



Energy-Using Product Group Analysis - Lot 5

Machine tools and related machinery

Task 3 Report – User Requirements

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

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Executive Summary – Task 3

Machine tools are **business-to-business products**. Recent survey results show, that “energy efficiency” – despite some outstanding initiatives - is not very important in the marketing of the machine tool manufacturers. The important facts are price, cutting speed and innovative equipment.

Although machine tools users’ interest regarding energy efficiency aspects is growing, technical features and performance criteria are dominating. The growing interest and related marketing initiatives do not result in a broad demand for and implementation of energy efficient modules in machine tools. This is the case particularly in the wood-working sector, although some manufacturers of machine tools actively promote “green” features of their machine tools. In the metal working sector there is a somewhat higher level of awareness and interest among the automotive industry and its suppliers, but for most other market segments energy efficiency is not among the decisive criteria for purchasing a machine tool.

Implementation obstacles regarding new energy efficient solutions on the users’ side can be observed. For most machine tool users the price-profitability relation and therefore the amortisation time of such solutions as well as limited financial resources are some of these barriers. Still, the main marketing aspects are price, cutting speed and the innovative equipment of products. The Total Cost of Ownership approach is realised mainly in large-scale producing branches such as in the automotive industry.

Nevertheless, machine tool users are aware of the growing importance of realising environmental, especially energy saving aspects in machine tools.

Retrofitting and refurbishment of machine tools after a certain time in use is very common and reported to take place a couple of times throughout the lifetime of a machine tool. Due to the business-to-business nature of the machine tools market and the material value of scrapped machine tools a high recycling quota can be anticipated although statistical data on this aspect is not available at all.

3 Task 3 – User Requirements

3.1 User information

Machine tools are typical business-to-business products. The user is therefore not a single (private) consumer (user), but an enterprise. This enterprise could be a manufacturing company of varying size (e.g. small, medium or large). Within this entity product related (user) information are necessary on various levels. This ranges from technicians and production managers working with the machine tool to financial administration and desk personnel responsible for procurement of a machine. These corporate users have different information requirements with respect to the products technical and environmental performance.

With respect to eco-design, relevant information for the corporate user of machine tools would include at best an environmental footprint or life cycle performance data of the product, detailed information regarding specific energy and material consumption during use phase including varying configurations and modes, as well as specific information concerning maintenance and the end-of-life treatment.

The objective of this task is to provide references for the current status of environmentally related product information disclosure in the market. The investigation is focusing on determining the types and availability of environmental product information in the sales/procurement situation (e.g. power consumption, consumable efficiency). The goal is to collect evidence as an input for later tasks. An analysis of the available user information including shortcomings in that respect is a secondary task.

3.1.1 Metal working machine tools

▪ Product information supplied by machine tool manufacturers

A brief investigation showed that is justified to say that today's communication between manufacturers of machine tools and their customers (users) is usually limited to technical product data and service information. The study investigated exemplarily, product information provided by machine tool manufacturers including the following machinery:

- 5-axis machining centre by Roeders, Soltau,
- 3+2-axis milling machine by Deckel Maho, Seebach,

- turning-milling centre by Gildemeister, Bielefeld,
- 4-revolver turning machine by Traub, Reichenbach,
- profile grinding machine by Blohm, Hamburg, and
- die sinking EDM machine by Zimmer & Kreim, Brensbach.

All surveyed offers are related to machine tools with CNC. The machine tools have common working space for stand-alone solutions of between 300 mm and 1250 mm per linear axis. The use for workshops as well as line manufacturing was taken into account. The product description includes all means, e. g. main drive, feed drives, working space, control system, meeting customer demands on the output of the machine tool. This also includes displaying power and torque against rotational speed of main drive, acceleration and maximum velocity of feed drives, electricity supply data, the flow-rate of lubrication, hydraulic system and pneumatic system as well as noise emission.

