- Off mode: 5-10%

Given these ranges a realistic, but simplified use phase scenario for a CO_2 laser machine tool is as outlined in the following table. These values are much higher, than those stated by the UK Manufacturing Technologies Association (MTA) for "laser, ultrasonic and the like" (0,1 kW minimum, 1,5 kW typical, 4 kW maximum)[17], but values below have been confirmed by industry sources and literature. This discrepancy obviously stems from a different understanding of this market segment: Whereas MTA might have referred e.g. to smaller work shop laser engraving units, our focus is on large-scale industrial 2D laser cutting machine tools[18].

Table 4-19: Use phase scenario for a CNC laser cutting machine

Laser type	Off mode	Standby mode	Working mode
Time share	5%	40%	55%
Duration per working day, 2 shifts	0,8 h/d	6,4 h/d	8,8 h/d
Average power consumption	0 kW	26 kW	70 kW
laser unit	*0 kW*	*5 kW*	*35 kW*
control unit	*0 kW*	*1 kW*	*6 kW*
chiller unit	*0 kW*	*20 kW*	*24 kW*
exhaustion system	*0 kW*	*0 kW*	*5 kW*

However, it should be noted, that the power consumption profile is far from featuring constant power consumption in the various modes. For illustration see below measurements by Duflou[19] and Devoldere[20] for a 5 kW CO2 laser machine, processing 1 mm steel plates with three different laser output settings (see Figure 4-2).

17 SKM Enviros: Estimating the Energy Saving Potential from Small Motors and Machine Tools, Report on Machine Tools Research & Modelling, 11 July 2011, p.20

18 Consequently our results will be applied only to a smaller market share of laser machine tools, see chapter 4.5.2

19 Duflou, J.R.; Kellens, K.; Devoldere, T.; Deprez, W.; Dewulf, W.: Energy related environmental impact reduction opportunities in machine design: case study of a laser cutting machine. International Journal of Sustainable Manufacturing, 2010, 2(1), 80–98.

20 Devoldere, T.; Dewulf, W.; Deprez, W.; Duflou, J.R.: Energy Related Life Cycle Impact and Cost Reduction Opportunities in Machine Design: The Laser Cutting Case, Proc. 15th CIRP International Conference on Life Cycle Engineering, Sydney, Australia, ISBN 1-877040-67-3. pp. 412-419.

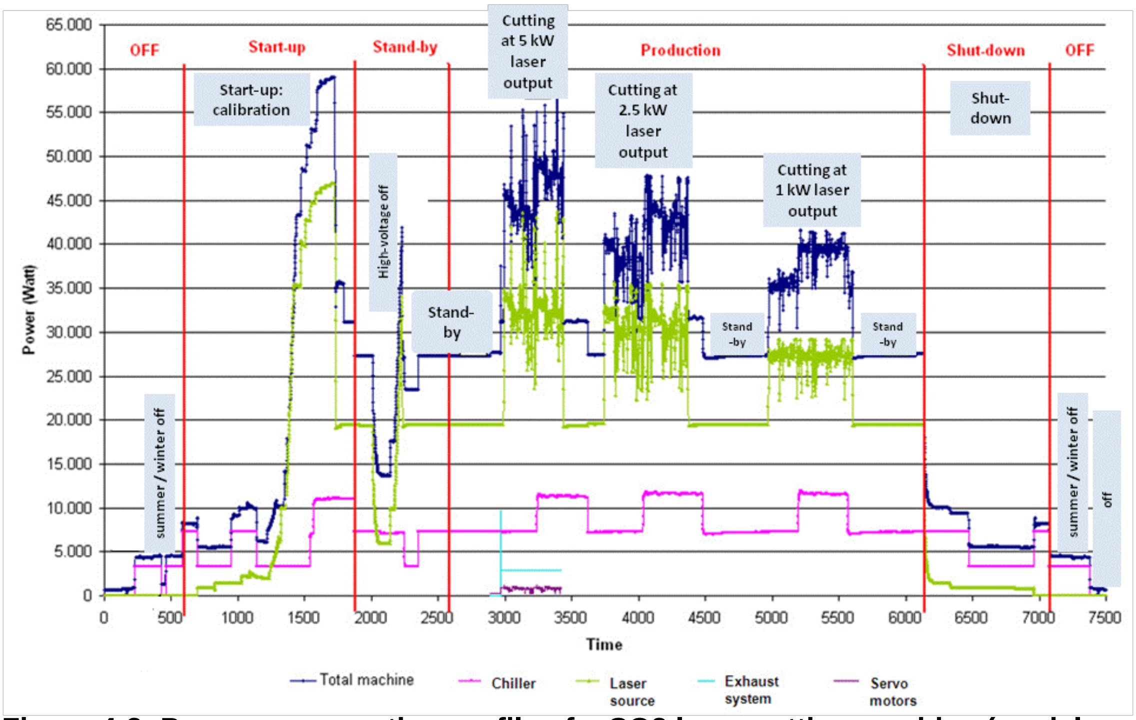


Figure 4-2: Power consumption profile of a CO2 laser cutting machine (model LVD Axel 3015 S, adapted from Deflou et al.)

The various modules are monitored throughout the start-up, stand-by, production, and shut-down phase, demonstrating the huge relevancy of the laser system as such, followed by the chiller, which switches on one or two compressors depending on cooling needs. Stand-by power is also dominated by the laser at a stable level of 27 kW in this case. A lower power mode is “high voltage off”, which un-excites the laser source, but is followed by a power consumption peak when the laser sources is reactivated. Motors, contrary to CNC machining centers, play a minor role regarding energy consumption: Servomotors are employed to move the laser head in three axes, when cutting a sheet. In average Duflou et al. measured a power consumption of 0,86 kW for these, compared to 32,7 kW for the laser source (at 5 kW output) and 7,24 to 11 kW for the chiller unit.

Another power consumption profile is provided by Oliveira et al.[21] comparing a 2,5 kW CO2 laser and a 4.5 kW CO2 laser in regular production. Exemplary measurements

21 Oliveira, M.; Santos, J.P.; Almeida, F.G.; Reis, A.; Pereira, J.P.; Rocha, A.B.: Impact of Laser-Based Technologies in the Energy-Consumption of Metal Cutters: Comparison between Commercially Available Systems, Journal Key Engineering Materials, Vol. 473, 2011, pp. 809-815

are depicted in Figure 4-3, differentiating power consumption for the laser source, chiller, and control unit, which covers power supply of motors and drives and remaining electronics controls. Again, laser and chiller are dominating. Laser power consumption is characterised is subject to a large fluctuation when cutting is performed. Depending on sheet thickness, power consumption of the laser is adapted (visible in the right example). The chiller unit features two different profiles for the two machines measured, a rectangular profile for the 2,5 kW laser with longer standby periods, whereas the chiller for the 4,5 kW unit is constantly on a high level with regular peaks.

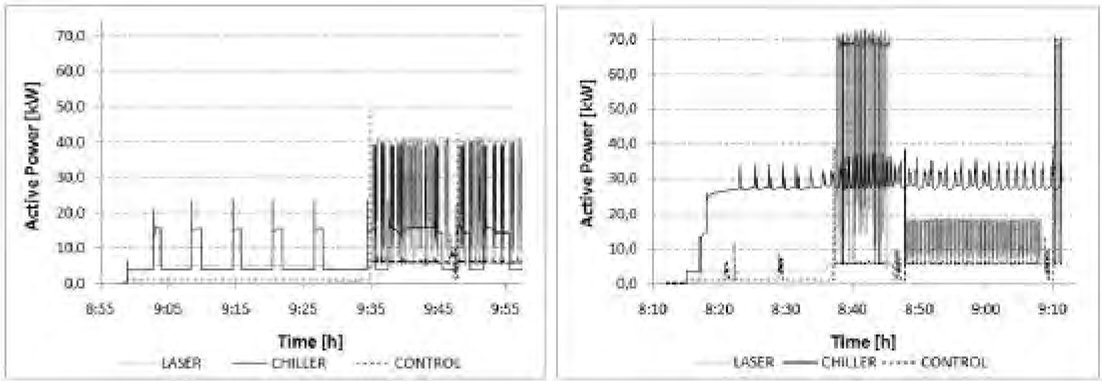


Figure 4-3: Exemplary Power consumption profiles of CO2 laser cutting machine (left: 2.5 kW, right: 4.5 kW, Oliveira et al.)

Regarding consumables, assumptions are as follows:

- (cooling) water: 2 m³/a
- (“Auxiliary material 1”:) Laser gas CO_2 / N_2 / He: 20 l/h, i.e. 0,01 kg/h[22] (equals 80 m³/a, 40 kg/a at 16 h, 250 days)
- (“Auxiliary material 2”:) Cutting gas N_2: 5 m³/h, i.e. 6,25 kg/h (equals 20,000 m³/a, 25 t/a)

The consumption of nitrogen represents the lower end of consumption data as stated by Linde[23] for cutting stainless steel (see Table 4-20),

22 Assumption average density of gas mixture: 0,5 kg/m³

23 Berkmanns, J.; Faerber, M.: Facts About Laser technology - Laser cutting, Linde AG, Cleveland, USA / Unterschleißheim, Germany

Table 4-20: Parameters for laser cutting of stainless steel with laser cutting nitrogen including pressure and volume requirements

material thickness (mm)	laser power (W)	nozzle diameter (mm)	nitrogen pressure (bar)	gas volume (m³/h)	cutting speed (m/min)
1,0	1500	1,2–1,5	6,0	8,0	7,0
2,0	1500	1,2–1,5	9,0	12,0	4,0
4,0	3000	2,0–2,5	13,0	28,0	3,0
6,0	3000	2,5–3,0	14,0	52,0	1,5
9,0	4000	2,5–3,0	16,0	60,0	1,0
12,0	4000	2,5–3,0	18,0	68,0	0,5

Individual costs for laser gas depend on gas type and total consumption (rebates), but are roughly in the range of 20 €/m³, and for cutting gas 1 €/m³ [24].

Table 4-21: Use phase entries for a CNC laser cutting machine

Pos nr	USE PHASE Description		unit	Subtotals
211	Product Life in years	12	years	
	Electricity			
212	On-mode: Consumption per hour, cycle, setting, etc.	70	kWh	154000
213	On-mode: No. Of hours, cycles, settings, etc. / year	2200	#	
214	Standby-mode: Consumption per hour	26	kWh	41600
215	Standby-mode: No. Of hours / year	1600	#	
216	Off-mode: Consumption per hour	0	kWh	0
217	Off-mode: No. Of hours / year	4960	#	
	TOTAL over Product Life	2347,20	MWh (=000 kWh)	65
	Consumables (excl. spare parts)			material
221	Water	2	m^3/year	83-Water per m3
222	Auxilliary material 1 (Click & select)	40	kg/ year	85-None
223	Auxilliary material 2 (Click & select)	25000	kg/ year	85-None
224	Auxilliary material 3 (Click & select)	0	kg/ year	85-None
	Maintenance, Repairs, Service			
225	No. of km over Product-Life	6000	km / Product Life	86
226	Spare parts (fixed, 1% of product materials & manuf.)	120013	g	

24 Scholz, J.: Laser in der Materialbearbeitung – Wirtschaftlichkeitsbetrachtungen, Linde AG, 2008, http://www.laserdeal.com/techInfoFiles/Facts%20about%20Wirtschaftlichkeit%20Laser%20in%20der%20Mat.pdf

The electricity consumption totals correspond also with a scenario analysed by Duflou et al.[25], who state an annual power consumption for a 5 kW CO_2 laser cutting machine in 2 shifts operation of nearly 200 MWh, which exactly matches the total lifetime (12 years) electricity consumption of 2.347 MWh calculated above, although the shares attributed to the various modes are slightly different.

The efforts for maintenance, repair and service regard service travel of 500 kilometres per year for CNC machine tools.

4.1.3.3 Hydraulic Press Brake

Power consumption of hydraulic press brakes has been investigated by Santos et al.[26] Figure 4-4 depicts the power consumption of a press brake during a working day (based on real measured data for machine tool with maximum bending capacity of 170 t) clearly showing the different power consumption levels working mode, stand-by and off-mode: For a single bending cycle (depicted schematically only) a distinction has to be made regarding the following phases: The tool approaching the work piece with a power consumption on the stand-by level, the actual bending process with elevated power consumption, followed by a return movement of the tool.

[25] Duflou, J.R.; Kellens, K.; Dewulf, W.: Unit process impact assessment for discrete part manufacturing: A state of the art, CIRP Journal of Manufacturing Science and Technology 4 (2011) 129-135

[26] Santos, J.P.; Oliveira, M.; Almeida, F.G., Pereira, J.P.; Reis, A.: Improving the environmental performance of machine-tools: influence of technology and throughput on the electrical energy consumption of a press-brake, Journal of Cleaner Production (2010), article in press, October 28, 2010

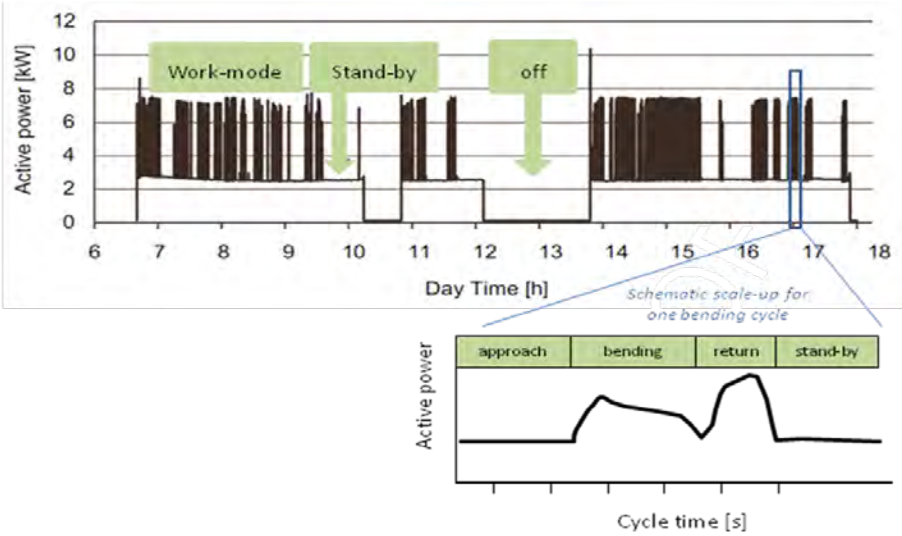


Figure 4-4: Power consumption cycles of press-brakes (adapted from Santos et al.)

For three hydraulic press brakes of a bending capacity of 110 t Santos et al. state work mode (approach / bending / return cycle) power consumption of 2-6 kW[27], stand-by (e.g. during workpiece change and fixing) power consumption of 1.5-3 kW, and off-mode values of maximum 0.5 kW. The actual use power consumption depends on throughput, i.e. cycle times and thus relation between work mode and stand-by times, the latter including load/unload times. Hydraulic oil consumption ("auxiliary material 2") is assumed to be 120 l, i.e. 108 kg/a.

For an exemplary use scenario of a hydraulic press-break the settings are listed in the table below. Product life time corresponds to the results of the analysis provided in task 2.

The efforts for maintenance, repair and service regard service travel of 500 kilometres per year for CNC machine tools.

27 this range corresponds with power ratings stated by MTA for "bending, folding and straightening": min-max 1.5 – 50 kW, typical 5 kW power *rating*, but is much lower than that stated for "forging or die-stamping machines and hammers; hydraulic presses and presses: min-max 5 – 180 kW, typical 20 kW power rating

Table 4-22: Use phase entries for a hydraulic press brake

Pos nr	USE PHASE Description		unit	Subtotals
211	Product Life in years	17	years	
	Electricity			
212	On-mode: Consumption per hour, cycle, setting, etc.	0,0165	kWh	1856,25
213	On-mode: No. Of hours, cycles, settings, etc. / year	112500	#	
214	Standby-mode: Consumption per hour	0,9481	kWh	1659,175
215	Standby-mode: No. Of hours / year	1750	#	
216	Off-mode: Consumption per hour	0	kWh	0
217	Off-mode: No. Of hours / year	0	#	
	TOTAL over Product Life	59,76	MWh (=000 kWh)	65
	Consumables (excl, spare parts)			material
221	Water	0	m^3/year	83-Water per m3
222	Auxilliary material 1 (Click & select)	0	kg/ year	85-None
223	Auxilliary material 2 (Click & select)	108	kg/ year	85-None
224	Auxilliary material 3 (Click & select)	0	kg/ year	85-None
	Maintenance, Repairs, Service			
225	No. of km over Product-Life	8500	km / Product Life	86
226	Spare parts (fixed, 1% of product materials & manuf.)	78720	g	

The on-mode values are based on a distinct theoretical analysis of the hydraulic system functioning sequence, provided by de Oliviera et al.[28] as listed in the following table.

Table 4-23: Bending cycle and related power consumption

Bending cycle	Duration [s]	active power [kW]	active energy [kWh]
Fast descending	1.5	1.79	0.0007
Slow descending without load	0.5	1.79	0.0002
Slow descending with load	2	12.13	0.0067
Stopping	2	12.13	0.0067
Ascending	2	3.66	0.0020
Totals per cycle	**8**	**-**	**0.0165**

28 e-mail February 23, 2011; the power consumption profile presented in Figure 4-4 does not fully correspond with these stated values, see the peak for "return" compared to the rather low value stated here

Unit for the entry in row 213 (i.e. on-mode time) is the number of bending cycles per year, calculated as follows:

- Time in on-mode: 8 hrs/day;
- Time in working-mode (daily production of 8 h): 12.5%;
- Bending cycle time: 8 s/cycle.

Under these assumptions a theoretical value of 450 cycles/day is gained, resulting in 112,500 bending cycles per year, based on 250 working days per year.

The stated time in standby is the remaining time during productive hours, i.e. 87.5% of the 8-hours shift, equalling 7 hours in standby per day, but it should be noted for later quantification of improvement potential, that this is rather understood to be idle time covering times of work piece change etc. and not lengthy production breaks.

Off-mode considers a complete switch-off at night and at weekends.

For a two-shift operation, number of bending cycles and times in standby/idle would be twice as high.

4.1.3.4 Non-numerical controlled metal working machine tools

Non-numerical controlled metal working machine tools are used in one-shift operation mostly. Therefore the machine is in “on-mode” 1500 hours per year. Most of the time, 6760 hours, it is in “Off-mode”. Stand-by (500 hours) is the time to change workpieces or tools by hand or breaks. Off-mode considers a complete switch-off at night and at weekends.

Consumables for non-numerical controlled metal working machine tools are

- Hydraulic oil
- Cooling lubricants

Consumption of both is assumed to be 2 kg per year (“auxiliary material 1 and 2”). Water is a consumable for water-miscible cooling lubricants.

Power consumption was measured by Fraunhofer IPK for an exemplary machine tool. The power consumption profile is depicted in Figure 4-5.

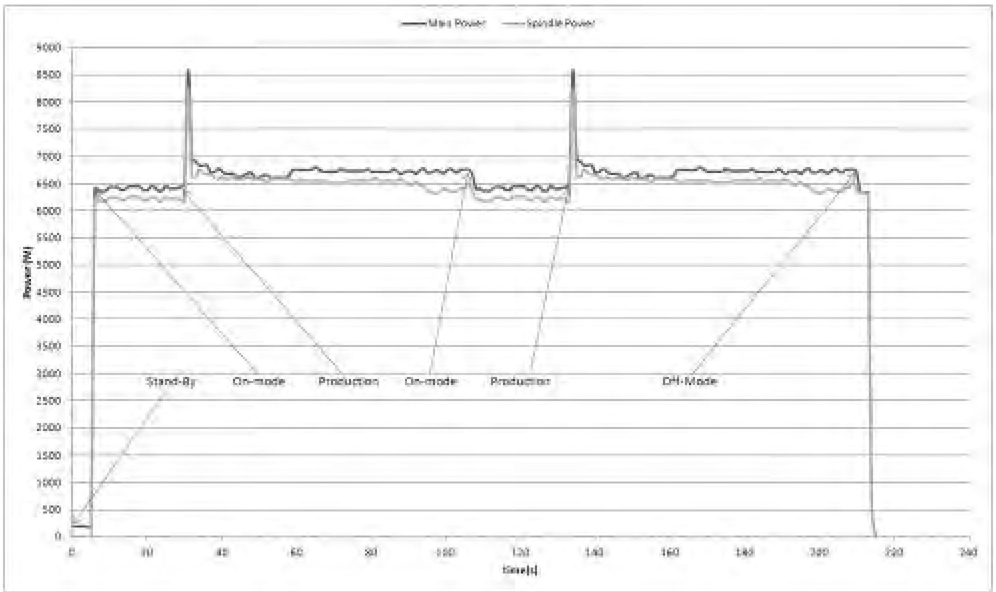


Figure 4-5: Power consumption non-numerical controlled metal working machine tools (own measures)

The parameter for these tests are:

- Cutting force v_C = 248 m/min
- Depth of cut a_p = 0,5 mm
- Feed rate = 0,8 m/min
- Workpiece diameter d = 77 mm
- Spindle speed = 180 min^{-1}
- Material: C45, round steel, hot rolled

The most relevant electric consumer is the main spindle (about 97 % of the machine energy). Cooling lubricant is often applied “by hand”.

The efforts for maintenance, repair and service regard service travel of a default value of 100 kilometres per year for non-CNC machine tools.

Table 4-24: Use phase entries for a non-numerical controlled metal working machine tools

Pos nr	USE PHASE Description		unit	Subtotals
211	Product Life in years	18	years	
	Electricity			
212	On-mode: Consumption per hour, cycle, setting, etc.	6,8	kWh	10200
213	On-mode: No. Of hours, cycles, settings, etc. / year	1500	#	
214	Standby-mode: Consumption per hour	0,2	kWh	100
215	Standby-mode: No. Of hours / year	500	#	
216	Off-mode: Consumption per hour	0	kWh	0
217	Off-mode: No. Of hours / year	6760	#	
	TOTAL over Product Life	185,40	MWh (=000 kWh)	65
	Consumables (excl, spare parts)			material
221	Water	0,5	m^3/year	83-Water per m3
222	Auxilliary material 1 (Click & select)	2	kg/ year	85-None
223	Auxilliary material 2 (Click & select)	2	kg/ year	85-None
224	Auxilliary material 3 (Click & select)	0	kg/ year	85-None
	Maintenance, Repairs, Service			
225	No. of km over Product-Life	1800	km / Product Life	86
226	Spare parts (fixed, 1% of product materials & manuf.)	10000	g	

4.1.3.5 Wood working machine tools: Table saw

For table saws manufacturers recommend lubrication according to maintenance manuals. Lubricants to be used for gear and tilt / elevating mechanism are e.g. dry silicone, teflon lubricants, or non-hardening lithium-based grease. Recommended frequency is once per month or more often, if required. For housed elevating mechanisms (which are more common for larger professional equipment), which are supplied through dedicated lubrication nipples, thorough maintenance might require a re-lubrication only once per year, or every 100 m aggregated travel distance. Assuming an application of 10 g lubricant per month as an approximation, total annual consumption is in the range of 120 g lubricant / grease per year per table saw.

Some manufacturers recommend applying a coat of paste wax or white talcum powder regularly to keep the table surface clean and free of rust. When such a saw is used for other material than wood, such as aluminium or plastics, usage of a spray cooling unit might be advisable, i.e. also cooling lubricants might be used occasionally for table saws.

Plausible use phase values for light-stationary woodworking tools, in particular table and radial arm saws, band saws and planer thicknessers have been cordially provided by EPTA as listed in Table 4-25 (for stationary, corded, with induction motor).

Table 4-25: Use scenarios for light-stationary woodworking tools

	Average Motor Efficiency	Average Design Life	Average Design Life	Average Input Power	Average Lifetime Energy	Average Annual Energy
					Use phase	Use phase
	%	Hours	Years	KW	KWh	KWh
Scenario 1	**70**	**2500**	**10**	**1,0**	**2500**	**250**
Scenario 2	**70**	**3750**	**15**	**1,0**	**3750**	**250**

Basically light stationary tools feature only the two modes on and off, realised through a hard-switch.

Motors used in light stationary woodworking tools are typically single or three-phase induction motors with 2 or 4 poles. Three-phase induction motors are covered by Commission Regulation (EC) No 640/2009 on ecodesign requirements for electric motors (see Task 1, 1.3.1; since June 2011 three-phase induction motors have to meet the IE2 level, which requires a motor efficiency of 77,4 to 85,5% for most frequently used motor ratings in light-stationary tools), whereas single phase motors are not[29]. Single-phase motors typically have got a lower efficiency than three phase motors, hence the scenario described above represents the multitude of single phase motor tools. However, single-phase motors are are also those intended for the DIY market, thus leaving a "grey area" with respect to the defined scope of this study, which is meant to cover only machine tools "intended for professional use" (see Task 1, 1.1.2.2).

Given the estimates provided by EPTA the power values translate into 250 hours (1 hour per working day) on-mode per year, 8510 hours switched off. The stated average design life of 10 and 15 years does not match with the initial estimate of a 20 years lifetime (see 2.2.1.2, task 2 report). For the sake of data coherence the following

[29] These might be covered under the upcoming Preparatory Study "Lot 30 - Other electric motors (outside Regulation 640/2009)"

calculations are still based on assumed 20 years lifetime, but this is related to significant uncertainties.

Spare parts can be ordered directly at the manufacturer and retailer (operation manuals frequently feature an explosion drawing with parts list to allow individual replacement orders), and repair and maintenance typically is not done by external service personal. Therefore, use phase calculations take into account much less travel distances for maintenance, repairs, service than for large-scale industrial type equipment (10 km, which reflects the shipment of some replacement parts instead of a service personnel visit).

Table 4-26: Use phase entries for a table saw

Pos nr	USE PHASE Description		unit	Subtotals
211	Product Life in years	20	years	
	Electricity			
212	On-mode: Consumption per hour, cycle, setting, etc.	1	kWh	250
213	On-mode: No. Of hours, cycles, settings, etc. / year	250	#	
214	Standby-mode: Consumption per hour	0	kWh	0
215	Standby-mode: No. Of hours / year	0	#	
216	Off-mode: Consumption per hour	0	kWh	0
217	Off-mode: No. Of hours / year	0	#	
	TOTAL over Product Life	5,00	MWh (=000 kWh)	65
	Consumables (excl. spare parts)			material
221	Water	0	m^3/year	83-Water per m3
222	Auxilliary material 1 (Click & select)	0,12	kg/ year	85-None
223	Auxilliary material 2 (Click & select)	0	kg/ year	85-None
224	Auxilliary material 3 (Click & select)	0	kg/ year	85-None
	Maintenance, Repairs, Service			
225	No. of km over Product-Life	10	km / Product Life	86
226	Spare parts (fixed, 1% of product materials & man-uf.)	270	g	

4.1.3.6 Wood working machine tools: Horizontal panel saw

A typical horizontal panel saw is characterised as follows:

- Connection power: 15 kW
- Extraction air volume: 5000 m³/h (in any mode)

- Pressurized air consumption: 0,15 Nm^3/h (in any mode)

Power consumption in absence of real measured values can be estimated as follow (which largely corresponds with estimates practiced by leading machinery manufacturers):

- Power consumption in operational mode: 12 kW (80% of connection power)
- Power consumption in idle mode: 7,5 kW (50% of connection power)
- Power consumption in standby: 750 W (5% of connection power)

These panel saws are used in the furniture industry, but in their majority in craft businesses, i.e. typically 1 shift operation. These assumptions result in the following mode scenario:

- 8 h/d, 250 days per year
- 6,25% in operational mode: 0.5 h per day
- 75% in idle mode: 6 h/d
- 18,75% in standby mode: 1.5 h per day

The efforts for maintenance, repair and service regard service travel of a default value of 100 kilometres per year for this kind of industrial wood working machine tools.