Further technical information available for machine tools comprises mostly description of components. Manuals include information on standardized interfaces such as for tool holders according to ISO 12164¹ or for electrical safety according to EN 60204². The standardized accuracy of machine tools is pointed out according to ISO 230³ or other related international, European or national standards. All hardware and software parts of machine tool are usually well described.

The service aspects are explained too. Here, transport from manufacturer to customer site, transport conditions, packaging, insurance and travel costs, initial set-up, warranty claims and customer training are all addressed. The availability is guaranteed by guidelines such as VDI 3423⁴.

Despite this sufficient technical information there is limited environmental information available from the machine tool manufacturers. Most eco-information is related to waste management and substances regulations such as the environmentally compliant

¹ ISO 12164-1:2001 (2008): Part 1-4: Hollow taper interface with flange contact surface.

² EN 60204-1:2006+A1:2009: Safety of machinery. Electrical equipment of machines. General requirements.

³ ISO 230:1996 (2010): Part 1-9 Test code for machine tools.

⁴ VDI 3423:2002: Technical availability of machines and production lines - Terms, definitions, determination of time periods and calculation.

using of coolant and lubrication. There are also few indications with respect to the recycling of machine components and take-back. Aspects such as material and energy consumption or efficiency are mentioned rather incidentally if all. A stakeholder comment from CECIMO argues that energy consumption is part of productivity, quality and life cycle costs. CECIMO therefore concludes that it is not correct to ask for energy consumption on top of those other factors.

The following table sums up the product information provided for the user by machine tool manufacturers. The numbers were collected from the survey of this study⁵.

Table 3-1: Machine Tool Information for the Users

Parameters	Yes	No
Technical	100 %	0 %
Ecological (for the use phase)	75 %	25 %
	Mainly environmentally compliant using of coolant and lubrication	
Ecological (End of life behaviour)	62.5 %	37.5 %
	mainly recycling of machine components	
Maintenance clearance (e.g. by reason of abrasion)	87.5 %	12.5 %
Spare part availability (e.g. time)	87.5 %	12.5 %

▪ **Ecodesign related marketing of machine tool manufacturers**

According to our survey and literature analysis the most dominant issue in the communication between manufacturer and the customer is the productivity that can be achieved with the machine. A survey at the EMO 2003 unveiled, which sales arguments were most relevant at that time⁶: The top three aspects are:

- Machine quality,

⁵ Online survey and direct contact; Questionnaires answered: nine; Countries: Germany, Italy, Japan; Machinable material: metal, wood

⁶ Sample size: 1.573 experts

- Qualification and availability of service technician,
- Services and availability of spare parts⁷.

Environmental aspects (green machine) were not mentioned. However, the rubric “Innovation power of providers” (rank 7) included innovation in relation to environmental improvement.

A more recent survey was carried out by the Institut für Werkzeugmaschinen und Fabrikbetrieb (IWF) at TU Berlin at the METAV 2010⁸. This survey focused on marketing aspects and safety of metal working machine tools. According to this survey, energy efficiency is becoming an important marketing strategy in the near future. The study concluded that internal and external corporate communication of eco-efficiency labels and solutions leads to improved corporate identity. But in the actual sales situation eco-efficiency is currently not a strong argument for a purchasing decision.

The results of the survey are still very similar to the survey of the EMO 2003. Over the past decade eco-design has gained only limited importance in the market. Relevant for marketing are price, technical performance (such as cutting speed) and other innovative features of the product. The top priorities for the customers are similar. They are high quality performance and an acceptable price. Energy saving or the design of “green machines” are considered of secondary importance.

There are nevertheless a few initiatives and trends that indicate a growing recognition of environmental performance and energy efficiency in particular in the machinery industry today. Important initiatives with respect to energy efficiency are:

- 2008: The German Machine Tool Builder Association (VDW) developed the label “Blue Competence”.
- 2009: Presentation of the label "Blue Competence" at the EMO.
- 2010: Funding of the German innovation platform “Resource Efficiency in Production” (German: “Effizienzfabrik”), founded by the German Federal Ministry of Education and Research (BMBF).

⁷ Kapitza, R. (2004): Erfolgreiches Marketing im Werkzeugmaschinenbau. In: Backhaus, K.; Voethe M. (Hrsg.): Industriegütermarketing, Wiesbaden: Gabler, 2004, S. 1105-1121.

⁸ Sample size: 35 machine tool manufacturers; international SMEs and major enterprises

- 2010: 15 companies addressed "Blue Competence" at the METAV and the additional symposium "The energy efficient machine tool" [in German: "Die energieeffiziente Werkzeugmaschine"] and 27 companies at the AMB.
- 2011: The Association of Italian Manufacturers of Machine Tools, Robots, Automation Systems and ancillary products, UCIMU, developed the label "Blue Philosophy". "Blue Competence" is operated by VDMA, and addresses mechanical- and plant construction.
- 2012: "Blue Competence" is operated by CECIMO, and addresses metal working machine tool manufacturers and their suppliers throughout Europe.

Eco-design and eco-performance is a growing marketing aspect (this has been indicated by the well frequented workshops and events on energy efficiency of machine tools in 2010), but energy saving measures are mainly driven forward by large-scale producing branches such as the automobile industry. Major enterprises implement life-cycle oriented energy saving measures increasingly, whereas SME remain reserved and sceptical due to the indistinct financial benefit that they perceive, regarding eco-solutions.

In the survey conducted by the authors of this study, it was explicitly asked for eco-design measures. The survey included a ranking regarding sales information in general. The manufacturers were asked to rank twelve aspects using a scale from 1 (most important) to 5 (not very important). According to the survey's results the productivity, quality, accuracy and availability ranked with an average value of 1.0 to 1.4 constitute the most important points. In contrast, life cycle costs, brand image, energy consumption and design of machine tools are less important and were ranked with an average value of 3.2 to 3.7 (see figure below). Detailed explanation will be given in Chapter 3.2.