Use phase entries for the environmental and cost assessment are as listed in Table 4-27.

Table 4-27: Use phase entries for a horizontal panel saw

Pos nr	USE PHASE Description		unit	Subtotals
211	Product Life in years	20	years	
	Electricity			
212	On-mode: Consumption per hour, cycle, setting, etc.	12	kWh	1500
213	On-mode: No. Of hours, cycles, settings, etc. / year	125	#	
214	Standby-mode: Consumption per hour	7,5	kWh	11250
215	Standby-mode: No. Of hours / year	1500	#	
216	Off-mode: Consumption per hour	0,75	kWh	281,25
217	Off-mode: No. Of hours / year	375	#	
	TOTAL over Product Life	260,63	MWh (=000 kWh)	65
	Consumables (excl, spare parts)			material

221	**Water**	0	m^3/year	**83-Water per m3**
222	**Auxilliary material 1 (Click & select)**	0	kg/ year	**85-None**
223	**Auxilliary material 2 (Click & select)**	0	kg/ year	**85-None**
224	**Auxilliary material 3 (Click & select)**	0	kg/ year	**85-None**
	Maintenance, Repairs, Service			
225	**No. of km over Product-Life**	2000	km / Product Life	86
226	**Spare parts** (fixed, 1% of product materials & manuf.)	50000	g	

4.1.3.7 Wood working machine tools: Throughfeed edge banding machine

Characteristics of such edge banding machines, being in operation at large currently, not including latest energy savings measures:

- Connection power: 12 kW
- Extraction air volume: 1800 m³/h (in any mode)
- Pressurized air consumption: 0,05 Nm³/h (in any mode)

Power consumption in absence of real measured values can be estimated as follow (which largely corresponds with estimates practiced by leading machinery manufacturers):

- Power consumption in operational mode: 9,6 kW (80% of connection power)
- Power consumption in idle mode: 6 kW (50% of connection power)
- Power consumption in standby: 600 W (5% of connection power)

These throughfeed edge banding machine are used in the furniture industry, but in their majority in craft businesses, i.e. typically 1 shift operation. These assumptions result in the following mode scenario:

- 8 h/d, 250 days per year
- 6,25% in operational mode: 0.5 h per day
- 75% in idle mode: 6 h/d
- 18,75% in standby mode: 1.5 h per day

Use phase entries for the environmental and cost assessment are as listed in Table 4-28.

The efforts for maintenance, repair and service regard service travel of a default value of 100 kilometres per year for this kind of industrial wood working machine tools.

Table 4-28: Use phase entries for a throughfeed edge banding machine

Pos nr	USE PHASE Description		unit	Subtotals
211	Product Life in years	20	years	
	Electricity			
212	On-mode: Consumption per hour, cycle, setting, etc.	9,6	kWh	1200
213	On-mode: No. Of hours, cycles, settings, etc. / year	125	#	
214	Standby-mode: Consumption per hour	6	kWh	9000
215	Standby-mode: No. Of hours / year	1500	#	
216	Off-mode: Consumption per hour	0,6	kWh	225
217	Off-mode: No. Of hours / year	375	#	
	TOTAL over Product Life	208,50	MWh (=000 kWh)	65
	Consumables (excl, spare parts)			material
221	Water	0	m^3/year	83-Water per m3
222	Auxilliary material 1 (Click & select)	0	kg/ year	85-None
223	Auxilliary material 2 (Click & select)	0	kg/ year	85-None
224	Auxilliary material 3 (Click & select)	0	kg/ year	85-None
	Maintenance, Repairs, Service			
225	No. of km over Product-Life	2000	km / Product Life	86
226	Spare parts (fixed, 1% of product materials & manuf.)	25000	g	

4.1.3.8 Wood working machine tools: CNC machining centre

Characteristics of such CNC centres, not including latest energy savings measures, are:

- Connection power: 25 kW
- Extraction air volume: 5000 m³/h (in any mode)
- Pressurized air consumption: *no data available*

Power consumption in absence of real measured values can be estimated as follow (which largely corresponds with estimates practiced by leading machinery manufacturers):

- Power consumption in operational mode: 20 kW (80% of connection power)
- Power consumption in idle mode: 12,5 kW (50% of connection power)
- Power consumption in standby: 1 kW (5% of connection power)

These machining centres are mainly used in furniture making industry, occasionally also in crafts business, but this is not the main market for this type of machines. Therefore typically a 2 shifts operation can be assumed, which leads to the following mode scenario:

- 16 h/d, 250 days per year
- 40% in operational mode: 6,4 h per day
- 40% in idle mode: 6,4 h/d
- 20% in standby mode: 3,2 h per day

Use phase entries for the environmental and cost assessment are as listed in Table 4-29.

The efforts for maintenance, repair and service regard service travel of 500 kilometres per year for CNC machine tools.

Table 4-29: Use phase entries for a wood working CNC machining centre

Pos nr	USE PHASE Description		unit	Subtotals
211	Product Life in years	20	years	
	Electricity			
212	On-mode: Consumption per hour, cycle, setting, etc.	20	kWh	32000
213	On-mode: No. Of hours, cycles, settings, etc. / year	1600	#	
214	Standby-mode: Consumption per hour	12,5	kWh	20000
215	Standby-mode: No. Of hours / year	1600	#	
216	Off-mode: Consumption per hour	1	kWh	800
217	Off-mode: No. Of hours / year	800	#	
	TOTAL over Product Life	1056,00	MWh (=000 kWh)	65
	Consumables (excl, spare parts)			material

221	**Water**	0	m^3/year	**83-Water per m3**
222	**Auxilliary material 1 (Click & select)**	0	kg/ year	**85-None**
223	**Auxilliary material 2 (Click & select)**	0	kg/ year	**85-None**
224	**Auxilliary material 3 (Click & select)**	0	kg/ year	**85-None**
	Maintenance, Repairs, Service			
225	**No. of km over Product-Life**	10000	km / Product Life	86
226	**Spare parts** (fixed, 1% of product materials & manuf.)	80000	g	

4.1.3.9 Welding equipment

Major consumables of welding and soldering processes are highly dependent on the technology, i.e. type of process applied.

The two major types of consumables are

- Welding wire or welding electrodes, or solder respectively
- Welding gases of various types

However, consumption is very specific for the intended purpose (type of weld, material).

Efficiency of arc welding power sources varies with the type of source and sees a steady shift towards more efficient units. Table 4-30 lists the mean efficiency of these technologies, related sales by EWA members 2009-2011 and the estimated installed stock in EU-27 according to data provided by EWA.

Table 4-30: Efficiency of arc welding units sales and stock (sales by EWA members)

Sales by EWA members	Mean Effiency	EWA Sales 2009	EWA Sales 2010	EWA Sales 2011	2012 EU-27 installed stock estimation
Inverter single-phase	78%	20%	24%	23%	20%↗
Inverter 3-phase	83%	39%	47%	51%	20%↗
Thyristor or Chopper 3-phase	73%	7%	6%	4%	16%↘
Transformer single-phase	68%	7%	1%	1%	10%↘
Transformer 3-phase	73%	27%	22%	21%	33%↘
Rotating type	45%	0%	0%	0%	1%↘
Total		100%	100%	100%	100%
Weighted efficiency average		77%	79%	79%	**75%**

The weighted efficiency average as of 2012 is estimated to be 75%.

A typical arc welding unit[30] has a primary continuous power consumption of 6.2 kVA (arc-on), equalling at 75% efficiency at 200 A an output power of 4.65 kW (23.25 V).

In their majority these units are used in 1-shift-operations. A realistic arc-on time (i.e. operating factor) is 25% (see also chapter 3.2.3). This operating factor might be much lower in smaller repair shops or in the construction sector, where the welding equipment is used only occassionally, and higher in industrial production, where a similar welding unit might be used at high load in a roboter based production line.

Given 25 % arc-on time, total arc-on time per year is 500 hours, idle time 1500 hours, based on one shift for 250 days a year.

Typical idle-mode power is 0.05 kVA, which used to be much higher for former transformer style welding power sources.

Repair and maintenance typically is not done by external service personal. Therefore, use phase calculations take into account much less travel distances for maintenance, repairs, service than for large-scale industrial type equipment (10 km, which reflects the shipment of some replacement parts instead of a service personnel visit).

Table 4-31: Use phase entries for an arc welding unit

Pos nr	USE PHASE Description		unit	Subtotals
211	Product Life in years	7	years	
	Electricity			
212	On-mode: Consumption per hour, cycle, setting, etc.	6,2	kWh	3100
213	On-mode: No. Of hours, cycles, settings, etc. / year	500	#	
214	Standby-mode: Consumption per hour	0,05	kWh	75
215	Standby-mode: No. Of hours / year	1500	#	
216	Off-mode: Consumption per hour	0	kWh	0
217	Off-mode: No. Of hours / year	0	#	
	TOTAL over Product Life	22,23	MWh (=000 kWh)	65
	Consumables (excl, spare parts)			material
221	Water	0	m^3/year	83-Water per m3
222	Auxilliary material 1 (Click & select)	500	kg/ year	85-None
223	Auxilliary material 2 (Click & select)	0	kg/ year	85-None
224	Auxilliary material 3 (Click & select)	0	kg/ year	85-None

30 See Bill-of-materials above

	Maintenance, Repairs, Service			
225	**No. of km over Product-Life**	10	km / Product Life	86
226	**Spare parts** (fixed, 1% of product materials & manuf.)	1400	g	

Based on these assumptions power consumption in on-mode, which is understood to be arc-on time is 3,100 kWh/a and in idle time 75 kWh/a.

For most gas metal arc welding applications as a rule of thumb a flow of shielding gas of 0,1 l/min per 1 mm welding wire diameter is recommended, resulting in 0,6 Nm³/h as an approximation for typical welding tasks, equalling roughly 1 kg/h Argon gas during arc-on time (listed as “auxiliary 1” in the table). Argon is taken here as a proxy for the multitude of welding gas mixtures, most of them being dominated by a high Argon content.

4.1.3.10 Other machine tools and related machinery

Consumables used in other machine tools and related machinery than those described above are manifold and frequently include hydraulic oil, occasionally also cooling lubricants (e.g. for stone working applications).

4.1.4 End-of-life phase

Disposal of machine tools and related machinery in the EU (but also worldwide) is characterised by metal recovery as the metal components represent a significant value. Although a minor share of composite or mixed materials might be disposed of in landfills this is considered negligible compared to the bulk metal parts. Hence, the ratio of material to landfill is set to 0% unless certain fractions are identified, which are likely to be disposed of in a landfill. For plastics end-of-life the default settings of MEEuP are 1% re-use, closed loop recycling, 9% materials recycling, and 90% thermal recycling for the larger share of mixed plastics. Given the fact, that the amount of homogenous bulk plastics parts is significant, a larger plastics fraction can be separated for materials recycling. Accordingly the standard settings are adjusted as follows to reflect this fact: 1% re-use, closed loop recycling, 19% materials recycling, and 80% thermal recycling. Printed Circuit Boards are considered easy to disassemble as these are typically used similar to PCs.

Table 4-32: End of life settings for B2B machine tools and related machinery

Pos nr	DISPOSAL & RECYCLING Description		unit
	Substances released during Product Life and Landfill		
227	Refrigerant in the product (Click & select)	0	g
228	Percentage of fugitive & dumped refrigerant	0%	
229	Mercury (Hg) in the product	0	g Hg
230	Percentage of fugitive & dumped mercury	0%	
	Disposal: Environmental Costs per kg final product		
231	Landfill (fraction products not recovered) in g en %	0	0%
232	Incineration (plastics & PWB not re-used/recycled)	[calculated]	g
233	Plastics: Re-use & Recycling ("cost"-side)	[calculated]	g
	Re-use, Recycling Benefit	in g	% of plastics fraction
234	Plastics: Re-use, Closed Loop Recycling (please edit %)	[calculated]	1%
235	Plastics: Materials Recycling (please edit% only)	[calculated]	19%
236	Plastics: Thermal Recycling (please edit% only)	[calculated]	80%
237	Electronics: PWB Easy to Disassemble? (Click&select)	[calculated]	YES
238	Metals & TV Glass & Misc. (95% Recycling)	[calculated]	

This scenario refers to the "final" end-of-life, but it should be acknowledged, that throughout the lifetime of a machine tool remanufacturing is very common, just as stated by SKM Enviros in their study for UK DEFRA[31]: "The machine tools market is a business to business market and operates differently to markets for consumer products. Given their relatively high value and the fact that the chassis design has changed little over the years a significant proportion of machine tools are 'recycled', where they are either refurbished or remanufactured and updated to new standards. This ranges from fairly modest improvements through full rebuilds incorporating full automation and control systems. Where a machine tool has been remanufactured it is quite possible for more energy efficient components or controls to be added thus leading to a reduction in the energy consumption of the whole machine." Neither aspect, neither the remanufacturing as such nor the potential efficiency improvements implemented at some point, are reflected in our analysis. However, what can be stated (also in line with reuse market data in Task 2 and the assessment in Task 3) is the fact, that remanufacturing and lifetime extension of machine tools actually happens frequently and is not a field of ma-

31 SKM Enviros: Estimating the Energy Saving Potential from Small Motors and Machine Tools, Report on Machine Tools Research & Modelling, 11 July 2011, p.26

jor additional improvement potential besides setting possibly incentives to equip machines with energy efficient components and control instruments when being refurbished or upgraded.

4.1.4.1 CNC 4-axis multifunctional milling centre

The amount of refrigerant remaining in the product at end of life is estimated to be 3 kilogram of remaining cooling lubricant liquid. Other cooling liquids for rarely applied closed cooling cycles are typically water based, potentially with additives to avoid fouling and corrosion, but amount is considered minor. Mercury is part of lightening and trace element of constructed metals. According to survey results and general experience both these materials are not released during product life or at landfill. A closer examination of leakage or similar possibilities of material release is not carried out, because refrigerants make up a very small share of the overall mass of the CNC 4-axis milling centre.

51 kilogrammes, or 0.2% of the final product weight, are to be dumped at landfill. 42.4 kilogrammes of plastics are to be recycled or re-used. 33.6 kilogram or 80% of plastics and printed wiring board (PWB) are fed to incineration. PWB are easy to disassemble with no further impact on disposal and recycling. Re-used and recycled plastics comprise a weight of 8.8 kilogram.

The outstanding part of materials with a weight of 24.4 tonnes or 95% of the final product weight is subject to re-use and recycling.

Table 4-33: End of life settings for the CNC 4-axis multifunctional milling centre

Pos nr	DISPOSAL & RECYCLING Description		unit
	Substances released during Product Life and Landfill		
227	Refrigerant in the product (Click & select)	3000	g
228	Percentage of fugitive & dumped refrigerant	0%	
229	Mercury (Hg) in the product	0,5	g Hg
230	Percentage of fugitive & dumped mercury	0%	
	Disposal: Environmental Costs perkg final product		
231	Landfill (fraction products not recovered) in g en %	51550	0%
232	Incineration (plastics & PWB not re-used/recycled)	33600	g
233	Plastics: Re-use & Recycling ("cost"-side)	8820	g

	Re-use, Recycling Benefit	in g	% of plastics fraction
234	**Plastics: Re-use, Closed Loop Recycling (please edit%)**	420	1%
235	**Plastics: Materials Recycling (please edit% only)**	8400	20%
236	**Plastics: Thermal Recycling (please edit% only)**	33600	80%
237	**Electronics: PWB Easy to Disassemble ? (Click&select)**	0	YES
238	**Metals & TV Glass & Misc. (**95% Recycling)	24446350	

4.1.4.2 CNC laser cutting machine

For CNC laser cutting machines the standard settings as listed in Table 4-32 are applied.

4.1.4.3 Hydraulic Press Brake

For hydraulic press brakes the standard settings as listed in Table 4-32 are applied.

4.1.4.4 Non-numerical controlled metal working machine tools

For non-numerical controlled metal working machine tools the standard settings as listed in Table 4-32 are applied.

4.1.4.5 Wood working machine tools: Table saw

For wood working machine tools the standard settings as listed in Table 4-32 are applied.

4.1.4.6 Wood working machine tools: Horizontal panel saw

For wood working machine tools the standard settings as listed in Table 4-32 are applied.

4.1.4.7 Wood working machine tools: Throughfeed edge banding machine

For wood working machine tools the standard settings as listed in Table 4-32 are applied.

4.1.4.8 Wood working machine tools: CNC machining centre

For wood working machine tools the standard settings as listed in Table 4-32 are applied.

4.1.4.9 Welding equipment

Smaller units of welding equipment fall under the WEEE directive and hence the manufacturers are responsible to agree on disposal conditions with their B2B customers, hence a proper disposal and recycling can be assumed for the whole welding equipment product range.

4.1.4.10 Other machine tools and related machinery

End-of-life of other machine tools and related machinery are likely to be similar to the standard settings listed in Table 4-32 as defined in in most cases. Exemptions are for example contaminated machine tools from the semiconductor industry, which might be disposed of as hazardous waste as certain explosive or toxic gases diffused into the material.

4.2 Definition of Base Cases

The definition of the Base Cases should allow for a broad coverage of the machine tools market. Market relevancy and coverage by Base Cases is an important criterion to select suitable machinery archetypes. Various characteristics have to be taken into account to realise such a coverage. First of all, the broad variety of application scenarios has to be considered:

- Application area (workshop, industrial plant),
- Number of shifts (1 or 2, 3 and more),
- Embedding (Single machine, automated production system),
- Control system (Mechanic, Automatic),
- Energy system (Switch-off, power data for sub-systems),
- Manufacturing method, and
- Sold number of machine tools.

The second classification order is the complexity and level of automation of the machine tool. Three categories were identified to summarise possible application scenarios:

- Complex CNC machine tools (high complexity)

Vertical or combined horizontal and vertical machining centres for working metal

Horizontal machining centres for working metal

Lathes, including turning centres, for removing metal

- Complex CNC machine tools (moderate complexity)

Machine tools for working any material by removal of material, operated by laser or other light or photon beam processes

Hydraulic presses for working metal

- Simple machine tools

Non-numerically controlled horizontal lathes, for removing metal

Non-numerically controlled presses for working metal

Highly complex CNC controlled machine tools are used for realising processes with highest productivity and accuracy. Dedicated for metalworking they provide an exceptional functionality. These machine tools are to be designated for the integration in energy management systems via interfaces.

CNC machines of moderate complexity are used for machining various materials. Beside metals wood, ceramics, glass etc. are machined. More simple mechanic machining such as cutting and forming is carried out. Moreover, non-mechanic processes are to be realised with this category of machine tools. The integration in energy management systems is possible, too.

The simple machine tools have no CNC control. The are to be controlled mechanically or via path control. This category of machine tools is dedicated for cutting or forming metal with lower requirements on accuracy and productivity of the machining. An energy monitoring is not intended. The use occurs in low frequency and often without pre-planning.

Furthermore, an appropriate coverage of the various functional modules defined in task 1 is required to allow for an assessment of these modules in a given application. These are:

- Electrical system for control and for mechanic purposes,
- Pneumatic system,

- Hydraulic system,
- Main drives,
- Feed drives,
- Handling system for tools and workpieces,
- Handling of support and waste materials, and
- Control system.

Furthermore, specifics of highly relevant technologies should be reflected by complementary Base Cases.

Derived from all these assumptions the following Base Cases are defined:

- Numerically controlled machining centre,
- Numerically controlled deep drawing or bending machine tool,
- Laser cutting machine tools,
- Non-numerically controlled metal working drilling machine,
- Machine tool for woodworking
  - Table saw,
  - Horizontal panel saw,
  - Throughfeed edge banding machine,
  - CNC machine centre, and
- Transportable welding equipment.

Justification for the chosen Base Cases is summarised in **Table 4-34**. This segmentation is the best possible compromise to accommodate the above criteria with a limited number of Base Cases.

Table 4-34: Base Case characteristics

		Metal working	Wood working	High market relevancy (according to task 2 analysis)	CNC	Further specifics
(1)	CNC machining centres (and similar)	x		x	x	Typical representative of CNC machine tools
(2)	CNC Laser cutting machine tools	x			x	Very specific technology, which is not properly covered by any other Base Case, complementary to Base Case 1
(3)	CNC Bending machine tools (and similar)	x			x	Highly relevant process, which is not properly covered by machining centre, complementary to Base Case 1
(4)	Non-NC metal working machine tools (and similar)	x		x		Typical representative of non-NC machine tools
(5)	Table saw (and similar)		x	x		Represents all light stationary wood working machine tools
(6)	Horizontal panel saw (and similar)		x		x	Represents typical industrial wood working machine tools
(7)	Throughfeed edge banding machine (and similar)		x		x	Widespread industrial use, but technically very different from horizontal panel saws, complementary to Base Case 6
(8)	CNC machining centre (and similar)		x		x	Represents upper market segment in terms of machinery complexity
(9)	Welding equipment	x		x		Very specific technology, which is not properly covered by any other Base Case

Every Base Case is meant not only to represent the machine tools archetype, which is analysed in detail, but also market segments, which are similar in terms of complexity, use patterns, and process technology.

4.2.1 Base Case 1: CNC 4-axis multifunctional milling centre

According to product-specific inputs in chapter 4.1 the CNC 4-axis multifunctional milling centre is a highly complex machining centre applying all functions needed for highly flexible work-piece machining. It enables besides milling operations, turning and hobbing machining steps. It is built-up by modules representing the state-of-the-art system for productivity oriented manufacturing. The machine tool is applied in mass as well as workshop production with various shift types. The control system allows to implement the milling centre in energy monitoring systems with the options of operation, sleep mode and switch-off. The overall stock of the machine tool in Europe is 280 items with an annual sale of 30 units.

4.2.2 Base Case 2: Laser cutting machine tool

Laser cutting machine tools have been chosen as a complementary base case to cover the specifics of this technology and as laser technology gains steadily increasing market shares in metal processing (but also other materials). The base case reflects the currently dominating technology of CO_2 lasers. Assumptions are outlined in 4.1 and are based on technology insights, but the base case data does not come from any specific real laser cutting machine and constitutes an abstraction of reality.

4.2.3 Base Case 3: CNC Metal working bending machine tools

This base case is based on five press-brakes and their assessment as provided by Santos et al. [32]. Specification of these five press-brakes is as listed in Table 4-35.

Table 4-35: Technical characteristics of the press-brakes

	A	B	C	D	E
Technology	hydraulic	hydraulic robot-assisted	hydraulic	hydraulic	electric
Max. bending capacity [t]	170	110	110	110	100
Motor rated power [kW]	15	11	11	7.5	11
Max. bending length				3 m	
Year of construction				2006	
Base Case data origin and assumptions					
BOM				x	
Hydraulic oil consumption				120 l/a[33]	
Electricity consumption	x	x	x	x	x
Lifetime	**17 years** as stated in Task 2 for hydraulic metal working presses (whereas the assessment by Santos et al. is based on 15 years assumed lifetime)				

[32] Santos, J.P. et al.: Improving the environmental performance of machine-tools: influence of technology and throughput on the electrical energy consumption of a press-brake, Journal of Cleaner Production (2010)

[33] According to the preventive maintenance plan

It has to be acknowledged, that these press brakes rather cover a level of lower bending capacity and are not representative for larger presses and bending machine tools as used in e.g. the automotive sector for processing larger chassis parts. The range of 100-170 t bending capacity according to VDMA Fachverband Fluidtechnik is a market segment, where electromechanical presses are common. Hydraulic press brakes are typically applied where bending capacities of up to several thousand tonnes are required[34], where electromechanical solutions are not an option, but there is also a market segment, where high bending capacities are required and both hydraulic presses and electromechanical presses are offered.

4.2.4 Base Case 4: Non-numerical controlled metal working machine tools

Engine and feed shaft lathes may be equipped with the following features:

- mechanical facilities for mechanical feed or thread cutting,
- electronic facilities for constant surface speed (CSS),
- copying attachments (cam, template, etc.),
- but shall have no limited or full numeric control system (NC).

All movements are initiated and controlled by the operator, one at a time. These machine tool allows all turning process on one machine. The feed is usable manual or by machine. Hand wheels are available for these operations. Engine and feed shaft lathes are used for one-off and small batch production because of the low planning expenditure as well as the low price.

Connected power: 5 kW to 11 kW.

4.2.5 Base Case 5: Wood working machine tools: Table saw

Typical table saws feature characteristics as outlined in Table 4-36. The saw is manually switched on and off. The operator feeds the workpiece manually, and all settings are made manually. There is only one motor and no auxiliary units.

[34] Statement provided by VDMA Fachverband Fluidtechnik, J. Dürer, December 6, 2010

Table 4-36: Technical characteristics of an exemplary table saw

Parameter	
Table size	641 x 737 mm
Depth x length x height	730 x 780 x 340 mm
No-load speed	3.650 rpm
Saw blade diameter	254 mm
Saw blade bore	30 mm
Powerful motor rating	1800 W
Max. cutting heights	79 mm

4.2.6 Base Case 6: Wood working machine tools: Horizontal panel saw

Typical horizontal panel saws, for illustration only, are Holz-her CUT 6120, SCM SIGMA 105 Impact, HOLZMA HPP 250.

Technical characteristics of such panel saws are: manual panel feed, cutting length in the range of 4000 mm, max. saw carriage speed 100 m/min; main saw (7 – 10 kW) and scoring saw (in the range of 1 kW), air table, horizontal beam with integrated extraction system.

A typical price for such a machine is in the range of 60.000 Euro.

4.2.7 Base Case 7: Wood working machine tools: Throughfeed edge banding machine

Throughfeed edge banding machine tools are multi-purpose machines with automatic transfer of the workpieces, planning, milling or moulding (by cutting) machines

Typical machine models, for illustration only, are: BRANDT KDF 650, Holz-her SPRINT 1312 / ARCUS 1334, WINTER KANTOMAX speed.