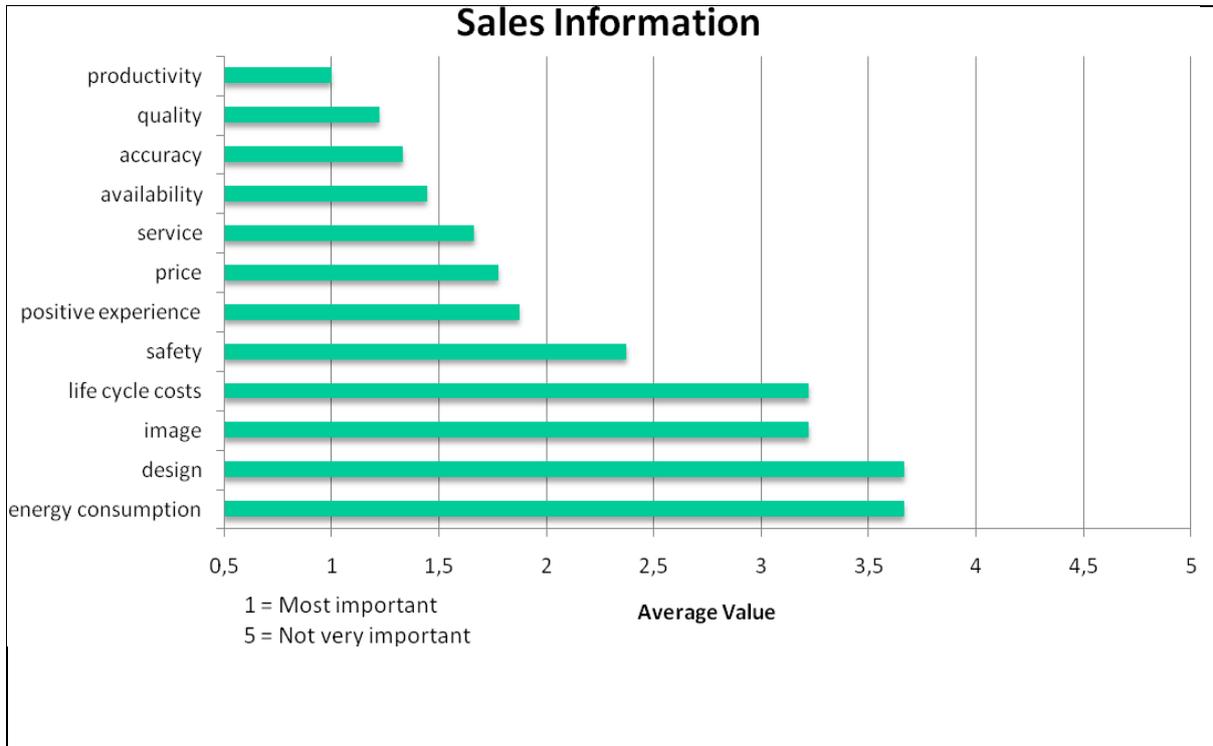


Figure 3-1: Important Sales Information

The results of our survey is furthermore supported by other (some older) studies.

Core customer demands regarding machine tools comprise the following⁹:

- Productivity, quality, flexibility (verified through the survey of this study)
- Process oriented machine tools
- High availability and reliability
- Exploitation of the machines' full capacity
- Cost transparency at purchase and use

Figure 3-2 illustrates the results of a survey by University of Hannover (IFW) among 11 machine tool users of different company size / branch (each with 5-1500 CNC-machine tools in use) regarding the importance of certain factors for investment decisions.

⁹ B. Denkena, A. Harms: Life-Cycle Oriented Development of Machine Tools, LCE Congress, Leuven, 30/05/2006.

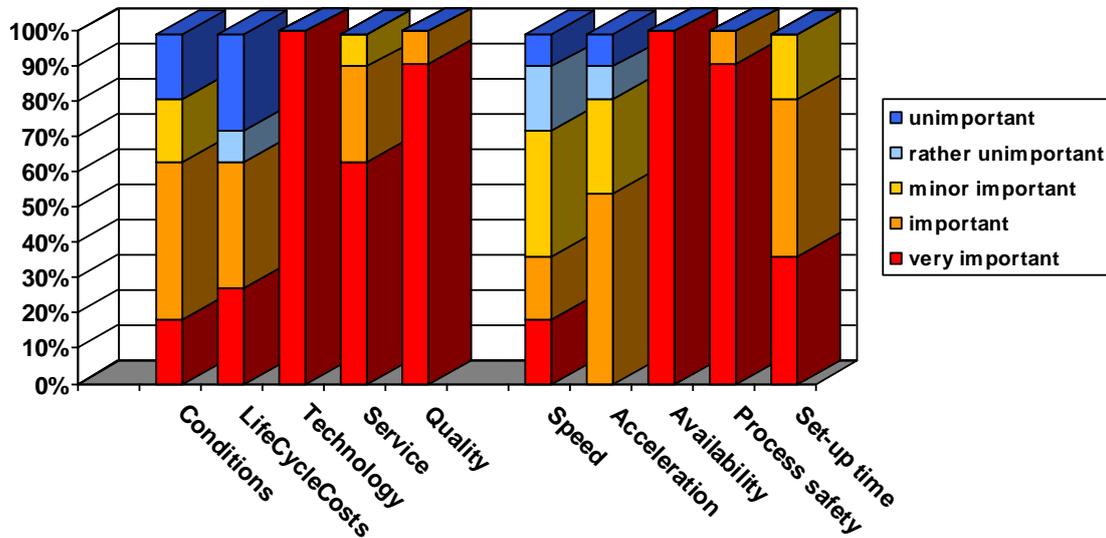


Figure 3-2: Survey among machine tools users

Figure 3-3 shows the cost structure of the producing industry. This is a very interesting statistic because it indicates two important aspects with respect to eco-design. First of all, the total material costs are with just over 46 % the most important (absolute dominant) cost factor. The improvement of material efficiency should be therefore of highest concern. This would also benefit the environmental performance. A stakeholder comment from CLASP points out that the ratio of output value (46% x 5) to energy (1.8%) is 130:1. Although very crude, this illustrates the over-riding importance of throughput compared to energy consumption, according to CLASP.

We have to notice therefore the rather low cost factor of energy with only 1.8 %¹⁰. That figure might change however with rising energy prices and also vary from enterprise to enterprise. According to a German source the energy costs will increase from 4.3 % in 2003 to 7.6 % in 2013 in relation to the total annual costs of producing companies¹¹.

¹⁰ Statistisches Bundesamt: Kostenstruktur im Produzierenden Gewerbe (2007).

¹¹ http://www.karlsruhe.ihk.de/produktmarken/innovation/Verborgene_Dateien_Innovation_und_Umwelt/Anlagen_Innovation_und_Umwelt/Umwelt/Energiepreise_und_Unternehmensentwicklung_in_Baden-Wuerttemberg.pdf. Access on 01/06/2010.

Similar trend can be seen according to a survey by Thamling et al.¹² one third of the companies from producing industry estimate their energy consumption at more than 5 % and one seventh at more than 10 % of total production costs.

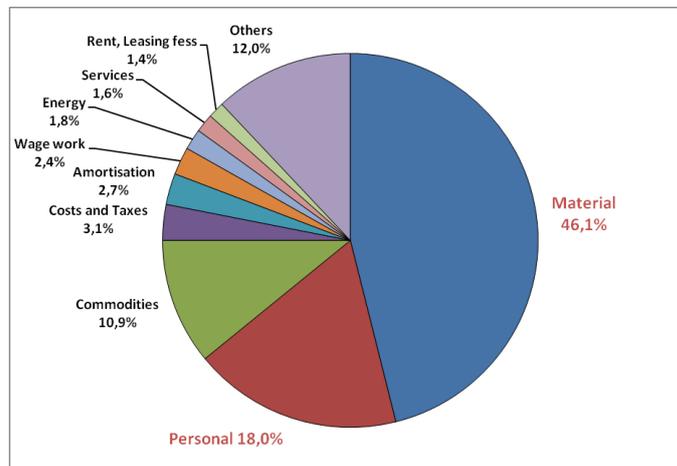


Figure 3-3: Cost structure of producing industry in Germany in 2007

Machine tools manufacturers are mostly part of the first third. The long amortization times and the limited financial resources are to be named as obstacles for implementation of energy reducing measures. The focus is rather on facility related energy savings measures, than on the production equipment.

Nevertheless the main impact in terms of energy and material appears during use phase of machine tools. The potentials for cost reductions regarding improved energy efficiency are estimated between 5 % and 20 % according to Thamling et al. The machine tool related energy efficiency measures of SME are mainly situated in a mean range of up to 5 %. 15 % to 35 % of SME estimate machine tool related energy efficiency measures between 11 % and 30 %.

- **Environmental requirements in procurement specifications**

Only very occasionally customers – mostly large enterprises of the automotive or woodworking branch – ask in a systematic way for EHS (environmental, health and safety) aspects of the machinery they purchase. One such example is the SKF EHS

¹² Thamling, N.; Seefeldt, F.; Glöckner, U.: Rolle und Bedeutung von Energieeffizienz und Energiedienstleistungen in KMU. Report of Prognos AG on behalf of the KfW Bankengruppe, Berlin, 05/02/2010, p. 8

Delivery Specifications¹³. It was designed as a comprehensive guide to the EHS Management System in a check list style. The guide is used by the company's procurement to evaluate supplier of purchased products and parts. The components of the SKF EHS Delivery Specifications include not only environmental aspects, but also Industrial safety, machinery safety, fire safety regulations and plant protection. An exemplary segment from this specification is shown in Figure 3-4, actually addressing environmental protection issues. The main focus is the proper substance and waste handling.