Technical characteristics: processed edge thickness 0,4 - 12 mm, workpiece thickness 8 - 60 mm, max. feed speed 15 m/min.

Main modules are the aggregates (1) magazine and pre-melter/ radiant heater/ pressure zone, (2) end-trimming unit, (3) trimming unit, (4) corner rounding unit, (5) profile scraping unit, (6) buffing unit, PC, chassis.

Such a throughfeed edge banding machine tool comprises a rather larger number of auxiliary motors: 6 or more smaller motors in the range of 0,25 – 0,4 kW connection power, 2 motors at roughly 2 kW connection power, and 2 small motors for the buffing unit in the range of 0,1 kW connection power.

A typical price for such a machine is in the range of 60.000 Euro.

4.2.8 Base Case 8: Wood working machine tools: CNC machining centre

The base case on wood working CNC machining centres represents those for drilling and multipurpose (drilling, milling, sawing). Typical machine models, for illustration only, in this category comprise: SCM Accord 40 Prisma, WEEKE Venture 440/450, MORBIDELLI Author X 5.

Technical characteristics (exemplarily) comprise: vacuum clamping system, 5 axis milling spindle (main milling spindle with liquid cooling, auxiliary milling spindle), drilling head with multiple vertical and horizontal spindles, grooving saw, multiple tool changer, working range X, Y, Z = 4.500 x 2.000 x 300 mm, central greasing system.

Main modules are spindles / tool changers / tool magazine / saw with related drives, movable, grooving table, vacuum clamping system, machine frame, PC, chassis.

A typical price for such a CNC machining centre is in the range of 300.000 Euro.

4.2.9 Base Case 9: Welding equipment

Fully or partly automatic electric machines for arc welding of metals are among those with the highest calculated stock figures among welding equipment (see task 2). A typical unit for this segment is a MIG/MAG welding unit with 200 – 400 A maximum welding current. Such units could be air or liquid cooled. A liquid cooling unit typically is supplied separately and not as part of the equipment as such.

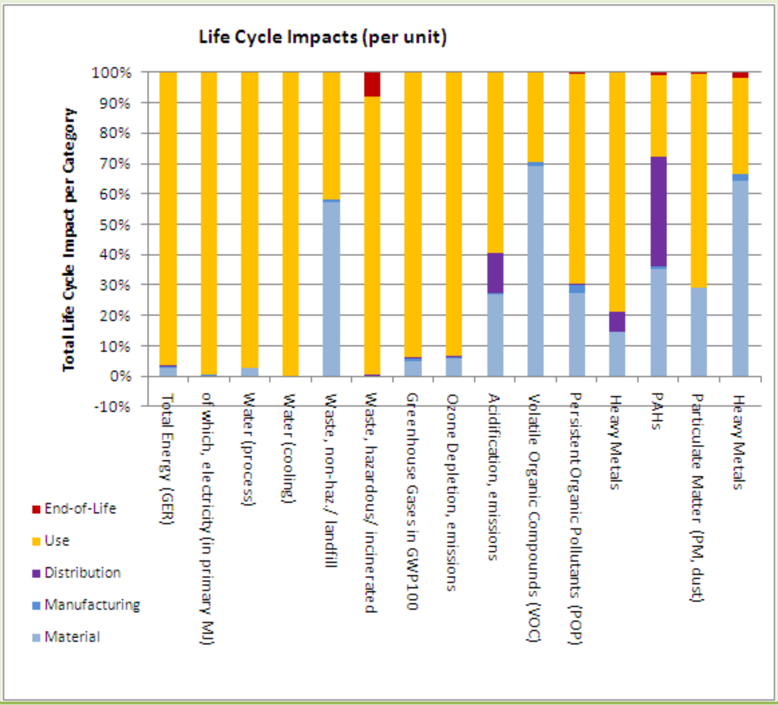
The bill-of-materials listed in 4.1.1.9 is a typical unit for this product category. As it represents rather the slightly more powerful range of equipment (with 340 A maximum output current, 140 kg weight and an above-average price), such a base case might lead to a slight overestimation of impacts of this distinct product group "fully or partly automatic electric machines for arc welding of metals".

4.3 Base Cases Environmental Impact Assessment

As there is no power consumption standard for machine tools yet, which reflects different modes and use patterns the base case calculations do not need to be split in a “standard Base case” and “a real-life-base case”, there will be only **a “real life” scenario**, reflecting typical use patterns identified in task 3.

4.3.1 Base Case 1: Horizontal CNC 4-axis multifunctional machining centre

The figure below displays the environmental impact according to the MEEuP EcoReport for one unit. The highest impact is related to the use phase. The second most important impact is related to the materials to be used for the machine tool construction. It contributes with ratios of 55% to 70% to waste (non-hazardous materials to landfill), volatile organic compounds and heavy metals (emissions to water). PAHs as well as acidification show also a relatively high impact from material and distribution.



Lifetime assumed:

12 years

Shift pattern assumed:

2 shifts / day

6 days/week

Operational time per year assumed:

4.400 h/a

Figure 4-6: Environmental Assessment – Base Case 1: CNC 4-axis horizontal machining centre

Totals for this Base Case for each life cycle phase and each unit indicator are presented in the table below.

Total life cycle impacts of one such machining centre are e.g. 17,4 TJ total energy (i.e. primary energy) consumption, and a Global Warming Potential of 782 t CO_2-eq.

Table 4-37: Environmental Assessment – Base Case 1: CNC 4-axis horizontal machining centre

Nr	Life cycle Impact per product:							Date	Author		
0	Non-NC controlled metal working lathe							0			
	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Total	
	Materials	unit									
1	Bulk Plastics	g			500			450	50	500	0
2	TecPlastics	g			0			0	0	0	0
3	Ferro	g			230090			11505	218586	230090	0
4	Non-ferro	g			27894			1395	26499	27894	0
5	Coating	g			0			0	0	0	0
6	Electronics	g			0			0	0	0	0
7	Misc.	g			0			0	0	0	0
	Total weight	g			258484			13349	245135	258484	0
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	16476	3725	20202	6715	1951235	3447	-21	3468	1981619
9	of which, electricity (in primary MJ)	MJ	892	2201	3093	17	1946731	0	0	0	1949841
10	Water (process)	ltr	1363	32	1394	0	138794	0	0	0	140188
11	Water (cooling)	ltr	2730	507	3729	0	5191237	0	1	-1	5194965
12	Waste, non-haz./ landfill	g	897187	14242	911430	2774	2266203	61297	1	61297	3241703
13	Waste, hazardous/ incinerated	g	18	1	20	55	44858	450	0	450	45382
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	1442	209	1651	396	85304	257	-2	259	87610
15	Ozone Depletion, emissions	mg R-11 eq.	negligible								
16	Acidification, emissions	g SO2 eq.	9137	904	10041	1212	501710	505	-2	507	513470
17	Volatile Organic Compounds (VOC)	g	118	2	120	124	804	14	0	14	1063
18	Persistent Organic Pollutants (POP)	ng i-Teq	9407	194	9601	16	12856	422	0	422	22894
19	Heavy Metals	mg Ni eq.	3817	454	4271	141	34377	1008	0	1008	39796
	PAHs	mg Ni eq.	221	0	221	267	4773	0	0	0	5261
20	Particulate Matter (PM, dust)	g	10902	139	11041	20509	26693	4487	0	4487	62730
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	1456	0	1456	4	12566	286	0	286	14313
22	Eutrophication	g PO4	34	2	36	0	60	16	0	16	113
23	Persistent Organic Pollutants (POP)	ng i-Teq	negligible								

Not included in these assessments are the production related impacts of lubrication oil, hydraulic oil and cooling lubricants. For simplification all oil based auxiliaries are assessed with the background data documented in Table 4-15, p. 36. Total impacts for the production of 2,67 t oil (lubricant oil, hydraulic oil, cooling lubricants over 12 years lifetime of the machining centre base case) is listed in Table 4-38.

Table 4-38: Environmental Assessment – Base Case 1: CNC 4-axis horizontal machining centre – lubrication oil / hydraulic oil / cooling lubricants

Impact 1 kg mineral oil production for hydraulics			MEEuP equivalents	total oil production related impact of 2670 kg oil consumption (aggregate of lubrication oil, hydraulic oil, cooling lubricants over 12 years; emission during use and end of life not included)
Greenhouse gases	Kilograms CO_2 equivalent	3,56	Global Warming Potential (GWP)	9505,2
Ozone-depleting gases	Kilograms CFC-11 equivalent	$8.90 * 10^{-12}$	None, category considered irrelevant for EuPs	Not applicable
Acidification	Kilograms SO equivalent	0,00383	Acidification (AD)	10,2261
Eutrophication	Kilograms PO equivalent	0,000378	Eutrophication (EUP)	1,00926
Heavy metals	Kilograms Pb equivalent	$5.02 * 10^{-7}$	Not transferrable to Ni and Hg equivalents	Not applicable
Carcinogens	Kilograms B(a)P equivalent	$1.62 * 10^{-12}$	none	Not applicable
Winter smog	Kilograms SPM equivalent	0,0018	none	4,806
Summer smog	Kilograms C_2H_4 equivalent	1,61E-08	Approximation: Volatile Organic Compounds (VOC)	4,2987E-05
Energy	Megajoules LHV equivalent	5,94	Approximation: Total Energy	15859,8
Solid waste	Kilograms	0,00519	Approximation: Waste, non-hazardous, landfill	13,8573

For those impact categories, for which impact indicators corresponding to MEEuP are available, the correlation between oil (production) related impacts and all other life cycle phases of the machining centre is available is depicted in Figure 4-7. There is only one impact category, which is eutrophication, where the mineral oil production in comparison to all other life cycle phases has an important impact of nearly 38%[35]. The contribution to the total lifecycle Global Warming Potential is 1,2%, to acidification 0,22% and to all other available categories less than 0,1%.

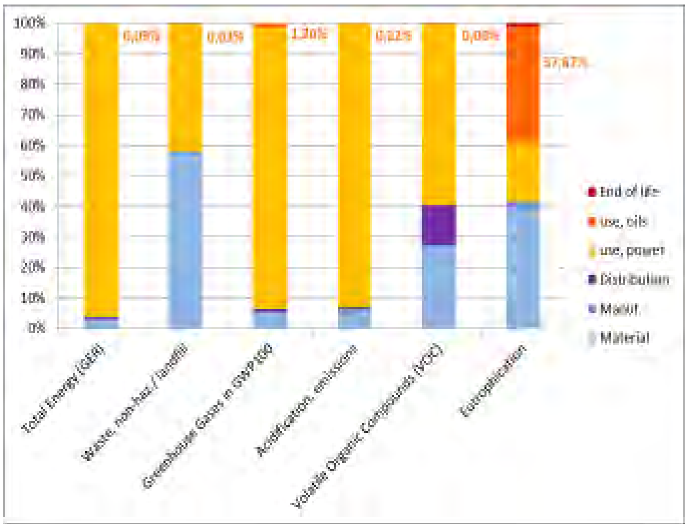


Figure 4-7: Environmental Assessment – Base Case 1: CNC 4-axis horizontal machining centre – lubrication oil / hydraulic oil / cooling lubricants included

For comparison, the averaged data based on the input provided by CECIMO and stemming from their LCA activities in preparation of the SRI result in an MEEuP assessment as shown in Figure 4-8: The overall trends are confirmed, but in some categories deviations are obvious.

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35 The LCA study by CECIMO in preparation of the SRI did not result in a similar relevancy for oil towards the category eutrophication despite the fact, that similar assumptions where made as in our Base Case – which obviously means, the background dataset used by CECIMO / PE has a much lower impact on eutrophication than McManus et al.

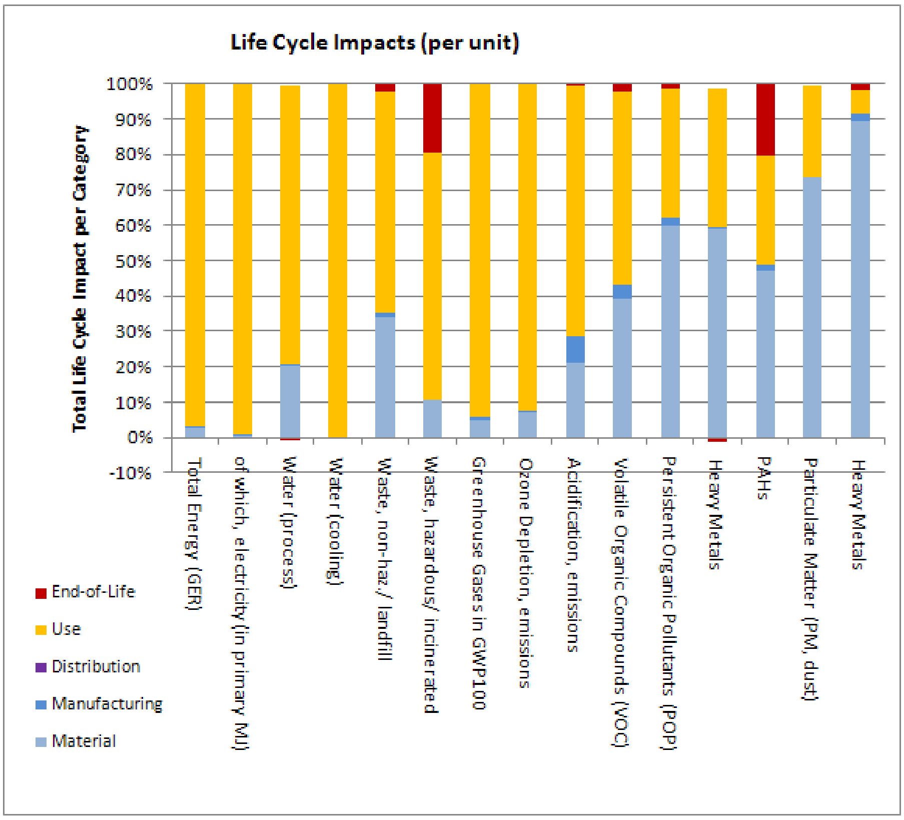


Figure 4-8: Comparative environmental assessment results based on CECIMO's base figures

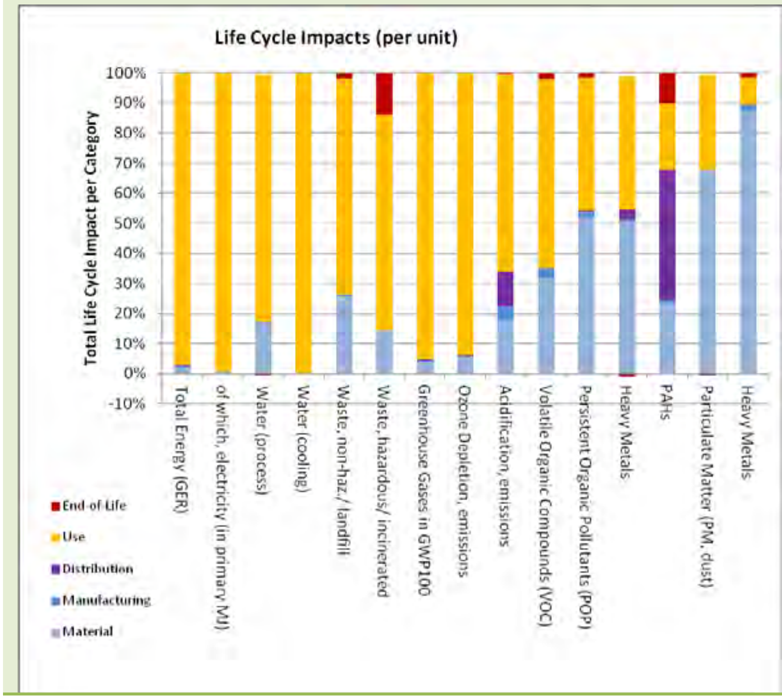
4.3.2 Base Case 2: CNC Laser cutting machine tools

The assessment findings for the Base Case "CNC laser cutting machine tools" are depicted in Figure 4-11. Not considered in this figure are the use phase impacts of laser and cutting gas consumption.

The categories total energy and Global Warming Potential are clearly dominated by use phase impacts (power consumption), whereas several other categories are dominated by the impacts of the material used to construct the laser cutting machine tool:

- Persistent Organic Pollutants
- Heavy metals emitted to air and water
- Particulate matter (dust)

Consequently, power consumption in the use phase is not the only relevant life cycle aspect for laser cutting machine tools, but the environmental impacts related to machinery material actually is related to the bulk of steel parts and components.



Lifetime assumed:

12 years

Shift pattern assumed:

2 shifts / day

6 days/week

Operational time per year assumed:

3.800 h/a

Figure 4-9: Base case CNC laser cutting machine tools

Not included in these assessments are the production related impacts of cutting gas nitrogen.

Impacts in absolute numbers for this Base Case are listed in the table below, referring to one unit i.e. machine. The total energy consumption over the life cycle is 25 TJ, and the Global Warming Potential is 1,130 t CO_2-eq. over the whole product life of 12 years.

Table 4-39: Environmental Assessment – Base Case 2: CNC laser cutting machine tools

Nr	Life cycle impact per product:	Date	Author
0	Generic CNC Laser cutting machine tool	0	KSchi

Nr	Life Cycle phases --> / Resources Use and Emissions	unit	PRODUCTION Material	PRODUCTION Manuf.	PRODUCTION Total	DISTRI-BUTION	USE	END-OF-LIFE* Disposal	END-OF-LIFE* Recycl.	END-OF-LIFE* Total	TOTAL
	Materials	unit									
1	Bulk Plastics	g			12000			10800	1200	12000	0
2	TecPlastics	g			15000			13500	1500	15000	0
3	Ferro	g			10980000			549000	10431000	10980000	0
4	Non-ferro	g			462000			23100	438900	462000	0
5	Coating	g			0			0	0	0	0
6	Electronics	g			370000			270000	100000	370000	0
7	Misc.	g			160300			8015	152285	160300	0
	Total weight	g			11999300			874415	11124885	11999300	0
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	524933	102152	627086	88902	24666313	49381	28139	21242	25403541
9	of which, electricity (in primary MJ)	MJ	129833	44879	174712	227	24647347	0	11600	-11600	24810686
10	Water (process)	ltr	340451	2965	343416	0	1670474	0	10474	-10474	2003416
11	Water (cooling)	ltr	93090	26217	112307	0	65722723	0	2169	-2169	65832060
12	Waste, non-haz./ landfill	g	######	371896	10530155	36350	28680476	735652	33633	702019	39949001
13	Waste, hazardous/ incinerated	g	115190	892	116082	722	569068	124300	13055	111245	797117
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	43090	6052	49142	5226	1077128	3685	1957	1728	1133224
15	Ozone Depletion, emissions	mg R-11 eq.					negligible				
16	Acidification, emissions	g SO2 eq.	364968	28652	393620	16012	6351294	7249	9912	-2663	6758263
17	Volatile Organic Compounds (VOC)	g	2498	693	3191	1651	9547	188	145	43	14432
18	Persistent Organic Pollutants (POP)	ng i-Teq	82018	8396	90414	205	162446	5065	127	4938	258003
19	Heavy Metals	mg Ni eq.	499667	19798	519465	1843	431140	14243	1470	12773	965222
	PAHs	mg Ni eq.	56981	523	57503	3622	52839	0	1208	-1208	112656
20	Particulate Matter (PM, dust)	g	147580	5885	153465	273446	190005	63991	469	63523	680439
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	349232	96	349327	58	167401	4113	6666	-2554	509232
22	Eutrophication	g PO4	8242	172	8415	1	842	235	94	141	9398
23	Persistent Organic Pollutants (POP)	ng i-Teq					negligible				

Taking into account also the nitrogen consumption (cutting gas) the assessment changes slightly. Taking the ELCD dataset[36] as cradle-to-gate inventory for 1 kg nitrogen inter alia yields in 1,8 MJ net caloric value of all energy carriers (comparable to Total Energy GER), and emissions of 0.083 kg CO2 as the dominating greenhouse gas. The machinery's consumption of 25 t nitrogen per year thus equals 45,000 MJ/a, and 540,000 MJ over the total life cycle – roughly 2% of the Total Energy consumption which can be attributed to nitrogen consumption. Similarly the nitrogen related CO2 emissions of slightly more than 2,000 kg per year and close to 25,000 kg over the total

36 European Life Cycle Data ELCD database 2.0: Nitrogen; via cryogenic air separation; production mix, at plant; gaseous

life cycle equal 2% of the total life cycle impacts of the laser cutting machine tool as such.

Total impacts for the production of 300 t N_2 (over 12 years lifetime of the laser cutting machine tools base case) is listed in Table 4-40. Background data is derived from ProBas (dataset: Xtra-generischN2, gasförmig).

Table 4-40: Environmental Assessment – Base Case 2: CNC laser cutting machine tools – laser cutting gas nitrogen

Impact 1 kg nitrogen			**MEEuP equivalents**	**total nitrogen production related impact of 300 t consumption** (over 12 years)
Greenhouse gases	Kilograms CO2 eq.	0,0739	Global Warming Potential (GWP)	22170 kg
Acidification	Kilograms SO2 equivalent	0,0000965	Acidification (AD)	28,95 kg
Heavy metals	Kilograms Hg (water)	$272 * 10^{-18}$	Emissions to water (mg Hg/20) (other heavy metals – As, Cd, Cr, Pb – listed as well in ProBas, but no equivalent in MEEuP available)	0,00163 mg Hg/20
	Kilograms Ni (air)	$4,24 * 10^{-9}$	Emissions to air (mg Ni eq.) (other heavy metals – As, Cd, Hg, Pb – listed as well in ProBas, but no equivalent in MEEuP available)	1270 mg Ni.eq
Eutrophication	Kilograms PO equivalent	k.A.	Eutrophication (EUP)	0

For those impact categories, for which impact indicators corresponding to MEEuP are available, the correlation between nitrogen (production) related impacts and all other life cycle phases of the laser cutting machine tool is depicted in Figure 4-10, which basically confirms the data based on ELCD.

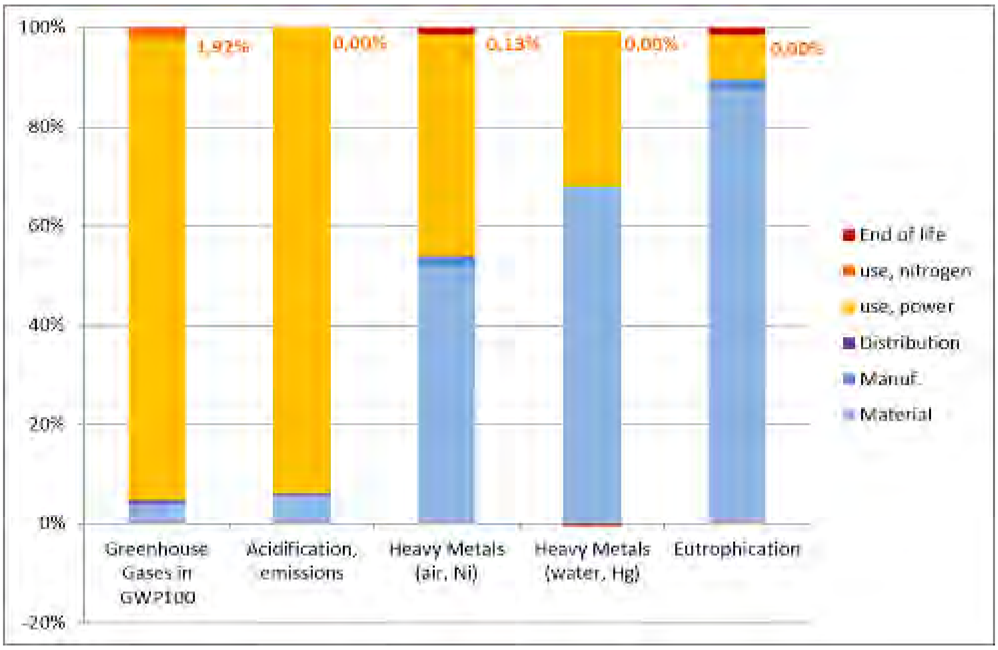


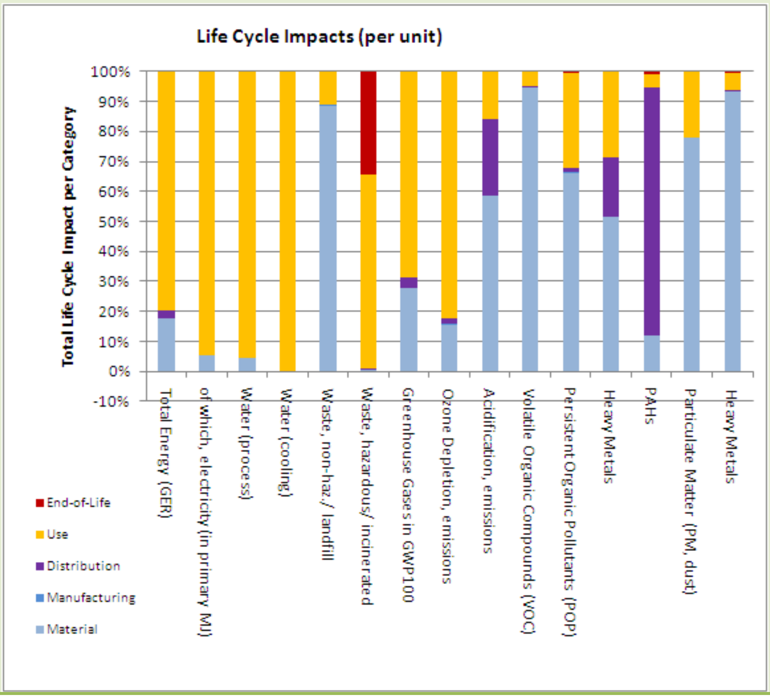
Figure 4-10: Environmental Assessment – Base Case 2: CNC laser cutting machine tools – nitrogen included

4.3.3 Base Case 3: CNC Metal working bending machine tools

The assessment findings for the Base Case "Metal working bending machine tools" is depicted in Figure 4-11. The categories total energy and Global Warming Potential are clearly dominated by use phase impacts (power consumption), whereas several other categories are dominated by the impacts of the material used to construct the bending machine tool:

- Non-hazardous waste to landfill
- Acidification
- Volatile Organic Compounds
- Persistent Organic Pollutants
- Heavy metals emitted to air and water
- Particulate matter (dust)

Consequently, power consumption in the use phase is not the only relevant life cycle aspect for bending machine tools.



Lifetime assumed:

17 years

Shift pattern assumed:

1 shift / day

5 days/week

Operational time per year assumed:

2.000 h/a

Figure 4-11: Base case CNC Bending machine tools

As a 1-shifts operation of this kind of bending machine is common, but the lower end of the actual use scenarios, the following figure depicts the assessment results, if a 2-shifts production model is calculated: Not surprisingly, the use phase sees a higher impact share in all impact categories, but even under these conditions several categories are still dominated by material related impacts: In 8 out of 15 categories the use phase impacts have a share of less than 50% of the total impacts.

INEGI provided a complementary assessment of the same base case with the Eco-Indicator approach, which allows a cross-check of the MEEuP results with other LCA approaches. INEGI's assessment results are depicted in Figure 4-12.

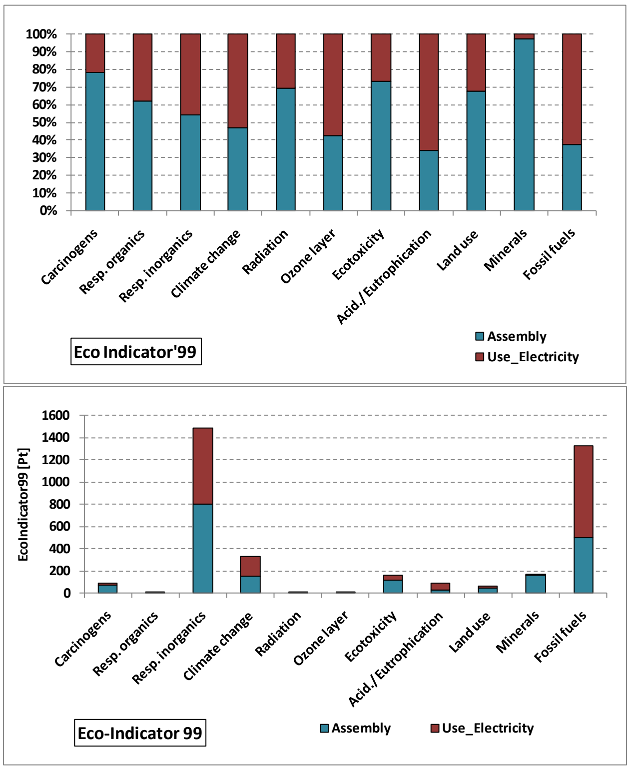
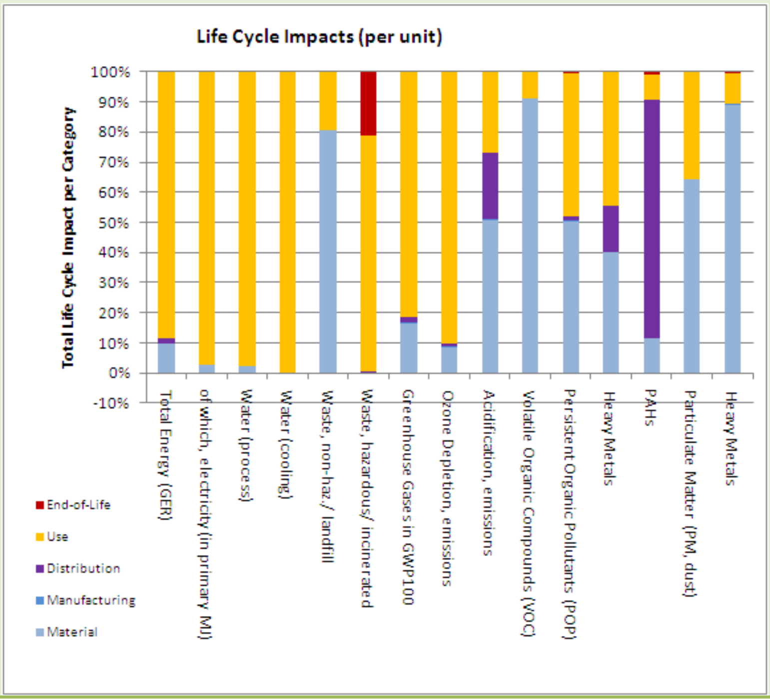


Figure 4-12: Eco-Indicator 99 assessment of Base case CNC Bending machine tools (1-shift)

INEGI's interpretation of these Eco-Indicator 99 results can be summarized as follows and is shared by Fraunhofer: The comparative analysis of the MEEuP and Eco-Indicator 99 charts makes evident that the relative contributions values seem to be valid for the analysis of the contribution of each life cycle stage to the overall environmental impact. In terms of relative contributions of the 2 life-cycle stages, the results obtained with both methodologies are indeed comparable, as, from both charts (a) and (b) one can retain that the 2 life-cycle stages analyzed (assembly and use of electricity in the use phase) indeed share more or less equally the full environmental impact. However, the analysis per impact categories is quite difficult to evaluate, even in cases where the correspondence is easier, such as Acidification and Eutrophication.

The analysis of absolute impact values (only possible with the normalized Eco-Indicator 99) unveils a high relevancy of emissions of respiratory inorganics, which have a similar degree of relevance as fossil fuels, and much more than Global Warming Potential. This leads to the insight that conclusions should not only be based on GWP or energy criteria.



Lifetime assumed:

17 years

Shift pattern assumed:

2 shifts / day

5 days/week

Operational time per year assumed:

4.000 h/a

Figure 4-13: Base case CNC Bending machine tools – variant: 2-shifts operation

Impacts in absolute numbers for this Base Case (relating to a 1-shifts production model) are listed in the table below, referring to one unit i.e. machine. The total energy consumption over the life cycle is 790 GJ, and the Global Warming Potential is 40 t CO2-eq. over the whole product life of 17 years.

Table 4-41: Environmental Assessment – Base Case 3: CNC bending machine tools

Nr	Life cycle Impact per product:	Date	Author
0	CNC Bending machine tool	Dec, 2011	KSchi

Nr	Life Cycle phases -->		PRODUCTION			DISTRI-BUTION	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total			Disposal	Recycl.	Total	
	Materials	**unit**									
1	Bulk Plastics	g			**0**			0	0	**0**	**0**
2	TecPlastics	g			**9690**			8721	969	**9690**	**0**
3	Ferro	g			**7841450**			0	7841450	**######**	**0**
4	Non-ferro	g			**20830**			0	20830	**20830**	**0**
5	Coating	g			**0**			0	0	**0**	**0**
6	Electronics	g			**0**			0	0	**0**	**0**
7	Misc.	g			**0**			0	0	**0**	**0**
	Total weight	g			**7871970**			8721	7863249	**######**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	138115	1343	**139458**	**21886**	**649357**	593	-886	**1479**	**812180**
9	of which, electricity (in primary MJ)	MJ	35710	785	**36495**	**56**	**627868**	0	4	**-4**	**664416**
10	Water (process)	ltr	1981	11	**1993**	**0**	**41853**	0	2	**-2**	**43844**
11	Water (cooling)	ltr	3121	347	**3468**	**0**	**1673377**	0	20	**-20**	**1676825**
12	Waste, non-haz./ landfill	g	######	5650	**6326688**	**8972**	**790821**	3	14	**-11**	**7126470**
13	Waste, hazardous/ incinerated	g	72	1	**72**	**178**	**14460**	8721	2	**8719**	**23430**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq	11092	76	**11168**	**1288**	**29077**	44	-69	**113**	**41646**
15	Ozone Depletion, emissions	mg R-11 e	negligible								
16	Acidification, emissions	g SO2 eq.	30763	329	**31091**	**3944**	**163474**	89	-85	**174**	**198683**
17	Volatile Organic Compounds (VOC)	g	922	1	**923**	**406**	**576**	1	-1	**3**	**1907**
18	Persistent Organic Pollutants (POP)	ng i-Teq	93566	109	**93675**	**51**	**5050**	0	0	**0**	**98776**
19	Heavy Metals	mg Ni eq.	22876	255	**23130**	**455**	**15417**	158	0	**158**	**39161**
	PAHs	mg Ni eq.	2265	0	**2265**	**868**	**5682**	0	0	**0**	**8815**
20	Particulate Matter (PM, dust)	g	9694	50	**9744**	**67200**	**78519**	768	-1	**769**	**156231**
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	14923	0	**14923**	**14**	**4195**	50	0	**50**	**19182**
22	Eutrophication	g PO4	370	1	**371**	**0**	**23**	3	0	**3**	**397**
23	Persistent Organic Pollutants (POP)	ng i-Teq	negligible								

This assessment does not include the consumption of hydraulic oil in absence of a related data set in the MEEuP methodology. For estimating the relevancy of hydraulic oil consumption we apply the background dataset introduced in 4.1.3 to the total hydraulic oil consumption of the machine tools lifetime of estimated 17 years: Total impacts for the production of 1,836 t oil is listed in Table 4-42.

Table 4-42: Environmental Assessment – Base Case 3: CNC bending machine tools – hydraulic oil

Impact 1 kg mineral oil production for hydraulics			MEEuP equivalents	total oil production related impact of 1836 kg oil consumption (hydraulic oil over 17 years; emission during use and end of life not included)
Greenhouse gases	Kilograms CO2 equivalent	3,56	Global Warming Potential (GWP)	6536,16
Ozone-depleting gases	Kilograms CFC-11 equivalent	$8.90 * 10^{-12}$	None, category considered irrelevant for EuPs	Not applicable
Acidification	Kilograms SO equivalent	0,00383	Acidification (AD)	7031,88
Eutrophication	Kilograms PO equivalent	0,000378	Eutrophication (EUP)	694,008
Heavy metals	Kilograms Pb equivalent	$5.02 * 10^{-7}$	Not transferrable to Ni and Hg equivalents	Not applicable
Carcinogens	Kilograms B(a)P equivalent	$1.62 * 10^{-12}$	none	Not applicable
Winter smog	Kilograms SPM equivalent	0,0018	none	3,3048
Summer smog	Kilograms C2H4 equivalent	1,61E-08	Approximation: Volatile Organic Compounds (VOC)	0,0295596
Energy	Megajoules LHV equivalent	5,94	Approximation: Total Energy	10905,84
Solid waste	Kilograms	0,00519	Approximation: Waste, non-hazardous, landfill	9528,84

For those impact categories, for which impact indicators corresponding to MEEuP are available, the correlation between oil (production) related impacts and all other life cycle phases of the CNC bending machine tool is available is depicted in Figure 4-14. There is one impact category, which is eutrophication, where the mineral oil production in comparison to all other life cycle phases has dominating impact of nearly 64%, and one category, which is Greenhouse Gas emissions, where there is a significant impact as well (13,6%).

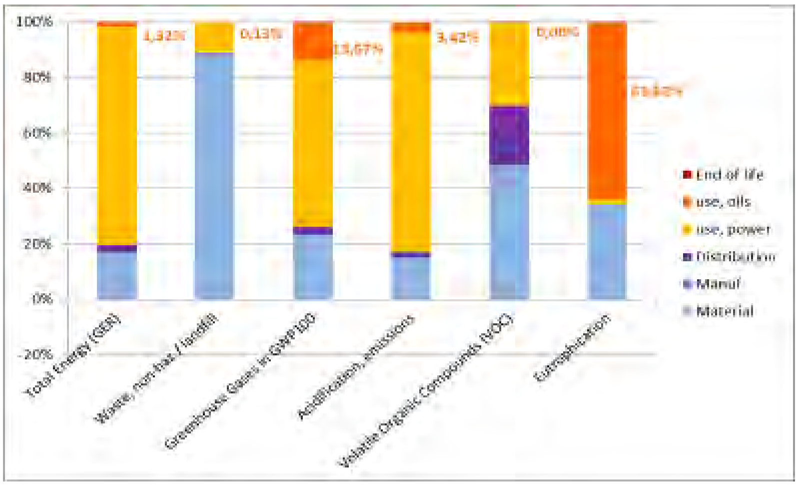


Figure 4-14: Environmental Assessment – Base Case 3: CNC bending machine tool – hydraulic oil included

INEGI provided a stakeholder comment to this study, which outlines the relevancy of hydraulic oil in their einvironmental assessments of press brakes:

The LCA analysis was followed with Simapro software and EcoInvent databases. ... The oil source considered was a standard crude oil, and incineration was the end-of-life scenario associated.

Based on this, it was expected that the use of no-renewable resources would determine the environmental impact profile related to the oil consumption. This is indeed confirmed from Figure 4-15*. The results show both (a) the relative contributions and (b) the absolute Eco-indicator99 values of the impact of the Assembly-phase and Use-phase (Electricity and Oil) to the different middle-point impact categories.*

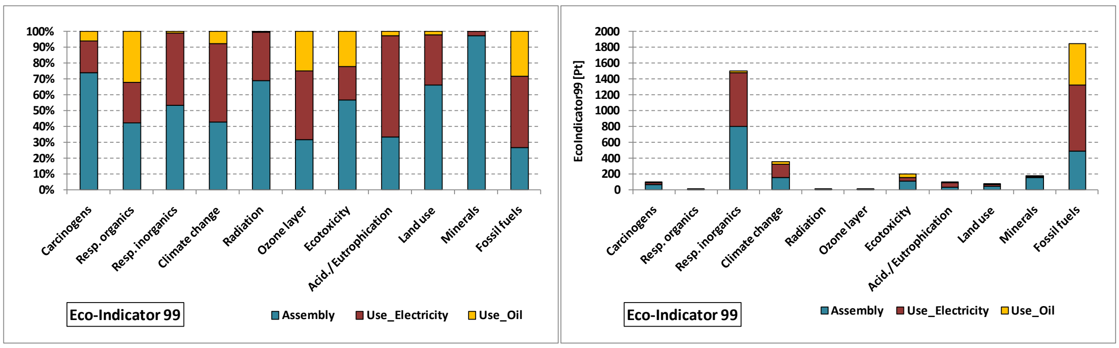


Figure 4-15: Results per impact category (middle-point) by analysing: (a) the relative contributions and (b) the absolute Eco-indicator99 values, of the Assembly-phase and Use-phase (Electricity and Oil) inputs

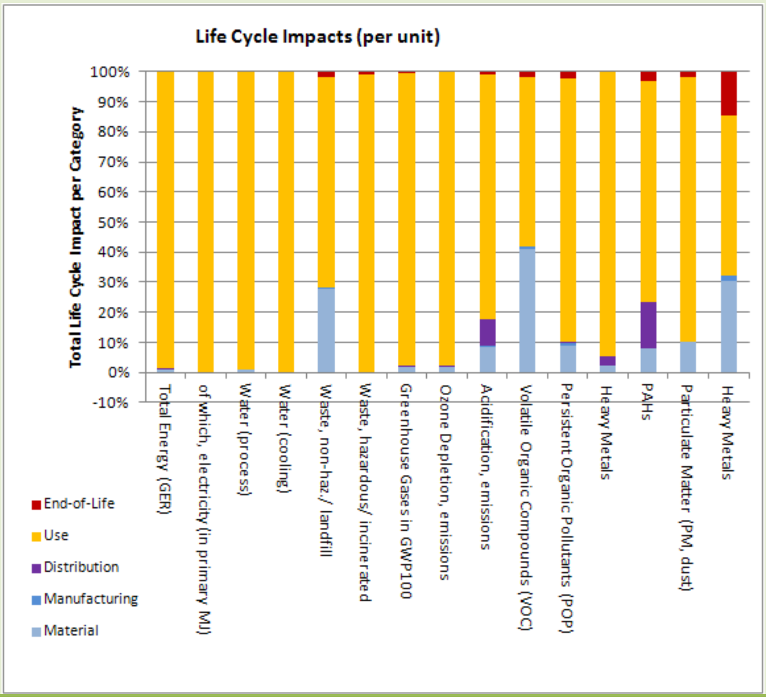
From these results, the following is to be highlighted:

- *The relative contribution of the oil consumption to the global environmental impact of the machine is higher than 20%, in 4 of the 11 impact categories analyzed;*
- *The main impact of the oil consumption, in absolute value of the indicator, is on the depletion of fossil fuels, and, in this category, the impact is similar to that of the assembly resources;*
- *The significant relative contributions of the oil consumption in other categories correspond only to minor impact values (such as in ecotoxicity or respiratory organics) or are even negligible (such as the effect on ozone layer).*

Compared to the Base Case 1 assessment the results for Base Case 3 show a higher relevancy of hydraulic oil consumption, which is of some relevance compared to other life cycle aspects.

4.3.4 Base Case 4: Non-numerical controlled metal working machine tools

The figure below displays the environmental impact according to the MEEuP EcoReport for one unit of the Base Case “Non-numerical controlled metal working machine tools”. The highest impact is related to the use phase. The second most important impact is related to the materials to be used for the machine tool construction similar to Base Case 1. The categories total energy and Global Warming Potential are clearly dominated by use phase impacts (power consumption throughout all impact categories.



Lifetime assumed:

18 years

Shift pattern assumed:

1 shift / day

5 days/week

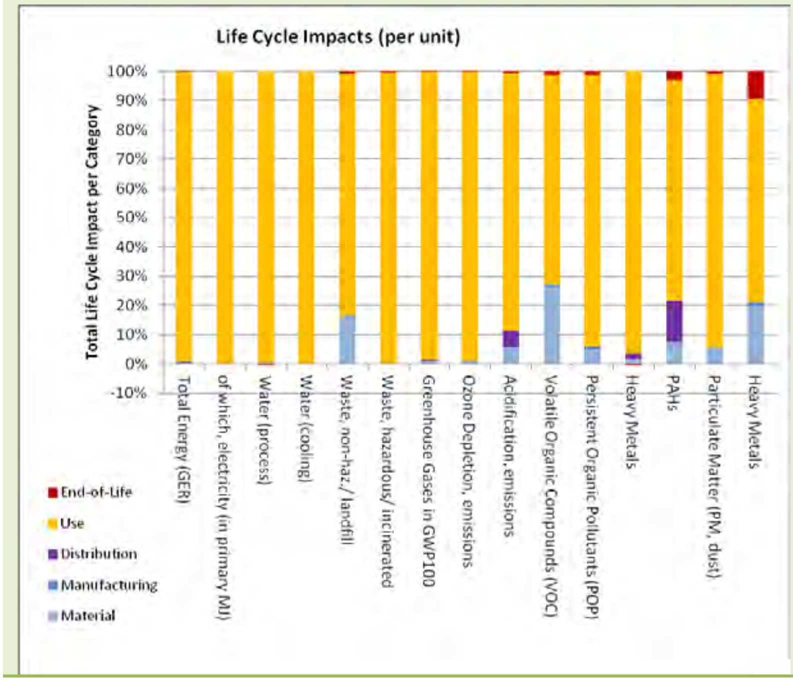
Operational time per year assumed:

2.000 h/a

Figure 4-16: Base case Non-numerical controlled metal working machine tools (1-shift-operation)

As a 1-shifts operation is common, but the lower end of the actual use scenarios, the following figure depicts the assessment results, if a 2-shifts production model is calculated: Not surprisingly, the use phase sees a higher impact share in all impact categories. This phase has a proportion of over 70 % in all categories.

The relevance of energy consumption rises if these machines are used in 2-shift-operation, as shown in Figure 4-17.



Lifetime assumed:	18 years
Shift pattern assumed:	2 shifts / day 5 days/week
Operational time per year assumed:	4.000 h/a

Figure 4-17: Base case Non-numerical controlled metal working machine tool (2-shift-operation)

Impacts in absolute numbers for this Base Case (relating to a 1-shifts production model) are listed in the table below, referring to one unit i.e. machine. The total energy consumption over the life cycle is 2000 GJ the Global Warming Potential is at 89 t CO2-eq over the whole product life of 18 years.

Table 4-43: Environmental Assessment – Base Case 4: Non-numerical controlled metal working machine tools

Nr	Life cycle Impact per product:	Date	Author
0	Non-NC controlled metal working lathe	0	

Nr	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Total	
	Materials	**unit**									
1	Bulk Plastics	g			**500**			450	50	**500**	**0**
2	TecPlastics	g			**0**			0	0	**0**	**0**
3	Ferro	g			**230090**			11505	218586	**230090**	**0**
4	Non-ferro	g			**27894**			1395	26499	**27894**	**0**
5	Coating	g			**0**			0	0	**0**	**0**
6	Electronics	g			**0**			0	0	**0**	**0**
7	Misc.	g			**0**			0	0	**0**	**0**
	Total weight	g			**258484**			13349	245135	**258484**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	16476	3725	**20202**	**6715**	**1951235**	3447	-21	**3468**	**1981619**
9	of which, electricity (in primary MJ)	MJ	892	2201	**3093**	**17**	**1946731**	0	0	**0**	**1949841**
10	Water (process)	ltr	1363	32	**1394**	**0**	**138794**	0	0	**0**	**140188**
11	Water (cooling)	ltr	2732	997	**3729**	**0**	**5191237**	0	1	**-1**	**5194965**
12	Waste, non-haz./ landfill	g	897187	14242	**911430**	**2774**	**2266203**	61297	1	**61297**	**3241703**
13	Waste, hazardous/ incinerated	g	18	1	**20**	**55**	**44858**	450	0	**450**	**45382**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	1442	209	**1651**	**396**	**85304**	257	-2	**259**	**87610**
15	Ozone Depletion, emissions	mg R-11 eq.					negligible				
16	Acidification, emissions	g SO2 eq.	9137	904	**10041**	**1212**	**501710**	505	-2	**507**	**513470**
17	Volatile Organic Compounds (VOC)	g	118	2	**120**	**124**	**804**	14	0	**14**	**1063**
18	Persistent Organic Pollutants (POP)	ng i-Teq	9407	194	**9601**	**16**	**12856**	422	0	**422**	**22894**
19	Heavy Metals	mg Ni eq.	3817	454	**4271**	**141**	**34377**	1008	0	**1008**	**39796**
	PAHs	mg Ni eq.	221	0	**221**	**267**	**4773**	0	0	**0**	**5261**
20	Particulate Matter (PM, dust)	g	10902	139	**11041**	**20509**	**26693**	4487	0	**4487**	**62730**
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	1456	0	**1456**	**4**	**12566**	286	0	**286**	**14313**
22	Eutrophication	g PO4	34	2	**36**	**0**	**60**	16	0	**16**	**113**
23	Persistent Organic Pollutants (POP)	ng i-Teq					negligible				

This assessment does not include the consumption of hydraulic oil in absence of a related data set in the MEEuP methodology. For estimating the relevancy of hydraulic oil consumption we apply the background dataset introduced in 4.1.3 to the total hydraulic oil and cooling lubricant consumption of the machine tools lifetime of estimated 18 years: Total impacts for the production of 72 kg oil is listed in Table 4-44.

Table 4-44: Environmental Assessment – Base Case 4: Non-numerical controlled metal working machine tools – hydraulic oil / cooling lubricants

Impact 1 kg mineral oil production for hydraulics			MEEuP equivalents	total oil production related impact of 72 kg oil consumption (hydraulic oil and cooling lubricant over 18 years; emission during use and end of life not included)
Greenhouse gases	Kilograms CO2 equivalent	3,56	Global Warming Potential (GWP)	256,32
Ozone-depleting gases	Kilograms CFC-11 equivalent	$8.90 * 10^{-12}$	None, category considered irrelevant for EuPs	Not applicable
Acidification	Kilograms SO equivalent	0,00383	Acidification (AD)	275,76
Eutrophication	Kilograms PO equivalent	0,000378	Eutrophication (EUP)	27,216
Heavy metals	Kilograms Pb equivalent	$5.02 * 10^{-7}$	Not transferrable to Ni and Hg equivalents	Not applicable
Carcinogens	Kilograms B(a)P equivalent	$1.62 * 10^{-12}$	none	Not applicable
Winter smog	Kilograms SPM equivalent	0,0018	none	0,1296
Summer smog	Kilograms C2H4 equivalent	1,61E-08	Approximation: Volatile Organic Compounds (VOC)	0,0011592
Energy	Megajoules LHV equivalent	5,94	Approximation: Total Energy	427,68
Solid waste	Kilograms	0,00519	Approximation: Waste, non-hazardous, landfill	373,68

For those impact categories, for which impact indicators corresponding to MEEuP are available, the correlation between oil (production) related impacts and all other life cycle phases of the non-numerical controlled metal working machine tool is available is depicted in Figure 4-18. There is only one impact category, which is eutrophication, where the mineral oil production in comparison to all other life cycle phases has an important impact of nearly 20%. The contribution to the total lifecycle Global Warming Potential is 0,3%.

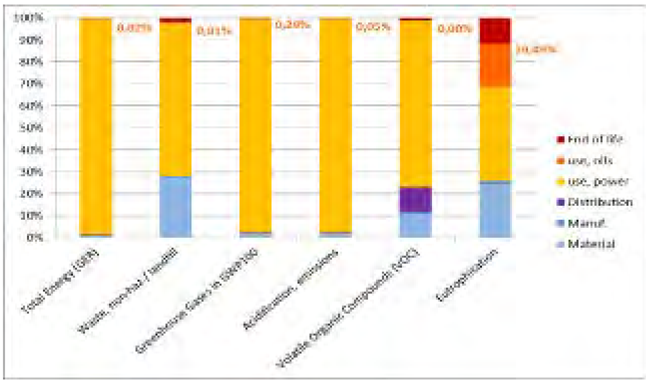


Figure 4-18: Environmental Assessment – Base Case 4: Non-numerical controlled metal working machine tools – hydraulic oil / cooling lubricant included

Given these findings it can be concluded, that auxiliaries for non-NC machine tools are of minor relevancy.

4.3.5 Base Case 5: Wood working machine tools: Table saw

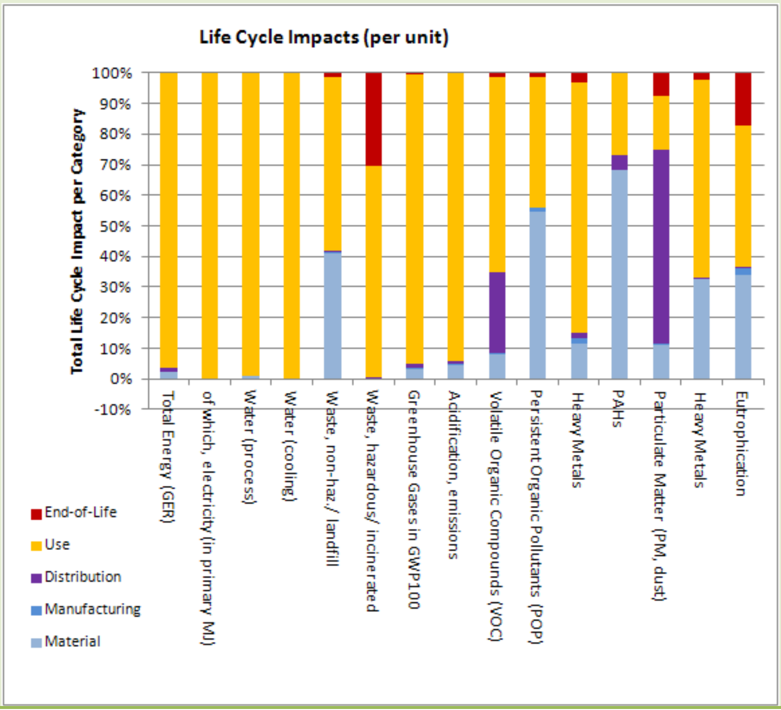
The assessment findings for the Base Case "Table saw" are depicted in Figure 4-21.

The categories total energy and Global Warming Potential are clearly dominated by use phase impacts (power consumption), whereas several other categories are dominated by the impacts of the material used to construct the table saw:

- Persistent Organic Pollutants
- Polyaromatic hydrocarbons' emissions to air

Consequently, power consumption in the use phase is not the only relevant life cycle aspect for table saws, but the environmental impacts related to machinery material actually is related to die cast aluminium for the sawing table used by some manufacturers. Cast iron, which is used by others, according to the MEEuP base data, comes at much lower environmental impact than the aluminium.

Given the low use time per working day (1 hour) compared to 1- or 2-shifts-operation of industrial machine tools it might have been expected, that the use phase is less dominant, but this is outweighed by the also much less material intensive design of light-stationary woodworking tools, and the anticipated long lifetime of 20 years.



Lifetime assumed:

20 years

Shift pattern assumed:

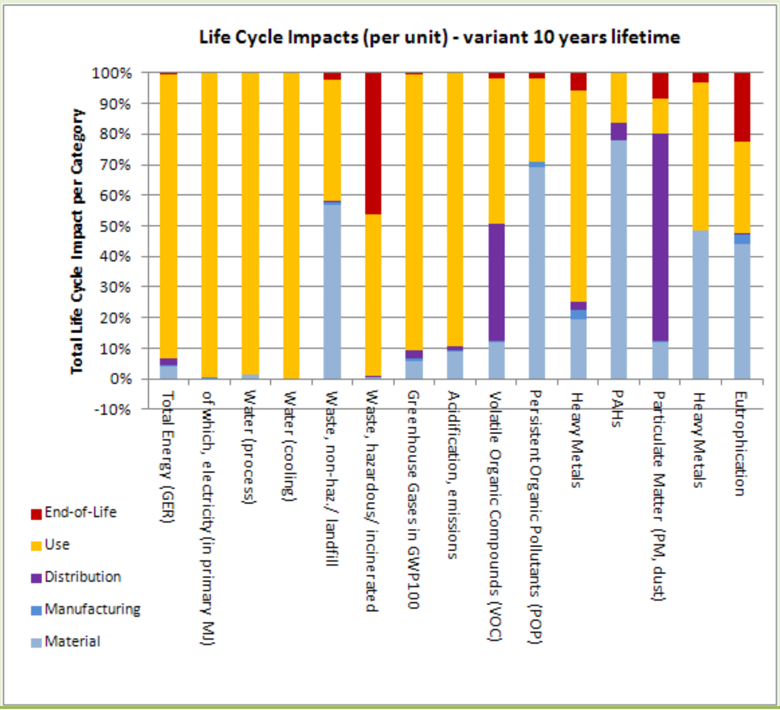
1 h of use / day

Operational time per year assumed:

250 h/a

Figure 4-19: Base case Table saw

To give an impression of the effect of shorter lifetime assumptions Figure 4-20 depicts the result for 10 years lifetime of the same table saw: Dominance of energy consumption in the use phase is still evident, but relevancy of material related up-stream impacts increases apparently.



Lifetime assumed:

10 years

Shift pattern assumed:

1 h of use / day

Operational time per year assumed:

250 h/a

Figure 4-20: Base case Table saw – variant 10 years lifetime

Impacts in absolute numbers for this Base Case (referring now again to the initial assumption of 20 years lifetime) are listed in the table below, referring to one unit i.e. machine. The total energy consumption over the life cycle is 55 GJ, the Global Warming Potential is 2,4 t CO_2-eq. over the whole product life.

Table 4-45: Environmental Assessment – Base Case 5: Table saw

Nr	Life cycle Impact per product:	Date	Author
0	Light Stationary Wood Working Equipment / Table Saw	0	Kschi

Nr	Life Cycle phases --> Resources Use and Emissions	unit	PRODUCTION Material	PRODUCTION Manuf.	PRODUCTION Total	DISTRI-BUTION	USE	END-OF-LIFE* Disposal	END-OF-LIFE* Recycl.	END-OF-LIFE* Total	TOTAL
	Materials	**unit**									
1	Bulk Plastics	g			490			441	49	490	0
2	TecPlastics	g			100			90	10	100	0
3	Ferro	g			14875			744	14131	14875	0
4	Non-ferro	g			11530			577	10954	11530	0
5	Coating	g			0			0	0	0	0
6	Electronics	g			0			0	0	0	0
7	Misc.	g			5			0	5	5	0
	Total weight	g			27000			1852	25149	27000	0
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	1143	172	1315	594	52537	128	18	110	54556
9	of which, electricity (in primary MJ)	MJ	15	102	117	1	52501	0	0	0	52619
10	Water (process)	ltr	26	1	27	0	3500	0	0	0	3528
11	Water (cooling)	ltr	88	46	134	0	140001	0	1	-1	140134
12	Waste, non-haz./ landfill	g	44210	661	44871	313	61319	1655	1	1654	108158
13	Waste, hazardous/ incinerated	g	4	0	4	6	1210	531	0	531	1751
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	75	10	84	37	2294	10	1	8	2423
15	Ozone Depletion, emissions	mg R-11 eq.				negligible					
16	Acidification, emissions	g SO2 eq.	663	42	705	111	13528	19	2	17	14360
17	Volatile Organic Compounds (VOC)	g	3	0	3	8	20	0	0	0	32
18	Persistent Organic Pollutants (POP)	ng i-Teq	450	9	459	2	349	11	0	11	821
19	Heavy Metals	mg Ni eq.	127	22	148	16	907	37	0	37	1108
	PAHs	mg Ni eq.	282	0	282	20	111	0	0	0	414
20	Particulate Matter (PM, dust)	g	242	6	248	1368	379	167	0	167	2162
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	171	0	171	0	340	11	0	11	523
22	Eutrophication	g PO4	1	0	1	0	2	1	0	1	4
23	Persistent Organic Pollutants (POP)	ng i-Teq				negligible					

4.3.6 Base Case 6: Wood working machine tools: Horizontal panel saw

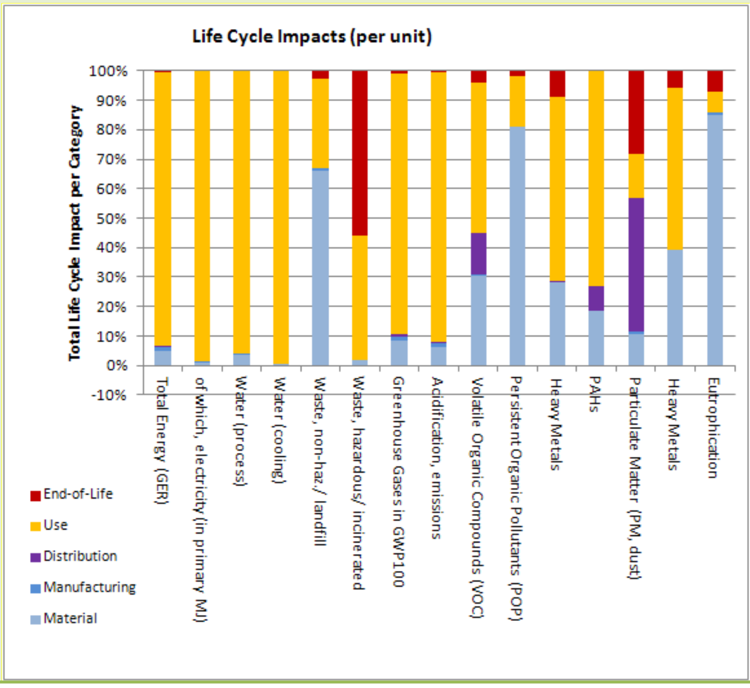
The assessment findings for the Base Case "Horizontal panel saw" are depicted in Figure 4-21. Not included is the energy consumption of a central extraction system.

The categories total energy and Global Warming Potential are clearly dominated by use phase impacts (power consumption), whereas several other categories are dominated by the impacts of the material used to construct the horizontal panel saw:

- Persistent Organic Pollutants
- Eutrophication

- Waste (non-hazardous)

Consequently, power consumption in the use phase is not the only relevant life cycle aspect for horizontal panel saws, but the environmental impacts related to machinery material actually is related to the bulk of steel parts and components.



Lifetime assumed:

20 years

Shift pattern assumed:

1 shift / day

5 days / week

Operational time per year assumed:

1.625 h/a (incl. idle)

Figure 4-21: Base case horizontal panel saw

Impacts in absolute numbers for this Base Case are listed in the table below, referring to one unit i.e. machine. The total energy consumption over the life cycle is 3 TJ, and the Global Warming Potential is 135 t CO_2-eq. over the whole product life of 20 years.

Table 4-46: Environmental Assessment – Base Case 6: Horizontal panel saw

Nr	Life cycle Impact per product:	Date	Author
0	Horizontal panel saw	0	Pwi

Nr	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Total	
	Materials	**unit**									
1	Bulk Plastics	g			1792			1434	358	1792	0
2	TecPlastics	g			101589			81271	20318	101589	0
3	Ferro	g			4796759			239838	4556921	4796759	0
4	Non-ferro	g			94817			4741	90076	94817	0
5	Coating	g			3			0	3	3	0
6	Electronics	g			1715			961	754	1715	0
7	Misc.	g			3326			166	3160	3326	0
	Total weight	g			5000000			328411	4671589	5000000	0
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	146100	37209	183309	15600	2743209	22832	4507	18325	2960444
9	of which, electricity (in primary MJ)	MJ	20845	22289	43134	40	2736994	0	164	-164	2780003
10	Water (process)	ltr	7040	353	7394	0	182511	0	130	-130	189775
11	Water (cooling)	ltr	39220	10565	49785	0	7297998	0	440	-440	7347343
12	Waste, non-haz./ landfill	g	######	116146	7224974	6404	3245139	306552	551	306001	10782517
13	Waste, hazardous/ incinerated	g	2648	6	2654	127	63085	83460	145	83314	149181
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	11194	2067	13261	918	119927	1703	279	1424	135530
15	Ozone Depletion, emissions	mg R-11 eq				negligible					
16	Acidification, emissions	g SO2 eq.	49299	8929	58228	2812	705619	3376	439	2937	769596
17	Volatile Organic Compounds (VOC)	g	623	7	630	289	1115	85	5	80	2114
18	Persistent Organic Pollutants (POP)	ng i-Teq	90208	0	90208	36	18839	2111	1	2110	111194
19	Heavy Metals	mg Ni eq.	21333	1	21335	325	48202	6532	11	6521	76383
	PAHs	mg Ni eq.	1376	5	1381	619	6445	0	13	-13	8431
20	Particulate Matter (PM, dust)	g	11048	1388	12436	47853	32815	29936	17	29920	123024
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	12718	1	12719	10	17772	1893	50	1843	32344
22	Eutrophication	g PO4	1226	17	1243	0	97	108	2	106	1446
23	Persistent Organic Pollutants (POP)	ng i-Teq				negligible					

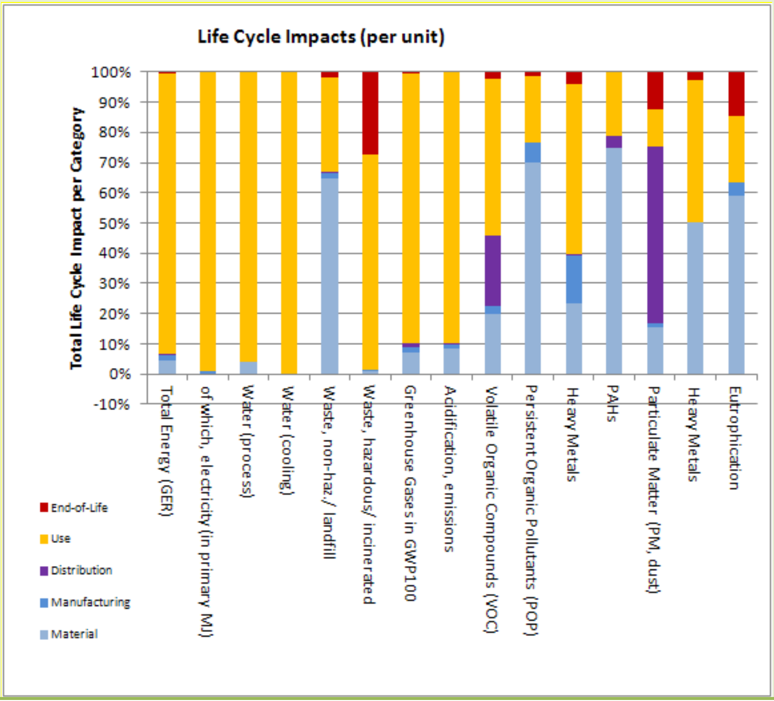
4.3.7 Base Case 7: Wood working machine tools: Throughfeed edge banding machine

The assessment findings for the Base Case "Throughfeed edge banding machine" are depicted in Figure 4-22. Not included is the consumption of glue and energy consumption of a central extraction system.

The categories total energy and Global Warming Potential are clearly dominated by use phase impacts (power consumption), whereas several other categories are dominated by the impacts of the material used to construct the throughfeed edge banding machine:

- Waste (non-hazardous)
- Persistent Organic Pollutants
- Polyaromatic Hydrocarbons
- Eutrophication

Consequently, power consumption in the use phase is not the only relevant life cycle aspect for throughfeed edge banding machines, but the environmental impacts related to machinery material actually is related to the bulk of steel parts and components.



Lifetime assumed:

20 years

Shift pattern assumed:

1 shift / day

5 days / week

Operational time per year assumed:

1.625 h/a (incl. idle)

Figure 4-22: Base case throughfeed edge banding machine

Including also the allocated energy consumption share of a centralised extraction system the energy consumption in the use phase increases by nearly 50%, and so does the impact of the use phase throughout all impact categories, see **Figure 4-23**. This calculation is based on an extraction volume of 1.600 m³/h and and an electrical power of 1,8 kW per 1000 m³/h extraction volume at 2.500 Pa[37].

[37] Following a calculation example stated by HOMAG in their ecoPlus brochure

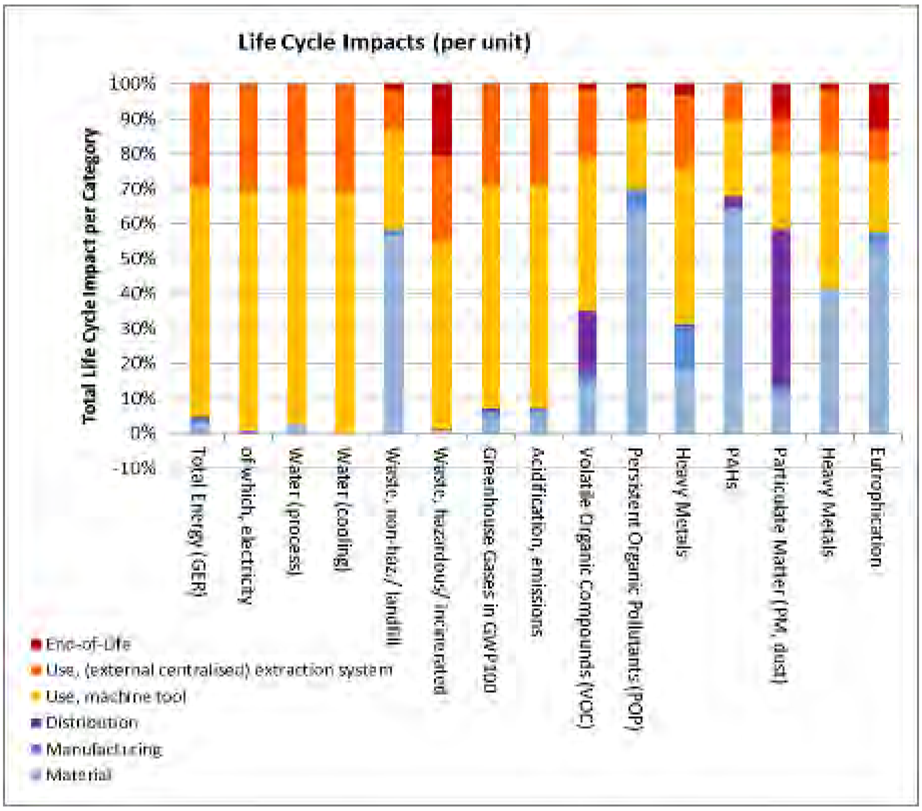


Figure 4-23: Environmental Assessment – Base Case 7: Throughfeed edge banding machine – extraction system power consumption included

Impacts in absolute numbers for this Base Case (extraction system not included) are listed in the table below, referring to one unit i.e. machine. The total energy consumption over the life cycle is 2,4 TJ, the Global Warming Potential is 107 t CO_2-eq. over the whole product life of 20 years.

Table 4-47: Environmental Assessment – Base Case 7: Throughfeed edge banding machine

Nr	Life cycle Impact per product:	Date	Author
0	Throughfeed edge banding machine	0	Pwl

Nr	Life Cycle phases --> / Resources Use and Emissions	unit	PRODUCTION Material	PRODUCTION Manuf.	PRODUCTION Total	DISTRI-BUTION	USE	END-OF-LIFE* Disposal	END-OF-LIFE* Recycl.	END-OF-LIFE* Total	TOTAL
	Materials	unit									
1	Bulk Plastics	g			1792			1434	358	1792	0
2	TecPlastics	g			21589			17271	4318	21589	0
3	Ferro	g			2196759			109838	2086921	2196759	0
4	Non-ferro	g			274817			13741	261076	274817	0
5	Coating	g			3			0	3	3	0
6	Electronics	g			1715			961	754	1715	0
7	Misc.	g			3326			166	3160	3326	0
	Total weight	g			2500000			143411	2356589	2500000	0
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	108084	33505	141589	20043	2195480	9880	1226	8654	2365765
9	of which, electricity (in primary MJ)	MJ	5520	19084	24605	51	2189496	0	105	-105	2214047
10	Water (process)	ltr	6103	274	6377	0	146014	0	90	-90	152300
11	Water (cooling)	ltr	3499	8072	11571	0	5838116	0	112	112	5849575
12	Waste, non-haz./ landfill	g	######	164999	5501072	8219	2593322	153258	321	152937	8255549
13	Waste, hazardous/ incinerated	g	783	32	815	163	50455	19459	109	19350	70783
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	7758	1919	9677	1179	96007	737	78	659	107522
15	Ozone Depletion, emissions	mg R-11 eq.					negligible				
16	Acidification, emissions	g SO2 eq.	52728	8349	61077	3612	564715	1454	161	1293	630697
17	Volatile Organic Compounds (VOC)	g	317	44	361	372	906	39	2	37	1675
18	Persistent Organic Pollutants (POP)	ng i-Teq	47932	4564	52496	46	14875	1055	1	1054	68471
19	Heavy Metals	mg Ni eq.	15869	10692	26561	417	38865	2857	11	2846	68689
	PAHs	mg Ni eq.	15889	8	15897	795	5512	0	10	-10	22193
20	Particulate Matter (PM, dust)	g	16309	1283	17592	61526	29857	12910	7	12903	121878
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	15191	6	15197	13	14268	820	50	770	30248
22	Eutrophication	g PO4	185	13	198	0	69	47	1	46	313
23	Persistent Organic Pollutants (POP)	ng i-Teq					negligible				

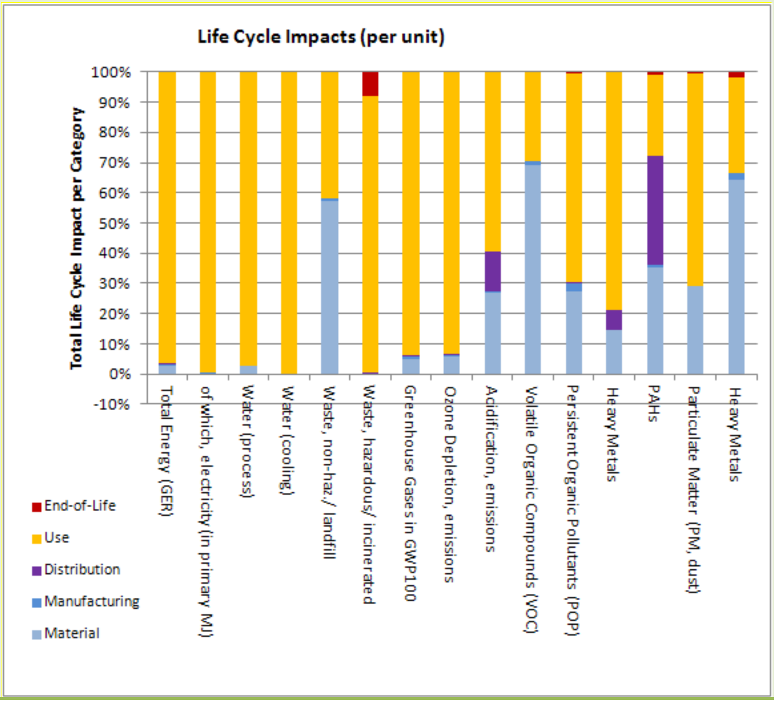
4.3.8 Base Case 8: Wood working machine tools: CNC machining centre

The assessment findings for the Base Case “Wood working CNC machining centre” is depicted in Figure 4-24. The energy consumption of a central extraction system is not included.

The categories total energy and Global Warming Potential are clearly dominated by use phase impacts (power consumption), whereas several other categories are dominated by the impacts of the material used to construct the horizontal panel saw:

- Waste (non-hazardous)
- Volatile Organic Compounds to air
- Heavy metals emissions to water

Consequently, power consumption in the use phase is not the only relevant life cycle aspect for horizontal panel saws, but the environmental impacts related to machinery material actually is related to the bulk of steel parts and components.



Lifetime assumed: 20 years
Shift pattern assumed: 2 shifts / day 5 days / week
Operational time per year assumed: 3.200 h/a (incl. idle)

Figure 4-24: Base case wood working CNC machining centre

Impacts in absolute numbers for this Base Case are listed in the table below, referring to one unit i.e. machine. The total energy consumption over the life cycle is 11,5 TJ, the Global Warming Potential is 515 t CO_2-eq. over the whole product life of 20 years.

Table 4-48: Environmental Assessment – Base Case 8: Wood working CNC machining centre

Nr	Life cycle Impact per product:	Date	Author
0	CNC machining center	0	Pwi

	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Total	
	Materials	**unit**									
1	Bulk Plastics	g			9718			7774	1944	9718	0
2	TecPlastics	g			11496			9197	2299	11496	0
3	Ferro	g			7334107			366705	6967402	7334107	0
4	Non-ferro	g			338819			16941	321878	338819	0
5	Coating	g			3			0	3	3	0
6	Electronics	g			190688			123885	66803	190688	0
7	Misc.	g			113628			5681	107946	113628	0
	Total weight	g			7998459			530184	7468275	7998459	0
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	312229	62411	374640	0	11115816	32995	17941	15054	11505509
9	of which, electricity (in primary MJ)	MJ	55223	27666	82889	0	11088829	0	7758	-7758	11163960
10	Water (process)	ltr	197154	1984	199139	0	741191	0	7003	-7003	933327
11	Water (cooling)	ltr	51855	17625	69481	0	29568695	0	1498	-1498	29636677
12	Waste, non-haz./ landfill	g	######	156036	7477666	0	12930683	490390	22502	467887	20876237
13	Waste, hazardous/ incinerated	g	40658	564	41223	0	255912	83774	8727	75048	372183
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq.	26151	3649	29800	0	486033	2462	1237	1226	517058
15	Ozone Depletion, emissions	mg R-11 eq					negligible				
16	Acidification, emissions	g SO2 eq.	227841	17370	245211	0	2859472	4846	6537	-1691	3102993
17	Volatile Organic Compounds (VOC	g	1311	418	1729	0	4582	126	96	30	6342
18	Persistent Organic Pollutants (POP	ng i-Teq	55310	13	55323	0	73230	3376	85	3291	131844
19	Heavy Metals	mg Ni eq.	328750	117	328867	0	198717	9514	982	8532	536117
	PAHs	mg Ni eq.	34671	345	35016	0	27394	0	808	-808	61602
20	Particulate Matter (PM, dust)	g	97091	3678	100769	0	150192	42808	312	42495	293456
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	213460	57	213517	0	73627	2747	4453	-1707	285438
22	Eutrophication	g PO4	5212	115	5327	0	394	157	63	94	5815
23	Persistent Organic Pollutants (POP	ng i-Teq					negligible				

4.3.9 Base Case 9: Welding equipment

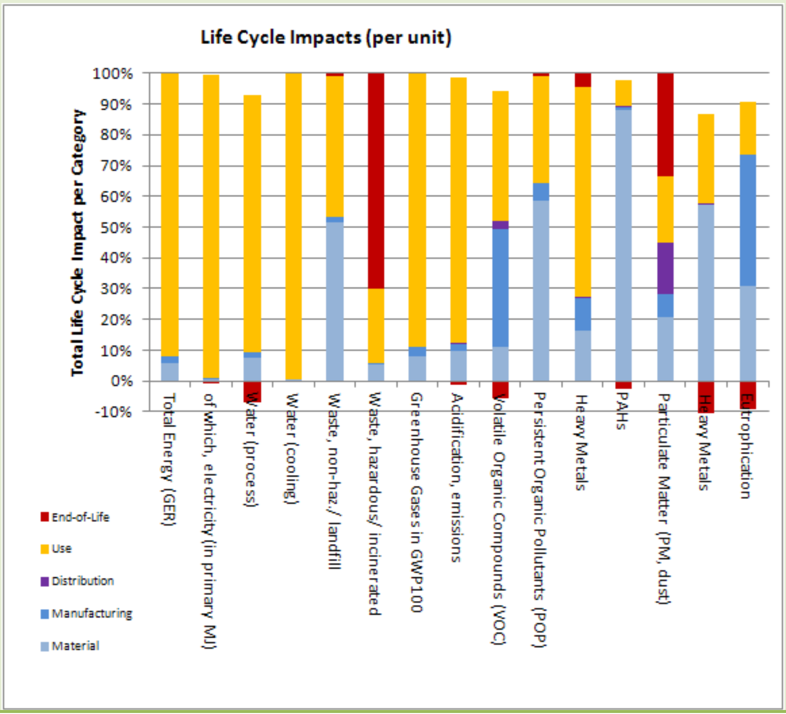
The assessment findings for the Base Case “Welding equipment” is depicted in Figure 4-24. Not included is the energy consumption of a central extraction system, nor the consumption of shielding gas or electrodes.

The categories total energy and Global Warming Potential are clearly dominated by use phase impacts (power consumption), whereas several other categories are dominated by the impacts of the material used to construct the welding equipment:

- Waste (non-hazardous)

- Volatile Organic Compounds to air
- Persistent Organic Pollutants to air
- Polyaromatic Hydrocarbons to air
- Heavy metals emissions to water

Consequently, power consumption in the use phase is not the only relevant life cycle aspect for welding equipment, but the environmental impacts related to machinery material actually is related to the bulk of steel sheets.



Lifetime assumed:

7 years

Shift pattern assumed:

1 shift / day

5 days / week

Operational time per year assumed:

2.000 h/a (incl. idle)

Figure 4-25: Base case Welding Equipment

Total impacts for the production of 3.5 t argon (proxy for used welding gases over 7 years lifetime of the equipment) is listed in Table 4-49. Background data is derived from ProBas (dataset: Xtra-generischArgon-DE-2005).

Table 4-49: Environmental Assessment – Base Case 9: Welding Equipment – argon

Impact 1 kg argon			MEEuP equivalents	total argon production related impact of 3500 kg gas consumption (aggregate over 7 years)
Greenhouse gases	Kilograms CO2	0,0689	Global Warming Potential (GWP)	241 kg
Acidification	Kilograms SO2 equivalent	0,0000862	Acidification (AD)	0,3017 kg
Heavy metals	Kilograms Hg (water)	$7.78 * 10^{-15}$	Emissions to water (mg Hg/20) (other heavy metals – As, Cd, Cr, Pb – listed as well in ProBas, but no equivalent in MEEuP available)	0,00054 mg Hg/20
	Kilograms Ni (air)	$6,94 * 10^{-9}$	Emissions to air (mg Ni eq.) (other heavy metals – As, Cd, Hg, Pb – listed as well in ProBas, but no equivalent in MEEuP available)	24,29 mg Ni.eq
Eutrophication	Kilograms PO equivalent	0	Eutrophication (EUP)	0

For those impact categories, for which impact indicators corresponding to MEEuP are available, the correlation between argon (production) related impacts and all other life cycle phases of the welding equipment is depicted in Figure 4-7. There is only one impact category, which is greenhouse gas, where the argon production in comparison to all other life cycle phases has at least a small impact of 2%. The contribution to the total lifecycle acidification is 0,44% and to heavy metals emissions to air 0,41%.

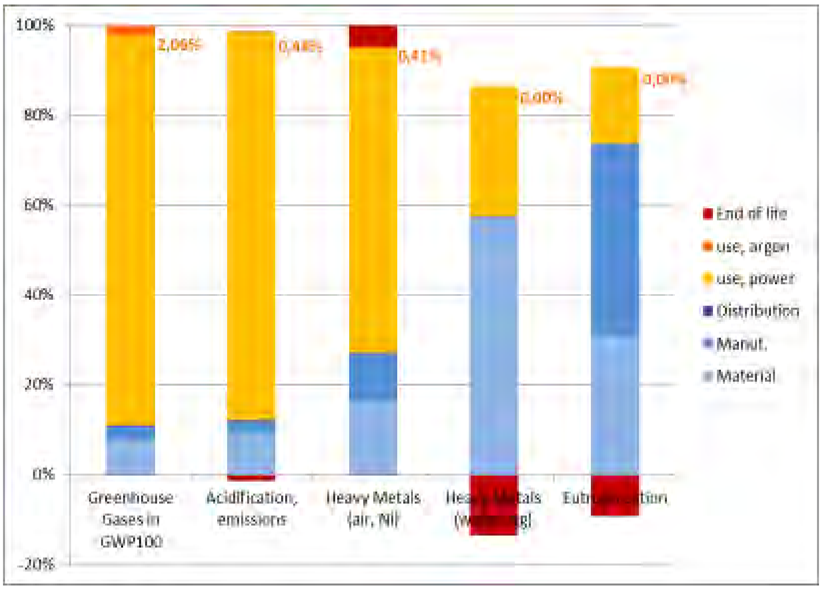


Figure 4-26: Environmental Assessment – Base Case 9: Welding equipment – argon consumption included

Impacts in absolute numbers for this Base Case are listed in the table below, referring to one unit. The total energy consumption over the life cycle is 250 GJ, the Global Warming Potential is 11,5 t CO_2-eq. over the whole product life. Consideration of shielding gas (for simplification: argon) results in additional upstream CO_2 emissions of 0,24 t over the whole product life of 7 years.

Table 4-50: Environmental Assessment – Base Case 9: Welding equipment

Nr	Life cycle Impact per product:	Date	Author
0	MIG/MAG-Welding Equipment	0	KSchi

Nr	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Total	
	Materials	**unit**									
1	Bulk Plastics	g			**5183**			4664	518	**5183**	**0**
2	TecPlastics	g			**0**			0	0	**0**	**0**
3	Ferro	g			**101467**			5073	96394	**101467**	**0**
4	Non-ferro	g			**7095**			355	6740	**7095**	**0**
5	Coating	g			**30**			2	29	**30**	**0**
6	Electronics	g			**26214**			13601	12614	**26214**	**0**
7	Misc.	g			**12**			1	11	**12**	**0**
	Total weight	g			**140000**			23695	116305	**140000**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	MJ	15044	5176	**20220**	**459**	**233589**	1644	2167	**-523**	**253745**
9	of which, electricity (in primary MJ)	MJ	857	1191	**2048**	**1**	**233383**	0	1464	**-1464**	**233968**
10	Water (process)	ltr	1438	312	**1750**	**0**	**15575**	0	1322	**-1322**	**16004**
11	Water (cooling)	ltr	2107	1371	**3478**	**0**	**622335**	0	277	**-277**	**625535**
12	Waste, non-haz./ landfill	g	306853	12137	**318991**	**248**	**273760**	8583	4245	**4338**	**597337**
13	Waste, hazardous/ incinerated	g	1158	108	**1266**	**5**	**5390**	17278	1647	**15631**	**22291**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	kg CO2 eq	935	326	**1260**	**29**	**10198**	123	143	**-21**	**11466**
15	Ozone Depletion, emissions	mg R-11 e					negligible				
16	Acidification, emissions	g SO2 eq.	6641	1716	**8357**	**86**	**60176**	244	1121	**-877**	**67743**
17	Volatile Organic Compounds (VOC)	g	23	80	**104**	**6**	**89**	4	17	**-12**	**187**
18	Persistent Organic Pollutants (POP)	ng i-Teq	2619	258	**2876**	**1**	**1558**	60	16	**44**	**4480**
19	Heavy Metals	mg Ni eq.	965	620	**1585**	**13**	**4025**	452	185	**266**	**5888**
	PAHs	mg Ni eq.	5489	65	**5554**	**16**	**527**	0	152	**-152**	**5945**
20	Particulate Matter (PM, dust)	g	1248	452	**1700**	**1026**	**1389**	2102	57	**2045**	**6160**
	Emissions (Water)										
21	Heavy Metals	mg Hg/20	3013	11	**3024**	**0**	**1535**	138	841	**-703**	**3856**
22	Eutrophication	g PO4	14	19	**32**	**0**	**7**	8	12	**-4**	**36**
23	Persistent Organic Pollutants (POP)	ng i-Teq					negligible				

4.4 Base cases Life Cycle Costs

For the economic life cycle cost calculations the exemplary Base Case assessments have to be extrapolated to larger market segments to allow for estimates on the EU-27 level instead of a solely machine-centric view.

4.4.1 Base Case 1: CNC 4-axis multifunctional milling centre

The following table lists the Life Cycle Cost (LCC) entries for this Base Case: Product life is 12 years corresponding to the analysis in task 2. During life time a sum of 0.

1 Mio. € is spent for maintenance and repair. Cooling lubricants (concentrate) are listed as “auxiliary 1”, hydraulic oil as “auxiliary 2”.

Table 4-51: Base Case 1 - Entries for LCC

nr	INPUTS FOR EU-Totals & economic Life Cycle Costs Description		unit
A	Product Life	12	years
B	Annual sales	0,011085	mln. units/year
C	EU Stock	0,288845	mln. Units
D	Product price	480000	Euro/unit
E	Installation/acquisition costs (if any)	0	Euro/ unit
F	Fuel rate (gas, oil, wood)		Euro/GJ
G	Electricity rate	0,11	Euro/kWh
H	Water rate	12	Euro/m3
I	Aux. 1: None	5	Euro/kg
J	Aux. 2 :None	2	Euro/kg
K	Aux. 3: None	2	Euro/kg
L	Repair & maintenance costs	100000	Euro/ unit

4.4.2 Base Case 2: CNC Laser cutting machine tools

The following table lists the Life Cycle Cost (LCC) entries for this Base Case 2: Product life is 12 years corresponding to the analysis in task 2. During life time additional costs of 20% of the initial investment are related to maintenance and repair. Hydraulic oil is listed as “auxiliary 2”.

Table 4-52: Base Case 2 - Entries for LCC

nr	INPUTS FOR EU-Totals & economic Life Cycle Costs Description		unit
A	Product Life	12	years
B	Annual sales	0,0015	mln. Units/year
C	EU Stock	0,015	mln. Units
D	Product price	400000	Euro/unit
E	Installation/acquisition costs (if any)		Euro/ unit
F	Fuel rate (gas, oil, wood)		Euro/GJ
G	Electricity rate	0,11	Euro/kWh
H	Water rate		Euro/m3
I	Aux. 1: None	10	Euro/kg
J	Aux. 2 :None	0,8	Euro/kg
K	Aux. 3: None		Euro/kg
L	Repair & maintenance costs	40000	Euro/ unit

4.4.3 Base Case 3: Metal working bending machine tools

The following table lists the Life Cycle Cost (LCC) entries for this Base Case: Product life is 17 years corresponding to the analysis in task 2. During life time additional costs of 20% of the initial investment are related to maintenance and repair. Hydraulic oil is listed as “auxiliary 2”.

Table 4-53: Base Case 3 - Entries for LCC

Table . Inputs for EU-Totals & LCC

nr	INPUTS FOR EU-Totals & economic Life Cycle Costs Description		unit
A	Product Life	17	years
B	Annual sales	0,031676	mln. Units/year
C	EU Stock	0,201579	mln. Units
D	Product price	100000	Euro/unit
E	Installation/acquisition costs (if any)		Euro/ unit
F	Fuel rate (gas, oil, wood)		Euro/GJ
G	Electricity rate	0,11	Euro/kWh
H	Water rate		Euro/m3
I	Aux. 1: None		Euro/kg
J	Aux. 2 :None	2	Euro/kg
K	Aux. 3: None		Euro/kg
L	Repair & maintenance costs	20000	Euro/ unit

4.4.4 Base Case 4: Non-numerical controlled metal working machine tools

The following table lists the Life Cycle Cost (LCC) entries for this Base Case: Product life is 18 years corresponding to the analysis in task 2. Cooling lubricants (concentrate) are listed as “auxiliary 1”, hydraulic oil as “auxiliary 2”.

Table 4-54: Base Case 4 - Entries for LCC

Table . Inputs for EU-Totals & LCC

nr	INPUTS FOR EU-Totals & economic Life Cycle Costs Description		unit
A	Product Life	18	years
B	Annual sales	0,038	mln. Units/year
C	EU Stock	0,69	mln. Units
D	Product price	5000	Euro/unit

E	Installation/acquisition costs (if any)	0	Euro/ unit
F	Fuel rate (gas, oil, wood)		Euro/GJ
G	Electricity rate	0,11	Euro/kWh
H	Water rate	12	Euro/m3
I	Aux. 1: None	5	Euro/kg
J	Aux. 2 :None	2	Euro/kg
K	Aux. 3: None		Euro/kg
L	Repair & maintenance costs	2500	Euro/ unit

4.4.5 Base Case 5: Wood working machine tools: Table saw

The following table lists the Life Cycle Cost (LCC) entries for this Base Case: Product life is 20 years corresponding to the analysis in task 2. No data is available regarding maintenance and repair costs, but given the low investment costs theses can be assumed to be minor and are approximated with 5% of the initial purchase price. Lubricants are listed as “auxiliary 1”, with an estimated price of 4 Euro/kg, which could be significantly higher, if sold in small units for DIY or semi-professional users.

Table 4-55: Base Case 5 - Entries for LCC

nr	INPUTS FOR EU-Totals & economic Life Cycle Costs Description		unit
A	Product Life	20	years
B	Annual sales	0,22	mln. Units/year
C	EU Stock	4,4	mln. Units
D	Product price	610	Euro/unit
E	Installation/acquisition costs (if any)		Euro/ unit
F	Fuel rate (gas, oil, wood)		Euro/GJ
G	Electricity rate	0,14	Euro/kWh
H	Water rate		Euro/m3
I	Aux. 1: Lubricants	4	Euro/kg
J	Aux. 2 :None		Euro/kg
K	Aux. 3: None		Euro/kg
L	Repair & maintenance costs	30,5	Euro/ unit

4.4.6 Base Case 6: Wood working machine tools: Horizontal panel saw

The following table lists the Life Cycle Cost (LCC) entries for this Base Case: Product life is 20 years corresponding to the analysis in task 2. For maintenance and repair costs 20% of the initial purchase price are assumed corresponding with data entries for other industrial equipment.

Table 4-56: Base Case 6 - Entries for LCC

nr	INPUTS FOR EU-Totals & economic Life Cycle Costs Description		unit
A	Product Life	20	years
B	Annual sales	0,0013	mln. Units/year
C	EU Stock	0,025	mln. Units
D	Product price	60000	Euro/unit
E	Installation/acquisition costs (if any)		Euro/ unit
F	Fuel rate (gas, oil, wood)		Euro/GJ
G	Electricity rate	0,14	Euro/kWh
H	Water rate		Euro/m3
I	Aux. 1: None		Euro/kg
J	Aux. 2 :None		Euro/kg
K	Aux. 3: None		Euro/kg
L	Repair & maintenance costs	12000	Euro/ unit

4.4.7 Base Case 7: Wood working machine tools: Throughfeed edge banding machine

The following table lists the Life Cycle Cost (LCC) entries for this Base Case: Product life is 20 years corresponding to the analysis in task 2. For maintenance and repair costs 20% of the initial purchase price are assumed corresponding with data entries for other industrial equipment.

Table 4-57: Base Case 7 - Entries for LCC

nr	INPUTS FOR EU-Totals & economic Life Cycle Costs Description		unit
A	Product Life	20	years
B	Annual sales	0,0104	mln. Units/year
C	EU Stock	0,207	mln. Units
D	Product price	60000	Euro/unit
E	Installation/acquisition costs (if any)		Euro/ unit
F	Fuel rate (gas, oil, wood)		Euro/GJ
G	Electricity rate	0,14	Euro/kWh
H	Water rate		Euro/m3
I	Aux. 1: None		Euro/kg
J	Aux. 2 :None		Euro/kg
K	Aux. 3: None		Euro/kg
L	Repair & maintenance costs	12000	Euro/ unit

4.4.8 Base Case 8: Wood working machine tools: CNC machining centre

The following table lists the Life Cycle Cost (LCC) entries for this Base Case: Product life is 20 years corresponding to the analysis in task 2. For maintenance and repair costs 20% of the initial purchase price are assumed corresponding with data entries for other industrial equipment.

Table 4-58: Base Case 8 - Entries for LCC

nr	INPUTS FOR EU-Totals & economic Life Cycle Costs Description		unit
A	Product Life	**20**	years
B	Annual sales	**0,00067**	mln. Units/year
C	EU Stock	**13494**	mln. Units
D	Product price	**300000**	Euro/unit
E	Installation/acquisition costs (if any)		Euro/ unit
F	Fuel rate (gas, oil, wood)		Euro/GJ
G	Electricity rate	**0,14**	Euro/kWh
H	Water rate		Euro/m3
I	Aux. 1: None		Euro/kg
J	Aux. 2 :None		Euro/kg
K	Aux. 3: None		Euro/kg
L	Repair & maintenance costs	**60000**	Euro/ unit

4.4.9 Base Case 9: Welding equipment

The following table lists the Life Cycle Cost (LCC) entries for this Base Case: Product life is 7 years corresponding to the analysis in task 2. For maintenance and repair costs 5% of the initial purchase price are assumed given the shorter lifetime compared to other industrial equipment.

Table 4-59: Base Case 9 - Entries for LCC

nr	INPUTS FOR EU-Totals & economic Life Cycle Costs Description		unit
A	Product Life	**7**	years
B	Annual sales	**0,18**	mln. Units/year
C	EU Stock	**1,27**	mln. Units
D	Product price	**1200**	Euro/unit
E	Installation/acquisition costs (if any)	**0**	Euro/ unit
F	Fuel rate (gas, oil, wood)		Euro/GJ
G	Electricity rate	**0,11**	Euro/kWh
H	Water rate		Euro/m3
I	Aux. 1: None	**3**	Euro/kg

J	Aux. 2 :None		Euro/kg
K	Aux. 3: None		Euro/kg
L	Repair & maintenance costs	**60**	Euro/ unit

4.5 EU-27 Total Impact

4.5.1 Base Case 1: CNC 4-axis multifunctional milling centre

This Base Case is meant to be a conscious abstraction, representing those product categories listed in Table 4-60.

Table 4-60: CNC machining centres - Installed stock 1995 and 2009

PRODCOM	Description	1995	2009
28411220	Horizontal machining centres for working metal	35.032	33.965
28411240	Vertical machining centres for working metal (including combined horizontal and vertical machining centres)	74.937	99.614
28411270	Multi-station transfer machines for working metal	24.746	22.828
28412123	Numerically controlled horizontal lathes, turning centres, for removing metal	32.253	34.214
28412127	Numerically controlled horizontal lathes, automatic lathes, for removing metal (excluding turning centres)	37.704	38.005
28412160	Lathes, including turning centres, for removing metal (excluding horizontal lathes)	57.653	58.210
	Totals	**264.320**	**288.845**

The following table lists the total extrapolated life cycle impacts for this Base Case on the EU-27 level for one year[38].

[38] Hydraulic oil and cooling lubricants not included with their life cycle impacts

Table 4-61: Base Case 1: CNC machining centres – Total EU-27 impacts per year[39]

Nr	EU Impact of Products in 2005 (produced, in use, discarded)***							Date	Author		
	4 Axis, CNC machining center							0			
	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	**Total**	BUTION		Disposal	Recycl.	**Total**	
	Materials	unit									
1	Bulk Plastics	kt			**0**			0	0	**0**	**0**
2	TecPlastics	kt			**0**			0	0	**0**	**0**
3	Ferro	kt			**98**			0	98	**98**	**0**
4	Non-ferro	kt			**10**			0	10	**10**	**0**
5	Coating	kt			**0**			0	0	**0**	**0**
6	Electronics	kt			**0**			0	0	**0**	**0**
7	Misc.	kt			**0**			0	0	**0**	**0**
	Total weight	kt			**108**			1	107	**108**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	PJ	5	1	**6**	**1**	**403**	0	0	**0**	**410**
9	of which, electricity (in primary PJ)	PJ	0	1	**1**	**0**	**403**	0	0	**0**	**404**
10	Water (process)	mln. m3	0	0	**0**	**0**	**32**	0	0	**0**	**32**
11	Water (cooling)	mln. m3	1	0	**1**	**0**	**1074**	0	0	**0**	**1075**
12	Waste, non-haz./ landfill	kt	297	4	**301**	**0**	**473**	1	0	**1**	**776**
13	Waste, hazardous/ incinerated	kt	0	0	**0**	**0**	**9**	0	0	**0**	**10**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	mt CO2 eq.	0	0	**0**	**0**	**18**	0	0	**0**	**18**
15	Ozone Depletion, emissions	t R-11 eq.	negligible								
16	Acidification, emissions	kt SO2 eq.	3	0	**3**	**0**	**104**	0	0	**0**	**107**
17	Volatile Organic Compounds (VOC)	kt	0	0	**0**	**0**	**0**	0	0	**0**	**0**
18	Persistent Organic Pollutants (POP)	g i-Teq	3	0	**3**	**0**	**3**	0	0	**0**	**6**
19	Heavy Metals	ton Ni eq.	1	0	**1**	**0**	**7**	0	0	**0**	**9**
	PAHs	ton Ni eq.	0	0	**0**	**0**	**1**	0	0	**0**	**1**
20	Particulate Matter (PM, dust)	kt	3	0	**3**	**3**	**4**	0	0	**0**	**10**
	Emissions (Water)										
21	Heavy Metals	ton Hg/20	0	0	**0**	**0**	**3**	0	0	**0**	**3**
22	Eutrophication	kt PO4	0	0	**0**	**0**	**0**	0	0	**0**	**0**
23	Persistent Organic Pollutants (POP)	g i-Teq	negligible								

The following table lists the Life Cycle Cost (LCC) for this Base Case on the EU-27 level.

39 Screenshot reference to 2005 is misleading, but cannot be changed in the template; actual figures refer to 2009

Table 4-62: Base Case 1: CNC machining centres – Total EU-27 total annual expenditure

	Hor. M/C - 500x500 pallet, 4 Axis, ATC 150, Multifunctional *Item*	LCC new product		total annual consumer expenditure in EU25	
D	Product price	480000	€	5321	mln.€
E	Installation/ acquisition costs (if any)	0	€	0	mln.€
F	Fuel (gas, oil, wood)	0	€	0	mln.€
F	Electricity	137036	€	4218	mln.€
G	Water	2027	€	62	mln.€
H	Aux. 1: None	5162	€	159	mln.€
I	Aux. 2 :None	1689	€	52	mln.€
J	Aux. 3: None	1689	€	52	mln.€
K	Repair & maintenance costs	78209	€	2407	mln.€
	Total	**705813**	€	**12271**	mln.€

4.5.2 Base Case 2: CNC laser cutting machine tools

Laser cutting machine tools addressed by this base case fall under PRODCOM 28411110, stock figures as calculated in task 2 shown in Table 4-63.

Table 4-63: CNC laser cutting machine tools - Installed stock 1995 and 2009

PRODCOM	Description	1995	2009
28411110	Machine-tools for working any material by removal of material, operated by laser or other light or photon beam processes	98.662	122.098

However, industry data indicates, that the total installed stock of larger equipment with high power laser sources modelled in the base case in the EU-27 might be rather in the range of 15,000 units instead of 120,000 units. These **15,000 units** cover 2D laser cutting machine tools for working metal sheets, 3D laser cutting machine tools, laser tube cutting machines and combined stamping[40] / laser cutting machine tools with a unit value of several 100,000 Euros typically[41]. The discrepancy with the (already corrected) PRODCOM figures cannot be solved out. Consequently the base case figures will be applied to an estimated stock of 15,000 units in EU-27, and annual sales of 1,500 units.

[40] note: hydraulics not properly covered by this base case

[41] Compared to a unit value of nearly 80,000 Euros according to PRODCOM figures.

The following table lists the total extrapolated life cycle impacts for this Base Case on the EU-27 level for one year[42].

Table 4-64: Base Case 2: CNC laser cutting machine tools – Total EU-27 impacts per year[43]

Table . EU Total Impact of STOCK of Generic CNC Laser cutting machine tool in 2005 (produced, in use, discarded)

Nr	EU Impact of Products in 2005 (produced, in use, discarded)***	Date	Author
	Generic CNC Laser cutting machine tool	0	KSchi

Nr	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	**Total**	BUTION		Disposal	Recycl.	**Total**	
	Materials	**unit**									
1	Bulk Plastics	kt			**0**			0	0	**0**	**0**
2	TecPlastics	kt			**0**			0	0	**0**	**0**
3	Ferro	kt			**16**			1	16	**16**	**0**
4	Non-ferro	kt			**1**			0	1	**1**	**0**
5	Coating	kt			**0**			0	0	**0**	**0**
6	Electronics	kt			**1**			0	0	**1**	**0**
7	Misc.	kt			**0**			0	0	**0**	**0**
	Total weight	kt			**18**			1	17	**18**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	PJ	1	0	**1**	**0**	**31**	0	0	**0**	**32**
9	of which, electricity (in primary PJ)	PJ	0	0	**0**	**0**	**31**	0	0	**0**	**31**
10	Water (process)	mln. m3	1	0	**1**	**0**	**2**	0	0	**0**	**3**
11	Water (cooling)	mln. m3	0	0	**0**	**0**	**82**	0	0	0	**82**
12	Waste, non-haz./ landfill	kt	15	1	**16**	**0**	**36**	1	0	**1**	**53**
13	Waste, hazardous/ incinerated	kt	0	0	**0**	**0**	**1**	0	0	**0**	**1**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	mt CO2 eq.	0	0	**0**	**0**	**1**	0	0	**0**	**1**
15	Ozone Depletion, emissions	t R-11 eq.					negligible				
16	Acidification, emissions	kt SO2 eq.	1	0	**1**	**0**	**8**	0	0	**0**	**9**
17	Volatile Organic Compounds (VOC)	kt	0	0	**0**	**0**	**0**	0	0	**0**	**0**
18	Persistent Organic Pollutants (POP)	g i-Teq	0	0	**0**	**0**	**0**	0	0	**0**	**0**
19	Heavy Metals	ton Ni eq.	1	0	**1**	**0**	**1**	0	0	**0**	**1**
	PAHs	ton Ni eq.	0	0	**0**	**0**	**0**	0	0	**0**	**0**
20	Particulate Matter (PM, dust)	kt	0	0	**0**	**0**	**0**	0	0	**0**	**1**
	Emissions (Water)										
21	Heavy Metals	ton Hg/20	1	0	**1**	**0**	**0**	0	0	**0**	**1**
22	Eutrophication	kt PO4	0	0	**0**	**0**	**0**	0	0	**0**	**0**
23	Persistent Organic Pollutants (POP)	g i-Teq					negligible				

The following table lists the Life Cycle Cost (LCC) for this Base Case on the EU-27 level.

42 Laser gas and cutting gas not included with their life cycle impacts

43 Screenshot reference to 2005 is misleading, but cannot be changed in the template; actual figures refer to 2009

Table 4-65: Base Case 2: CNC laser cutting machine tools – Total EU-27 total annual expenditure

nr	INPUTS FOR EU-Totals & economic Life Cycle Costs Description		unit
A	Product Life	12	years
B	Annual sales	0,0015	mln. Units/year
C	EU Stock	0,015	mln. Units
D	Product price	400000	Euro/unit
E	Installation/acquisition costs (if any)		Euro/ unit
F	Fuel rate (gas, oil, wood)		Euro/GJ
G	Electricity rate	0,11	Euro/kWh
H	Water rate		Euro/m3
I	Aux. 1: None	10	Euro/kg
J	Aux. 2 :None	0,8	Euro/kg
K	Aux. 3: None		Euro/kg
L	Repair & maintenance costs	40000	Euro/ unit

4.5.3 Base Case 3: Metal working bending machine tools

This Base Case is meant to be a conscious abstraction, representing those product categories listed in Table 4-66.

Table 4-66: Metal working bending machine tools - Installed stock 1995 and 2009

PRODCOM	Description	1995	2009
28413120	Numerically controlled bending, folding, straightening or flattening machines for working flat metal products (including presses)	34.504	76.542
28413140	Numerically controlled bending, folding, straightening or flattening machines for working metal (including presses) (excluding those for working flat metal products)	9.899	33.993
28413240	Numerically controlled punching or notching machines for working metal (including presses, combined punching and shearing machines)	9.266	17.591
28413310	Numerically controlled forging or die-stamping machines and hammers for working metal (including presses)	3.036	5.290
28413330	Presses for moulding metallic powders by sintering or for compressing scrap metal into bales	4.741	3.221
28413340	Other hydraulic presses, numerically controlled, for working metal	32.697	37.583
28413350	Hydraulic presses for working metal	not applicable	1.869
28413360	Non-hydraulic presses for working metal	not applicable	17.658
28413370	Other non-hydraulic presses, numerically controlled, for working metal	2.553	5.823
	Totals	**98.691**	**201.579**

The following table lists the total extrapolated life cycle impacts for this Base Case on the EU-27 level for one year[44].

Table 4-67: Base Case 3: CNC bending machine tools – Total EU-27 impacts per year[45]

Nr	EU Impact of Products in 2005 (produced, in use, discarded)***		Date	Author
	CNC Bending machine tool		Dec, 2011	KSchi

Nr	Life Cycle phases --> / Resources Use and Emissions	unit	PRODUCTION Material	PRODUCTION Manuf.	PRODUCTION Total	DISTRI-BUTION	USE	END-OF-LIFE* Disposal	END-OF-LIFE* Recycl.	END-OF-LIFE* Total	TOTAL
	Materials	**unit**									
1	Bulk Plastics	kt			0			0	0	0	0
2	TecPlastics	kt			0			0	0	0	0
3	Ferro	kt			248			0	248	248	0
4	Non-ferro	kt			1			0	1	1	0
5	Coating	kt			0			0	0	0	0
6	Electronics	kt			0			0	0	0	0
7	Misc.	kt			0			0	0	0	0
	Total weight	kt			249			0	249	249	0
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	PJ	4	0	4	1	8	0	0	0	13
9	of which, electricity (in primary PJ)	PJ	1	0	1	0	7	0	0	0	9
10	Water (process)	mln. m3	0	0	0	0	0	0	0	0	1
11	Water (cooling)	mln. m3	0	0	0	0	20	0	0	0	20
12	Waste, non-haz./ landfill	kt	200	0	200	0	9	0	0	0	210
13	Waste, hazardous/ incinerated	kt	0	0	0	0	0	0	0	0	0
	Emissions (Air)										
14	Greenhouse Gases in GWP100	mt CO2 eq.	0	0	0	0	0	0	0	0	1
15	Ozone Depletion, emissions	t R-11 eq.				negligible					
16	Acidification, emissions	kt SO2 eq.	1	0	1	0	2	0	0	0	3
17	Volatile Organic Compounds (VOC)	kt	0	0	0	0	0	0	0	0	0
18	Persistent Organic Pollutants (POP)	g i-Teq	3	0	3	0	0	0	0	0	3
19	Heavy Metals	ton Ni eq.	1	0	1	0	0	0	0	0	1
	PAHs	ton Ni eq.	0	0	0	0	0	0	0	0	0
20	Particulate Matter (PM, dust)	kt	0	0	0	2	1	0	0	0	3
	Emissions (Water)										
21	Heavy Metals	ton Hg/20	0	0	0	0	0	0	0	0	1
22	Eutrophication	kt PO4	0	0	0	0	0	0	0	0	0
23	Persistent Organic Pollutants (POP)	g i-Teq				negligible					

The following table lists the Life Cycle Cost (LCC) for this Base Case on the EU-27 level.

44 Hydraulic oil not included with related life cycle impacts

45 Screenshot reference to 2005 is misleading, but cannot be changed in the template; actual figures refer to 2009

Table 4-68: Base Case 3: CNC bending machine tools – Total EU-27 total annual expenditure

	CNC Bending machine tool *Item*	LCC new product		total annual consumer expenditure in EU25	
D	Product price	100000	€	3168	mln.€
E	Installation/ acquisition costs (if any)	0	€	0	mln.€
F	Fuel (gas, oil, wood)	0	€	0	mln.€
F	Electricity	4704	€	78	mln.€
G	Water	0	€	0	mln.€
H	Aux. 1: None	0	€	0	mln.€
I	Aux. 2 :None	2628	€	44	mln.€
J	Aux. 3: None	0	€	0	mln.€
K	Repair & maintenance costs	14313	€	237	mln.€
	Total	**121645**	€	**3526**	mln.€

4.5.4 Base Case 4: Non-numerical controlled metal working machine tools

This Base Case is meant to be a conscious abstraction, representing those product categories listed in Table 4-60.

Table 4-69: Non-numerical controlled metal working machine tools - Installed stock 1995 and 2009

PRODCOM	Description	1995	2009
28412140	Non-numerically controlled horizontal lathes, for removing metal	148116	100104
28412235	Non-numerically controlled drilling machines for working metal (excluding way-type unit head machines)	408178	320900
28412260	Non-numerically controlled boring and boring-milling machines for working metal (excluding drilling machines)	6393	3636
28412270	Non-numerically controlled milling machines for working metal (excluding boring-milling machines)	49576	36325
28412335	Non-numerically controlled flat-surface grinding machines for working metal, in which the positioning in any one axis can be set up to a minimum accuracy of 0.01mm	8299	4668
28412345	Non-numerically controlled cylindrical surface grinding machines for working metal, in which the positioning in any one axis can be set up to a minimum accuracy of 0.01mm	383	2024
28412355	Grinding machines for working metal; any one axis can be set to an accuracy of >=0.01mm excluding flat-surface grinding machines, cylindrical surface grinding machines	72575	49332
28412375	Non-numerically controlled sharpening (tool or cutter grinding)	43058	21950

	machines for working metal		
28412470	Sawing or cutting-off machines for working metal	**175033**	**137080**
28413160	Non-numerically controlled bending, folding, straightening or flattening machines for working flat metal products (including presses)	**42817**	**48355**
28413260	Non-numerically controlled shearing machines for working metal (including presses) (excluding combined punching and shearing machines)	**144300**	**146934**
28413320	Non-numerically controlled forging or die-stamping machines and hammers for working metal (including presses)	**224**	**291**
	Totals	**1100947**	**873608**

The following table lists the total extrapolated life cycle impacts for this Base Case on the EU-27 level for one year[46].

[46] Hydraulic oil and cooling lubricants not included with their life cycle impacts

Table 4-70: Base Case 4: Non-numerical controlled metal working machine tool – Total EU-27 impacts per year[47]

Nr	EU Impact of Products in 2005 (produced, in use, discarded)***	Date	Author
	Non-NC controlled metal working lathe	0	

Nr	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Total	
	Materials	**unit**									
1	Bulk Plastics	kt			0			0	0	0	0
2	TecPlastics	kt			0			0	0	0	0
3	Ferro	kt			11			1	10	11	0
4	Non-ferro	kt			1			0	1	1	0
5	Coating	kt			0			0	0	0	0
6	Electronics	kt			0			0	0	0	0
7	Misc.	kt			0			0	0	0	0
	Total weight	kt			12			1	12	12	0
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	PJ	1	0	1	0	94	0	0	0	96
9	of which, electricity (in primary PJ)	PJ	0	0	0	0	94	0	0	0	94
10	Water (process)	mln. m3	0	0	0	0	7	0	0	0	7
11	Water (cooling)	mln. m3	0	0	0	0	251	0	0	0	251
12	Waste, non-haz./ landfill	kt	43	1	44	0	110	3	0	3	156
13	Waste, hazardous/ incinerated	kt	0	0	0	0	2	0	0	0	2
	Emissions (Air)										
14	Greenhouse Gases in GWP100	mt CO2 eq.	0	0	0	0	4	0	0	0	4
15	Ozone Depletion, emissions	t R-11 eq.				negligible					
16	Acidification, emissions	kt SO2 eq.	0	0	0	0	24	0	0	0	25
17	Volatile Organic Compounds (VOC)	kt	0	0	0	0	0	0	0	0	0
18	Persistent Organic Pollutants (POP)	g i-Teq	0	0	0	0	1	0	0	0	1
19	Heavy Metals	ton Ni eq.	0	0	0	0	2	0	0	0	2
	PAHs	ton Ni eq.	0	0	0	0	0	0	0	0	0
20	Particulate Matter (PM, dust)	kt	1	0	1	1	1	0	0	0	3
	Emissions (Water)										
21	Heavy Metals	ton Hg/20	0	0	0	0	1	0	0	0	1
22	Eutrophication	kt PO4	0	0	0	0	0	0	0	0	0
23	Persistent Organic Pollutants (POP)	g i-Teq				negligible					

The following table lists the Life Cycle Cost (LCC) for this Base Case on the EU-27 level.

47 Screenshot reference to 2005 is misleading, but cannot be changed in the template; actual figures refer to 2009

Table 4-71: Base Case 4: Non-numerical controlled metal working machine tool – Total EU-27 total annual expenditure

	manually controlled lathe *Item*	LCC new product		total annual consumer expenditure in EU25	
D	Product price	5000	€	240	mln.€
E	Installation/ acquisition costs (if any)	0	€	0	mln.€
F	Fuel (gas, oil, wood)	0	€	0	mln.€
F	Electricity	14343	€	986	mln.€
G	Water	76	€	5	mln.€
H	Aux. 1: None	127	€	9	mln.€
I	Aux. 2 :None	51	€	3	mln.€
J	Aux. 3: None	0	€	0	mln.€
K	Repair & maintenance costs	1758	€	121	mln.€
	Total	**21354**	€	**1364**	mln.€

4.5.5 Base Case 5: Wood working machine tools: Table saw

Light stationary wood working machine tools, represented exemplarily by table saws, fall under three distinct PRODCOM codes, and it can be assumed, that the vast majority of products reported under these codes are light stationary wood working machine tools, although in exceptional cases also others might have been reported. Stock figures as calculated in task 2 are shown in Table 4-72.

Table 4-72: Table saws (and similar light stationary wood working machine tools) - Installed stock 1995 and 2009

PRODCOM	Description	1995	2009
28491235	Circular saws for working wood, cork, bone, hard rubber, hard plastics or similar hard materials *(98% of the market)*	1.231.220	1.241.318
28491237	Sawing machines for working wood, cork, bone, hard rubber, hard plastics or similar hard materials (excluding band saws, circular saws)	1.774.961	2.252.145
28491250	Planing, milling or moulding (by cutting) machines for working wood, cork, bone, hard rubber, hard plastics or similar hard materials	682.899	857.192
	Totals	**3.689.080**	**4.350.655**

The following table lists the total extrapolated life cycle impacts for this Base Case on the EU-27 level for one year.

Table 4-73: Base Case 5: Table saw – Total EU-27 impacts per year[48]

Table . EU Total Impact of STOCK of Light Stationary Wood Working Equipment / Table Saw in 2005 (produced, in use, discarded)

Nr	EU Impact of Products in 2005 (produced, in use, discarded)***	Date	Author
	Light Stationary Wood Working Equipment / Table Saw	0	Kschi

Nr	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Total	
	Materials	**unit**									
1	Bulk Plastics	kt			0			0	0	0	0
2	TecPlastics	kt			0			0	0	0	0
3	Ferro	kt			3			0	3	3	0
4	Non-ferro	kt			3			0	2	3	0
5	Coating	kt			0			0	0	0	0
6	Electronics	kt			0			0	0	0	0
7	Misc.	kt			0			0	0	0	0
	Total weight	kt			6			0	6	6	0
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	PJ	0	0	0	0	12	0	0	0	12
9	of which, electricity (in primary PJ)	PJ	0	0	0	0	12	0	0	0	12
10	Water (process)	mln. m3	0	0	0	0	1	0	0	0	1
11	Water (cooling)	mln. m3	0	0	0	0	31	0	0	0	31
12	Waste, non-haz./ landfill	kt	10	0	10	0	13	0	0	0	24
13	Waste, hazardous/ incinerated	kt	0	0	0	0	0	0	0	0	0
	Emissions (Air)										
14	Greenhouse Gases in GWP100	mt CO2 eq.	0	0	0	0	1	0	0	0	1
15	Ozone Depletion, emissions	t R-11 eq.				negligible					
16	Acidification, emissions	kt SO2 eq.	0	0	0	0	3	0	0	0	3
17	Volatile Organic Compounds (VOC)	kt	0	0	0	0	0	0	0	0	0
18	Persistent Organic Pollutants (POP)	g i-Teq	0	0	0	0	0	0	0	0	0
19	Heavy Metals	ton Ni eq.	0	0	0	0	0	0	0	0	0
	PAHs	ton Ni eq.	0	0	0	0	0	0	0	0	0
20	Particulate Matter (PM, dust)	kt	0	0	0	0	0	0	0	0	0
	Emissions (Water)										
21	Heavy Metals	ton Hg/20	0	0	0	0	0	0	0	0	0
22	Eutrophication	kt PO4	0	0	0	0	0	0	0	0	0
23	Persistent Organic Pollutants (POP)	g i-Teq				negligible					

The following table lists the Life Cycle Cost (LCC) for this Base Case on the EU-27 level.

48 Screenshot reference to 2005 is misleading, but cannot be changed in the template; actual figures refer to 2009

Table 4-74: Base Case 5: Table saw – Total EU-27 total annual expenditure

	Light Stationary Wood Working Equipment / Table Saw *Item*	LCC new product		total annual consumer expenditure in EU25	
D	Product price	610	€	134	mln.€
E	Installation/ acquisition costs (if any)	0	€	0	mln.€
F	Fuel (gas, oil, wood)	0	€	0	mln.€
F	Electricity	436	€	154	mln.€
G	Water	0	€	0	mln.€
H	Aux. 1: None	6	€	2	mln.€
I	Aux. 2 :None	0	€	0	mln.€
J	Aux. 3: None	0	€	0	mln.€
K	Repair & maintenance costs	19	€	7	mln.€
	Total	**1071**	€	**297**	mln.€

4.5.6 Base Case 6: Wood working machine tools: Horizontal panel saw

Horizontal panel saws represent a very typical product used in wood working although there is no dedicated PRODCOM code for these. It is anticipated, that these machine tools are reported under 28491235, which provides the best match in terms of terminology. Based on market insights and discussions with manufacturers a plausible stock is in the range of 2% (Table 4-60) of those products reported under this code (the vast majority being light stationary tools).

Table 4-75: Horizontal panel saws (and similar types of woodworking machine tools) - Installed stock 1995 and 2009

PRODCOM	Description	1995	2009
28491235	Circular saws for working wood, cork, bone, hard rubber, hard plastics or similar hard materials *(2% of the market)*	25.127	25.333
	Totals	**25.127**	**25.333**

The following table lists the total extrapolated life cycle impacts for this Base Case on the EU-27 level for one year.

Table 4-76: Base Case 6: Horizontal panel saw – Total EU-27 impacts per year[49]

Table . EU Total Impact of STOCK of Horizontal panel saw in 2005 (produced, in use, discarded)

Nr	EU Impact of Products in 2005 (produced, in use, discarded)***	Date	Author
	Horizontal panel saw	0	Pwi

Nr	Life Cycle phases --> / Resources Use and Emissions	unit	PRODUCTION Material	Manuf.	Total	DISTRI-BUTION	USE	END-OF-LIFE* Disposal	Recycl.	Total	TOTAL
	Materials	**unit**									
1	Bulk Plastics	kt			0			0	0	0	0
2	TecPlastics	kt			0			0	0	0	0
3	Ferro	kt			6			0	6	6	0
4	Non-ferro	kt			0			0	0	0	0
5	Coating	kt			0			0	0	0	0
6	Electronics	kt			0			0	0	0	0
7	Misc.	kt			0			0	0	0	0
	Total weight	kt			7			0	6	7	0
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	PJ	0	0	0	0	3	0	0	0	4
9	of which, electricity (in primary PJ)	PJ	0	0	0	0	3	0	0	0	3
10	Water (process)	mln. m3	0	0	0	0	0	0	0	0	0
11	Water (cooling)	mln. m3	0	0	0	0	9	0	0	0	9
12	Waste, non-haz./ landfill	kt	9	0	9	0	4	0	0	0	14
13	Waste, hazardous/ incinerated	kt	0	0	0	0	0	0	0	0	0
	Emissions (Air)										
14	Greenhouse Gases in GWP100	mt CO2 eq.	0	0	0	0	0	0	0	0	0
15	Ozone Depletion, emissions	t R-11 eq.				negligible					
16	Acidification, emissions	kt SO2 eq.	0	0	0	0	1	0	0	0	1
17	Volatile Organic Compounds (VOC)	kt	0	0	0	0	0	0	0	0	0
18	Persistent Organic Pollutants (POP)	g i-Teq	0	0	0	0	0	0	0	0	0
19	Heavy Metals	ton Ni eq.	0	0	0	0	0	0	0	0	0
	PAHs	ton Ni eq.	0	0	0	0	0	0	0	0	0
20	Particulate Matter (PM, dust)	kt	0	0	0	0	0	0	0	0	0
	Emissions (Water)										
21	Heavy Metals	ton Hg/20	0	0	0	0	0	0	0	0	0
22	Eutrophication	kt PO4	0	0	0	0	0	0	0	0	0
23	Persistent Organic Pollutants (POP)	g i-Teq				negligible					

The following table lists the Life Cycle Cost (LCC) for this Base Case on the EU-27 level.

49 Screenshot reference to 2005 is misleading, but cannot be changed in the template; actual figures refer to 2009

Table 4-77: Base Case 6: Horizontal panel saw – Total EU-27 total annual expenditure

	Horizontal panel saw *Item*	LCC new product		total annual consumer expenditure in EU25	
D	Product price	60000	€	78	mln.€
E	Installation/ acquisition costs (if any)	0	€	0	mln.€
F	Fuel (gas, oil, wood)	0	€	0	mln.€
F	Electricity	22736	€	46	mln.€
G	Water	0	€	0	mln.€
H	Aux. 1: None	0	€	0	mln.€
I	Aux. 2 :None	0	€	0	mln.€
J	Aux. 3: None	0	€	0	mln.€
K	Repair & maintenance costs	7477	€	15	mln.€
	Total	**90213**	€	**139**	mln.€

4.5.7 Base Case 7: Wood working machine tools: Throughfeed edge banding machine

This Base Case is meant to be a conscious abstraction, representing those product categories listed in Table 4-60. According to discussions with manufacturers of wood working machine tools, throughfeed edge banding machines typically would be reported as multi-purpose machines under PRODCOM code 28491220. As there is no distinct code for (the much smaller number of) wood working CNC machining centres also these are likely to be reported under this code, therefore only 90% of the market is allocated to the Base Case Throughfeed edge banding machines. Similar complexity is assumed also for multi-purpose machines where the workpiece is manually transferred between operations and – although featuring a different process – bending or assembling machines (code 28491265).

Table 4-78: Throughfeed edge banding machines (and similar types of wood-working machine tools) - Installed stock 1995 and 2009

PRODCOM	Description	1995	2009
28491210	Multi-purpose machines where the workpiece is manually trans-ferred between operations, for working wood, cork, bone, hard rubber, hard plastics or similar hard materials	80.874	85.973
28491220	Multi-purpose machines where the workpiece is automatically transferred between operations for working wood, cork, bone, hard rubber, hard plastics or similar hard materials *(90% of the market)*	85.839	121.444
28491265	Bending or assembling machines for working wood, cork, bone, hard rubber, hard plastics or similar hard materials[50]	56.602	51.460
	Totals	**223.315**	**258.877**

The following table lists the total extrapolated life cycle impacts for this Base Case on the EU-27 level for one year[51].

[50] Be aware, that „banding“ and „bending“ are different processes and bending machines are in included in this base case extrapolation only due to the similarity in complexity to throughfeed edge banding machines (see unit values)

[51] Glue not included with its life cycle impacts

Table 4-79: Base Case 7: Throughfeed edge banding machine – Total EU-27 impacts per year[52]

Table . EU Total Impact of STOCK of Throughfeed edge banding machine in 2005 (produced, in use, discarded)

Nr	EU Impact of Products in 2005 (produced, in use, discarded)***	Date	Author
	Throughfeed edge banding machine	0	Pwi

Nr	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	**Total**	BUTION		Disposal	Recycl.	**Total**	
	Materials	**unit**									
1	Bulk Plastics	kt			**0**			0	0	**0**	**0**
2	TecPlastics	kt			**0**			0	0	**0**	**0**
3	Ferro	kt			**23**			1	22	**23**	**0**
4	Non-ferro	kt			**3**			0	3	**3**	**0**
5	Coating	kt			**0**			0	0	**0**	**0**
6	Electronics	kt			**0**			0	0	**0**	**0**
7	Misc.	kt			**0**			0	0	**0**	**0**
	Total weight	kt			**26**			1	25	**26**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	PJ	1	0	**1**	**0**	**23**	0	0	**0**	**24**
9	of which, electricity (in primary PJ)	PJ	0	0	**0**	**0**	**23**	0	0	**0**	**23**
10	Water (process)	mln. m3	0	0	**0**	**0**	**2**	0	0	**0**	**2**
11	Water (cooling)	mln. m3	0	0	**0**	**0**	**60**	0	0	0	**61**
12	Waste, non-haz./ landfill	kt	55	2	**57**	**0**	**27**	2	0	**2**	**86**
13	Waste, hazardous/ incinerated	kt	0	0	**0**	**0**	**1**	0	0	**0**	**1**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	mt CO2 eq.	0	0	**0**	**0**	**1**	0	0	**0**	**1**
15	Ozone Depletion, emissions	t R-11 eq.	negligible								
16	Acidification, emissions	kt SO2 eq.	1	0	**1**	**0**	**6**	0	0	**0**	**7**
17	Volatile Organic Compounds (VOC)	kt	0	0	**0**	**0**	**0**	0	0	**0**	**0**
18	Persistent Organic Pollutants (POP)	g i-Teq	0	0	**1**	**0**	**0**	0	0	**0**	**1**
19	Heavy Metals	ton Ni eq.	0	0	**0**	**0**	**0**	0	0	**0**	**1**
	PAHs	ton Ni eq.	0	0	**0**	**0**	**0**	0	0	**0**	**0**
20	Particulate Matter (PM, dust)	kt	0	0	**0**	**1**	**0**	0	0	**0**	**1**
	Emissions (Water)										
21	Heavy Metals	ton Hg/20	0	0	**0**	**0**	**0**	0	0	**0**	**0**
22	Eutrophication	kt PO4	0	0	**0**	**0**	**0**	0	0	**0**	**0**
23	Persistent Organic Pollutants (POP)	g i-Teq	negligible								

The following table lists the Life Cycle Cost (LCC) for this Base Case on the EU-27 level.

52 Screenshot reference to 2005 is misleading, but cannot be changed in the template; actual figures refer to 2009

Table 4-80: Base Case 7: Throughfeed edge banding machine – Total EU-27 total annual expenditure

	Throughfeed edge banding machine *Item*	LCC new product		total annual consumer expenditure in EU25	
D	Product price	60000	€	624	mln.€
E	Installation/ acquisition costs (if any)	0	€	0	mln.€
F	Fuel (gas, oil, wood)	0	€	0	mln.€
F	Electricity	18189	€	302	mln.€
G	Water	0	€	0	mln.€
H	Aux. 1: None	0	€	0	mln.€
I	Aux. 2 :None	0	€	0	mln.€
J	Aux. 3: None	0	€	0	mln.€
K	Repair & maintenance costs	7477	€	124	mln.€
	Total	**85666**	€	**1050**	mln.€

4.5.8 Base Case 8: Wood working machine tools: CNC machining centre

This Base Case is meant to be a conscious abstraction, representing those product categories listed in Table 4-81, i.e. the remaining 10% of the market reported under 28491220 (multi-purpose machines).

Table 4-81: CNC machining centre (and similar types of woodworking machine tools) - Installed stock 1995 and 2009

PRODCOM	Description	1995	2009
28491220	Multi-purpose machines where the workpiece is automatically transferred between operations for working wood, cork, bone, hard rubber, hard plastics or similar hard materials *(10% of the market)*	9.538	13.494
	Totals	**9.538**	**13.494**

The following table lists the total extrapolated life cycle impacts for this Base Case on the EU-27 level for one year[53].

53 Hydraulic oil not included with their life cycle impacts

Table 4-82: Base Case 8: CNC machining centre (and similar types of woodworking machine tools) – Total EU-27 impacts per year[54]

Nr	EU Impact of Products in 2005 (produced, in use, discarded)***	Date	Author
	CNC machining center	0	Pwi

Nr	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	Total	BUTION		Disposal	Recycl.	Total	
	Materials	**unit**									
1	Bulk Plastics	kt			0			0	0	0	0
2	TecPlastics	kt			0			0	0	0	0
3	Ferro	kt			5			0	5	5	0
4	Non-ferro	kt			0			0	0	0	0
5	Coating	kt			0			0	0	0	0
6	Electronics	kt			0			0	0	0	0
7	Misc.	kt			0			0	0	0	0
	Total weight	kt			5			0	5	5	0
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	PJ	0	0	0	0	8	0	0	0	8
9	of which, electricity (in primary PJ)	PJ	0	0	0	0	7	0	0	0	8
10	Water (process)	mln. m3	0	0	0	0	1	0	0	0	1
11	Water (cooling)	mln. m3	0	0	0	0	20	0	0	0	20
12	Waste, non-haz./ landfill	kt	5	0	5	0	9	0	0	0	14
13	Waste, hazardous/ incinerated	kt	0	0	0	0	0	0	0	0	0
	Emissions (Air)										
14	Greenhouse Gases in GWP100	mt CO2 eq.	0	0	0	0	0	0	0	0	0
15	Ozone Depletion, emissions	t R-11 eq.				negligible					
16	Acidification, emissions	kt SO2 eq.	0	0	0	0	2	0	0	0	2
17	Volatile Organic Compounds (VOC)	kt	0	0	0	0	0	0	0	0	0
18	Persistent Organic Pollutants (POP)	g i-Teq	0	0	0	0	0	0	0	0	0
19	Heavy Metals	ton Ni eq.	0	0	0	0	0	0	0	0	0
	PAHs	ton Ni eq.	0	0	0	0	0	0	0	0	0
20	Particulate Matter (PM, dust)	kt	0	0	0	0	0	0	0	0	0
	Emissions (Water)										
21	Heavy Metals	ton Hg/20	0	0	0	0	0	0	0	0	0
22	Eutrophication	kt PO4	0	0	0	0	0	0	0	0	0
23	Persistent Organic Pollutants (POP)	g i-Teq				negligible					

The following table lists the Life Cycle Cost (LCC) for this Base Case on the EU-27 level.

54 Screenshot reference to 2005 is misleading, but cannot be changed in the template; actual figures refer to 2009

Table 4-83: Base Case 8: CNC machining centre – Total EU-27 total annual expenditure

	CNC machining center *Item*	LCC new product		total annual consumer expenditure in EU25	
D	Product price	300000	€	201	mln.€
E	Installation/ acquisition costs (if any)	0	€	0	mln.€
F	Fuel (gas, oil, wood)	0	€	0	mln.€
F	Electricity	92121	€	100	mln.€
G	Water	0	€	0	mln.€
H	Aux. 1: None	0	€	0	mln.€
I	Aux. 2 :None	0	€	0	mln.€
J	Aux. 3: None	0	€	0	mln.€
K	Repair & maintenance costs	37387	€	41	mln.€
	Total	**429507**	€	**341**	mln.€

4.5.9 Base Case 9: Welding equipment

This Base Case is meant to be a conscious abstraction, representing those product categories listed in Table 4-84. It is assumed that PRODCOM code 27903154 covers welding equipment, where the wire is fed automatically, but the electrode is hand-guided. There are two other codes (27903163, 27903172), which are for manual welding and other shielded arc welding, both with significant stock figures, but these are understood to be rather home use and semi-professional use products, with a basically different use scenario (much lower use times), hence these units are not properly represented by this base case.

Table 4-84: Welding equipment - Installed stock 1995 and 2009

PRODCOM	Description	1995	2009
27903154	Fully or partly automatic electric machines for arc welding of metals (including plasma arc)	1.678.333	1.271.472
	Totals	**1.678.333**	**1.271.472**

The following table lists the total extrapolated life cycle impacts for this Base Case on the EU-27 level for one year[55].

55 Welding gas not included with their life cycle impacts

Table 4-85: Base Case 9: Welding equipment – Total EU-27 impacts per year[56]

Table . EU Total Impact of STOCK of MIG/MAG-Welding Equipment in 2005 (produced, in use, discarded)

Nr	EU Impact of Products in 2005 (produced, in use, discarded)***	Date	Author
	MIG/MAG-Welding Equipment	0	KSchi

Nr	Life Cycle phases -->		PRODUCTION			DISTRI-	USE	END-OF-LIFE*			TOTAL
	Resources Use and Emissions		Material	Manuf.	**Total**	BUTION		Disposal	Recycl.	**Total**	
	Materials	**unit**									
1	Bulk Plastics	kt			**1**			1	0	**1**	**0**
2	TecPlastics	kt			**0**			0	0	**0**	**0**
3	Ferro	kt			**18**			1	17	**18**	**0**
4	Non-ferro	kt			**1**			0	1	**1**	**0**
5	Coating	kt			**0**			0	0	**0**	**0**
6	Electronics	kt			**5**			2	2	**5**	**0**
7	Misc.	kt			**0**			0	0	**0**	**0**
	Total weight	kt			**25**			4	21	**25**	**0**
									see note!		
	Other Resources & Waste							debet	credit		
8	Total Energy (GER)	PJ	3	1	**4**	**0**	**42**	0	0	**0**	**46**
9	of which, electricity (in primary PJ)	PJ	0	0	**0**	**0**	**42**	0	0	**0**	**42**
10	Water (process)	mln. m3	0	0	**0**	**0**	**3**	0	0	**0**	**3**
11	Water (cooling)	mln. m3	0	0	**1**	**0**	**113**	0	0	**0**	**113**
12	Waste, non-haz./ landfill	kt	55	2	**57**	**0**	**50**	2	1	**1**	**108**
13	Waste, hazardous/ incinerated	kt	0	0	**0**	**0**	**1**	3	0	**3**	**4**
	Emissions (Air)										
14	Greenhouse Gases in GWP100	mt CO2 eq.	0	0	**0**	**0**	**2**	0	0	**0**	**2**
15	Ozone Depletion, emissions	t R-11 eq.				negligible					
16	Acidification, emissions	kt SO2 eq.	1	0	**2**	**0**	**11**	0	0	**0**	**12**
17	Volatile Organic Compounds (VOC)	kt	0	0	**0**	**0**	**0**	0	0	**0**	**0**
18	Persistent Organic Pollutants (POP)	g i-Teq	0	0	**1**	**0**	**0**	0	0	**0**	**1**
19	Heavy Metals	ton Ni eq.	0	0	**0**	**0**	**1**	0	0	**0**	**1**
	PAHs	ton Ni eq.	1	0	**1**	**0**	**0**	0	0	**0**	**1**
20	Particulate Matter (PM, dust)	kt	0	0	**0**	**0**	**0**	0	0	**0**	**1**
	Emissions (Water)										
21	Heavy Metals	ton Hg/20	1	0	**1**	**0**	**0**	0	0	**0**	**1**
22	Eutrophication	kt PO4	0	0	**0**	**0**	**0**	0	0	**0**	**0**
23	Persistent Organic Pollutants (POP)	g i-Teq				negligible					

The following table lists the Life Cycle Cost (LCC) for this Base Case on the EU-27 level.

56 Screenshot reference to 2005 is misleading, but cannot be changed in the template; actual figures refer to 2009

Table 4-86: Base Case 9: Welding equipment – Total EU-27 total annual expenditure

	MIG/MAG-Welding Equipment *Item*	LCC new product		total annual consumer expenditure in EU25	
D	Product price	1200	€	216	mln.€
E	Installation/ acquisition costs (if any)	0	€	0	mln.€
F	Fuel (gas, oil, wood)	0	€	0	mln.€
F	Electricity	2021	€	444	mln.€
G	Water	0	€	0	mln.€
H	Aux. 1: None	8680	€	1905	mln.€
I	Aux. 2 :None	0	€	0	mln.€
J	Aux. 3: None	0	€	0	mln.€
K	Repair & maintenance costs	50	€	11	mln.€
	Total	**11950**	€	**2575**	mln.€

The total consumption of shielding gas equals 600 million kg Argon, compared to an EU-27 production of 720 million Nm^3 in 2010[57], equalling roughly 1.2 billion kg Argon. Although no distinct market data is available regarding Argon consumption for the various applications, it is plausible that at least half of the EU-27 consumption is for welding purposes. On the other hand this plausibility check indicates that by including the other two PRODCOM codes for manual and shielded welding at least the order of magnitude of gas consumption would increase maximum by a factor of two.

4.5.10 Base Cases Summary

4.5.10.1 Totals – Life Cycle Impacts

The total environmental impacts of the EU-27 stock per year are summarized in **Table 4-87**. It is evident, that metal working CNC machining centres are by far the most relevant Base Case and dominate the aggregated impacts of all Base Cases.

57 EuroStat / PRODCOM, code 20111120, imports and exports negligible

Table 4-87: Summary Environmental Impacts EU-Stock per year per Base Case

		Base Cases									
		Metal working				Wood working					
main life cycle indicators	unit	(1) CNC machining centres (and similar)	(2) CNC Laser cutting machine tools	(3) CNC Bending machine tools (and similar)	(4) Non-NC metal working machine tools (and similar)	(5) Table saw (and similar)	(6) Horizontal panel saw (and similar)	(7) Throughfeed edge banding machine (and similar)	(8) CNC machining centre (and similar)	(9) Welding equipment	Totals
Total Energy (GER)	PJ	**410**	**32**	**13**	**96**	**12**	**4**	**24**	**8**	**46**	**645**
of which, electricity	TWh	38,4	3,0	**0,8**	**9,0**	1,1	0,3	2,2	0,7	4,0	**59,5**
Water (process)*	mln.m3	32	3	1	**7**	1	0	2	1	3	**50**
Waste, non-haz./ landfill*	kt	**776**	**53**	**210**	**156**	**24**	**14**	**86**	**14**	**108**	**1441**
Waste, hazardous/ incinerated*	kt	**10**	**1**	**0**	**2**	**0**	**0**	**1**	**0**	**4**	**18**
Emissions (Air)											
Greenhouse Gases in GWP100	mt CO2eq.	**18**	**1**	**1**	**4**	**1**	**0**	**1**	**0**	**2**	**28**
Acidifying agents (AP)	kt SO2eq.	**107**	**9**	**3**	**25**	**3**	**1**	**7**	**2**	**12**	**169**
Volatile Org. Compounds (VOC)	kt	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Persistent Org. Pollutants (POP)	g i-Teq.	**6**	**0**	**3**	**1**	**0**	**0**	**1**	**0**	**1**	**12**
Heavy Metals (HM)	ton Ni eq.	**8**	**1**	**1**	**2**	**0**	**0**	**1**	**0**	**1**	**14**
PAHs	ton Ni eq.	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**2**
Particulate Matter (PM, dust)	kt	**9**	**1**	**3**	**3**	**0**	**0**	**1**	**0**	**1**	**19**
Emissions (Water)											
Heavy Metals (HM)	ton Hg/20	3	1	**1**	**1**	0	0	0	0	1	**7**
Eutrophication (EP)	kt PO4	0	0	**0**	**0**	0	0	0	0	0	**0**

***=caution: low accuracy for production phase**
"0" means "< 0.5"

Total energy consumption (primary energy) of CNC metal working machining centres is in the range of 410 PJ per year, which is much more than for any of the other calculated Base Cases. Further relevant machine tools segments are non-NC metal working machine tools (97 PJ per year), welding equipment (46 PJ per year), industrial wood working machine tools (represented by horizontal panel saws, throughfeed edge banding machines, and CNC machining centres; 36 PJ per year) and CNC laser cutting machine tools (32 PJ per year). The total energy consumption of all Base Cases is 645 PJ per year, thereof 59,5 TWh electricity, and aggregated Greenhouse Gas emissions total at 28 million tonnes CO_2-equivalents. Given the fact, that all Base Cases are dominated by use phase impacts, similarly Base Case 1 is the largest contributor to total life cycle impacts of machine tools in all categories. The Base Cases cover the most relevant market segments of machine tools covered by this study, but not all of them, which leads to an underestimation of total impacts; however the order of magnitude is plausible.

Oil-based auxiliaries where identified to be relevant for the impact category eutrophication, but even with these impacts included, the eutrophication on the total EU-27 level remains below 0,1 kt PO4.

Hagemann and Würz (VDW) cordially provided a top-down-estimate of electricity consumption of (metal working) machine tools in EU-27. Their calculations based on total EU-27 energy consumption and anticipated share of the manufacturing sector and thereof the industries using metal working machine tools are referenced in **Table 4-88**.

Table 4-88: Top-down estimate electricity consumption of metal working machine tools in EU-27 (estimate by VDW)

End-use energy consumption	unit	2000	2005	2006	2007	2008	2009
Totals EU-27 Eurostat: **http://epp.eurostat.ec.europa.eu/portal/page/portal/energy/data/main_tables**	[kt oil eq]	1120145	1192536	1193356	1166798	1175235	1113671
Totals EU-27	[TWh]	13027	13869	13879	13570	13668	12952
Manufacturing sector (estimate: 20% of totals)	[TWh]	2605	2774	2776	2714	2734	2590
Machine tools using sectors (estimate: 10% of manufacturing sector totals)	[TWh]	261	277	278	271	273	259
Machine tools (estimate: 25% of relevant sectors)	[TWh]	65,1	69,3	69,4	67,8	68,3	64,8

The estimated total electricity consumption of 65 – 70 TWh per year confirms roughly our own bottom-up (Base Case) estimates, taking into account that our aggregated Base Cases do not fully cover all machine tools categories.

To give an impression of the significance of the identified aggregated impacts of machine tools the following table lists the electricity consumption identified for other product groups in the course of EuP Preparatory Studies and the Impact Assessments (compilation by Reintjes et al.[58]).

Table 4-89: Electricity Consumption of other product groups under the Ecodesign Directive[59]

Lot	**Product Group**	**Electricity consumption in 2020 TWh/a (EU25/27)**	
		Business as usual	Ecodesign measure effective
ENER Lot 5	Television sets	132	104
ENER Lot 6	Standby and Off-mode losses	49	14
ENER Lot 7	External Power Supplies	31	22
ENER Lot 8/9	Tertiary Sector Lighting	260	222
ENER Lot 11	Electric Motors	1252	1117
ENER Lot 11	Circulators	55	32
ENER Lot 13	Domestic refrigerators and freezers	83	79-83
ENER Lot 19	Domestic Lighting (non-directional household lamps)	135	96

Total electricity consumption of machine tools (aggregated Base Cases) is roughly in the range of the 2020 prognosis for consumption for standby and off-mode losses (for consumer and office products) or circulators, but much lower than for electric motors. External power supplies are the only product group with significantly lower electricity consumption than identified for machine tools now, but for which an implementing measure has been adopted.

4.5.10.2 Totals – Life Cycle Costs

The total life cycle costs of the EU-27 stock per year are summarized in **Table 4-87**.

58 Ökopol GmbH. Analysis of Impact of Efficiency Standards on EU GHG Emissions (Ecodesign Directive); Task 3 Report – Outlook on the estimated GHG emissions reductions, September 2011 (EC, contract 070307/2008/506876/SER/C5)

59 Table lists only those product categories, for which an implementing measure has been adopted by early 2010

Table 4-90: Summary Life Cycle Costs EU-Stock per year per Base Case

		Base Cases									
		Metal working				Wood working					
		(1) CNC machining centres (and similar)	(2) CNC Laser cutting machine tools	(3) CNC Bending machine tools (and similar)	(4) Non-NC metal working machine tools (and similar)	(5) Table saw (and similar)	(6) Horizontal panel saw (and similar)	(7) Throughfeed edge banding machine (and similar)	(8) CNC machining centre (and similar)	(9) Welding equipment	Totals
LCC new product – per unit											
D Product price	k€	**480**	**400**	**100**	**5**	**0,6**	**60**	**60**	**300**	**1,2**	
F Electricity	k€	**137**	**191**	**5**	**14**	**0,4**	**23**	**18**	**92**	**2**	
G Water	k€	**2**	**0**	**0**	**0**	**0**	**0**	**0**		**0**	
H/I/J Auxiliaries	k€	**9**	**181**	**3**	**0,2**	**0,006**	**0**	**0**		**9**	
K Repair & maintenance costs	k€	**78**	**30**	**14**	**1,8**	**0,02**	**7**	**7**	**37**	**0,05**	
Total	k€	**706**	**801**	**122**	**21**	**1**	**90**	**86**	**430**	**12**	
Total annual user expenditure in EU27 (EU stock)											
D Product price	mln. €	**5321**	**600**	**3168**	**240**	**134**	**78**	**624**	**201**	**216**	**10582**
F Electricity	mln. €	**4218**	**323**	**78**	**986**	**154**	**46**	**302**	**100**	**444**	**6651**
G Water	mln. €	**62**	**0**	**0**	**5**		**0**	**0**	**0**	**0**	**0**
H/I/J Auxiliaries	mln. €	**263**	**306**	**12**	**10**	**2**	**0**	**0**	**0**	**1905**	**2498**
K Repair & maintenance costs	mln. €	**2407**	**50**	**121**	**96**	**7**	**15**	**124**	**41**	**11**	**2872**
Total	mln. €	**12271**	**1279**	**3526**	**1364**	**297**	**139**	**1050**	**341**	**2575**	**22842**

For almost all types of machine tools electricity consumption constitutes a major share of total life cycle costs, ranging from roughly 4% for bending machine tools (under a "manual discrete" production scenario) to nearly 25% for laser cutting machine tools. By far the highest cost share for auxiliaries is with welding equipment, where welding gases represent 75% of the life cycle costs. Be reminded, that for simplification these life cycle calculations do NOT include any of the following cost parameters, which are the more decisive criteria for any economic consideration of manufacturers:

- Product output / productivity / yield loss
- Labour costs

The total annual user expenditure, aggregated for all Base Cases per year is 22.8 billion Euro, thereof roughly 6.7 billion Euro for electricity and 2.5 billion Euro for those auxiliaries considered in the Base Cases.

4.5.10.3 Market coverage

It has to be noted, that numerous PRODCOM codes cannot be covered by the chosen Base Cases as technology complexity and process types deviates significantly from the Base Case archetypes, not allowing any extrapolation. Only an increased number of Base Cases would have allowed a broader coverage of the total market. The following table summarises coverage of the EU-27 by Base Cases.

Table 4-91: Metal working machine tools – Coverage of installed stock by Base Cases

PRODCOM	Description	2009	Base Case coverage
28411110	Machine-tools for working any material by removal of material, operated by laser or other light or photon beam processes	**18.978**	Base Case 2
28411130	Machine-tools for working any material by removal of material, operated by ultrasonic processes (excluding machines for the manufacture of semiconductor devices or of electronic integrated circuits)	**8762**	Not covered due to process specifics
28411150	Machine tools for working any material by removal of material, operated by electro-discharge processes	**33246**	Not covered due to process specifics
28411170	Machine-tools for working any material by removal of material, operated by electro-chemical, electron-beam, ionic-beam or plasma arc processes	**114266**	Not covered due to process specifics
28411220	Horizontal machining centres for working metal	**33965**	Base Case 1
28411240	Vertical machining centres for working metal (including combined horizontal and vertical machining centres)	**99614**	Base Case 1
28411250	Unit construction machines (single station) for working metal	**40955**	Not covered due to process specifics
28411270	Multi-station transfer machines for working metal	**22828**	Base Case 1
28412123	Numerically controlled horizontal lathes, turning centres, for removing metal	**34214**	Base Case 1
28412127	Numerically controlled horizontal lathes, automatic lathes, for removing metal (excluding turning centres)	**38005**	Base Case 1
28412129	Numerically controlled horizontal lathes, for removing metal (excluding turning centres, automatic lathes)	**44347**	Not covered (NC, but much less complex than BC1)
28412140	Non-numerically controlled horizontal lathes, for removing metal	**100104**	Base Case 4
28412160	Lathes, including turning centres, for removing	**53745**	Base Case 1

	metal (excluding horizontal lathes)		
28412213	Numerically controlled drilling machines for working metal (excluding way-type unit head machines)	**34743**	Not covered (NC, but much less complex than BC1)
28412217	Numerically controlled knee-type milling machines for working metal (excluding boring-milling machines)	**6859**	Not covered (NC, but much less complex than BC1)
28412223	Numerically controlled tool-milling machines for working metal (excluding boring-milling machines, knee-type machines)	**36197**	Not covered (NC, but much less complex than BC1)
28412225	Numerically controlled milling machines for working metal (including plano-milling machines) (excluding boring-milling machines, knee-type, tool-milling machines)	**23858**	Not covered (NC, but much less complex than BC1)
28412235	Non-numerically controlled drilling machines for working metal (excluding way-type unit head machines)	**320900**	Base Case 4
28412240	Numerically controlled boring and boring-milling machines for working metal (excluding drilling machines)	**23136**	Not covered (NC, but much less complex than BC1)
28412260	Non-numerically controlled boring and boring-milling machines for working metal (excluding drilling machines)	**3636**	Base Case 4
28412270	Non-numerically controlled milling machines for working metal (excluding boring-milling machines)	**36325**	Base Case 4
28412280	Threading or tapping machines for working metal (excluding drilling machines)	**141190**	Not relevant
28412305	Numerically controlled flat-surface grinding machines for working metal, in which the positioning in any one axis can be set up to a minimum accuracy of 0.01mm	**11152**	Not covered (NC, but much less complex than BC1)
28412315	Numerically controlled cylindrical surface grinding machines for working metal, in which the positioning in any one axis can be set up to a minimum accuracy of 0.01mm	**10852**	Not covered (NC, but much less complex than BC1)
28412325	Other numerically controlled grinding machines in which the positioning in any one axis can be set up to accuracy >0.01mm	**5987**	Not covered (NC, but much less complex than BC1)
28412335	Non-numerically controlled flat-surface grinding machines for working metal, in which the positioning in any one axis can be set up to a minimum accuracy of 0.01mm	**4668**	Base Case 4
28412345	Non-numerically controlled cylindrical surface grinding machines for working metal, in which the positioning in any one axis can be set up to a minimum accuracy of 0.01mm	**2024**	Base Case 4
28412355	Grinding machines for working metal; any one axis can be set to an accuracy >=0.01mm excluding flat-surface grinding machines, cylindrical surface grinding machines	**49332**	Base Case 4
28412365	Numerically controlled sharpening (tool or cutter grinding) machines for working metal	**43005**	Not covered (NC, but much less complex than BC1)

28412375	Non-numerically controlled sharpening (tool or cutter grinding) machines for working metal	**21950**	Base Case 4
28412385	Honing or lapping machines for working metal	**290527**	Not covered due to process specifics
28412395	Machines for deburring or polishing metal (excluding gear finishing machines)	**49371**	Not covered due to process specifics
28412410	Broaching machines for working metal	**916**	Not covered due to process specifics
28412430	Gear cutting, gear grinding or gear finishing machines, for working metals, metal carbides or cermets (excluding planing, slotting and broaching machines)	**6401**	Not covered due to process specifics
28412470	Sawing or cutting-off machines for working metal	**137080**	Base Case 4
28412490	Planing, shaping or slotting machines and other machine-tools working by removing metal or cermets, n.e.c.	**16187**	Not covered due to process specifics
28413120	Numerically controlled bending, folding, straightening or flattening machines for working flat metal products (including presses)	**76542**	Base Case 3
28413140	Numerically controlled bending, folding, straightening or flattening machines for working metal (including presses) (excluding those for working flat metal products)	**33993**	Base Case 3
28413160	Non-numerically controlled bending, folding, straightening or flattening machines for working flat metal products (including presses)	**48355**	Base Case 4
28413180	Non-numerically controlled bending, folding, straightening or flattening machines for working metal (including presses) (excluding those for working flat metal products)	**0**	
28413220	Numerically controlled shearing machines for working metal (including presses) (excluding combined punching and shearing machines)	**37512**	Not covered (NC, but much less complex than BC1)
28413240	Numerically controlled punching or notching machines for working metal (including presses, combined punching and shearing machines)	**17591**	Base Case 3
28413260	Non-numerically controlled shearing machines for working metal (including presses) (excluding combined punching and shearing machines)	**146934**	Base Case 4
28413280	Non-numerically controlled punching or notching machines for working metal (including presses, combined punching and shearing machines)	**185759**	Not covered due to process specifics
28413310	Numerically controlled forging or die-stamping machines and hammers for working metal (including presses)	**5290**	Base Case 3
28413320	Non-numerically controlled forging or die-stamping machines and hammers for working metal (including presses)	**291**	Base Case 4
28413330	Presses for moulding metallic powders by sintering or for compressing scrap metal into bales	**3221**	Base Case 3
28413340	Other hydraulic presses, numerically controlled,	**37583**	Base Case 3

	for working metal		
28413350[60]	Hydraulic presses for working metal	**1869**	Base Case 3
28413360	Non-hydraulic presses for working metal	**17658**	Base Case 3
28413370	Other non-hydraulic presses, numerically controlled, for working metal	**5823**	Base Case 3
28413380	Other non-numerically controlled presses for working metal	**395426**	Not covered (much less complex than BC3)
28413410	Draw-benches for bars, tubes, profiles, wire or the like of metal, sintered metal carbides or cermets	**7570**	Not covered due to process specifics
28413430	Thread rolling machines for working metal, sintered metal carbides or cermets	**14334**	Not covered due to process specifics
28413450	Machines for working wire (excluding draw-benches, thread rolling machines)	**187384**	Not covered due to process specifics
28413470	Riveting machines, swaging machines and spinning lathes for working metal, machines for manufacturing flexible tubes of spiral metal strip and electro-magnetic pulse metal forming machines, and other machine tools for working metal without removing metal	**319683**	Not covered due to process specifics
	Totals	**3.464.152**	

Table 4-92: Wood working machine tools – Coverage of installed stock by Base Cases

PRODCOM	Description	2009	Base Case coverage
28491210	Multi-purpose machines where the workpiece is manually transferred between operations, for working wood, cork, bone, hard rubber, hard plastics or similar hard materials	85.973	Base Case 7
28491220	Multi-purpose machines where the workpiece is automatically transferred between operations for working wood, cork, bone, hard rubber, hard plastics or similar hard materials	134.938	Split: 10% Base Case 8; 90% Base Case7
28491233	Band saws for working wood, cork, bone and hard rubber, hard plastics or similar hard materials	171.091	Not covered due to process specifics
28491235	Circular saws for working wood, cork, bone, hard rubber, hard plastics or similar hard materials	1.265.651	Split: 2% Base Case 6; 98% Base Case 5
28491237	Sawing machines for working wood, cork, bone, hard rubber, hard plastics or similar hard materials (excluding band saws, circular saws)	2.252.145	Base Case 5
28491250	Planing, milling or moulding (by cutting) ma-	857.192	Base Case 5

60 In 2009 PRODCOM codes 28413340 and 28413370 where replaced by codes 28413350 and 28413360, which explains a stock of “0” for the latter categories for 1995, as these where covered by other categories at that time

	chines for working wood, cork, bone, hard rubber, hard plastics or similar hard materials		
28491263	Grinding, sanding or polishing machines for working wood, cork, bone, hard rubber, hard plastics or similar hard materials	159.022	Not covered due to process specifics
28491265	Bending or assembling machines for working wood, cork, bone, hard rubber, hard plastics or similar hard materials	51.460	Base Case 7
28491267	Drilling or morticing machines for working wood, cork, bone, hard rubber, hard plastics or similar hard materials	144.628	Not covered due to process specifics
28491275	Splitting, slicing or paring machines for working wood, cork, bone, hard rubber, hard plastics or similar hard materials	284.247	Not covered due to process specifics
28491279	Machine tools for working wood, cork, bone, hard rubber, hard plastics or similar hard materials, n.e.c.	378.955	Not covered, category not defined
	Totals	**5.787.311**	

Table 4-93: Welding, soldering and brazing equipment – Coverage of installed stock by Base Cases

PRODCOM	Description	2009	Base Case coverage
27903118	Electric brazing or soldering machines and apparatus (excluding soldering irons and guns)	76.626	Industrial equipment covered by ENTR Lot 4
27903145	Electric machines and apparatus for resistance welding of metal	1.014.599	Not covered due to process specifics[61]
27903154	Fully or partly automatic electric machines for arc welding of metals (including plasma arc)	1.271.472	Base Case 9
27903163	Other for manual welding with coated electrodes	1.868.230	Not covered, use phase impact much lower than BC 9
27903172	Other shielded arc welding	1.406.819	Not covered, use phase impact much lower than BC 9
27903181	Machines and apparatus for welding or spraying of metals, n.e.c.	209.110	Not covered, category not defined
27903190	Machines and apparatus for resistance welding of plastics	1.087.628	Not covered due to process specifics
27903199	Machines and apparatus for welding (excluding for resistance welding of plastics, for arc and plasma arc welding, for treating metals)	139.121	Not covered, definition unclear
28297090	Machinery and apparatus for soldering, brazing, welding or surface tempering (excluding	59.533	Industrial equipment cov-

61 resistance welding equipment can not be compared with arc welding equipment for various reasons, e.g. the transformer used is designed by its thermal performance in order to allow very short welding time with very high welding current; hence, efficiency has to be analysed differently and findings for arc welding cannot be directly applied for resistance welding

	hand-held blow pipes and electric machines and apparatus)		ered by ENTR Lot 4
	Totals	**7.135.147**	