Pos.	SKF EHS Delivery Specifications	not applicable	accepted
2	Environmental protection		
2.1	Use of substances listed under http://www.gadsl.org is prohibited. Declarable substances have to be reported.	<input type="checkbox"/>	<input type="checkbox"/>
2.2	Components must exit the machine in such a dry condition that they do not contaminate the subsequent transport, processing and test systems.	<input type="checkbox"/>	<input type="checkbox"/>
2.3	During operation, no negative influence or pollution from machines or plants should interfere with the direct surrounding field. Legal limits should be under run as far as possible according to the state of the art.		
2.4	Machine oil must not be able to mix with the processing medium.	<input type="checkbox"/>	<input type="checkbox"/>
2.5	The use of FCKW or CKW as a cleaning or degreasing agent or as an active substance is not permitted.	<input type="checkbox"/>	<input type="checkbox"/>
2.6	When using water to cool various media (oil, emulsion, etc.), only safety heat exchangers may be used.	<input type="checkbox"/>	<input type="checkbox"/>
2.7	If the unauthorised use of SKF waste containers or SKF storage surfaces is observed, disposal will be arranged at the cost of the polluter.	<input type="checkbox"/>	<input type="checkbox"/>
2.8	Any kinds of liquid waste with the exception of household waste water or pure surface water must not be disposed of in the sewage system.	<input type="checkbox"/>	<input type="checkbox"/>
2.9	Any containers provided by the Contractor for the above purposes must be clearly labelled to guarantee the properly sorted collection of waste.	<input type="checkbox"/>	<input type="checkbox"/>
2.10	Used packaging will be taken back own expense and under proper disposal.	<input type="checkbox"/>	<input type="checkbox"/>
2.11	Labelling of electrical and electronic equipment according to EU directive 2002/96/EC (WEEE).	<input type="checkbox"/>	<input type="checkbox"/>
2.12	REACH / GHS conformal EU-safety data sheets for all materials supplied and used by the Contractor on site must be handed to SKF before (upon) delivery and start of work / use of these materials. The materials shall be approved for use by SKF.	<input type="checkbox"/>	<input type="checkbox"/>
2.13	In case of dusty and noisy activities, effective measures for prevention are mandatory in agreement with SKF.	<input type="checkbox"/>	<input type="checkbox"/>
2.14	Integration of containment with sufficient slope for machines using liquid medias?	<input type="checkbox"/>	<input type="checkbox"/>
2.15	Nomination of an on-site official responsible for environmental protection.	<input type="checkbox"/>	<input type="checkbox"/>

Figure 3-4: SKF EHS Delivery Specifications for Procurement

¹³ <http://www.skf.com/files/882847.pdf>. Access on 03/06/2010.

Furthermore, table 3-2 indicates the percentage of machine tool manufacturers applying EHS guidelines and delivery specifications according to the study's survey. The results show most of the asked companies actually apply EHS guidelines.

Table 3-2: Applying EHS

	Yes	No
Does your company apply "Environmental, Health and Safety (EHS) Guidelines"?	87.5 %	12.5 %
Does your company apply EHS Delivery Specifications (Machinery and installations)?	87.5 %	12.5 %

- **Measuring environmental product parameters**

One of the main problems, why unambiguous information on environmental aspects rarely can be stated by machine tools manufacturers is the lack of appropriate standards to come up with comparable measurements of e.g. power consumption. Furthermore the power consumption is a function of the use mode the most energy is used in the production process.¹⁴ Therefore it is difficult to receive comparable values. The stakeholder CLASP commented: "It is stated that there is no common way to assess the energy performance of a machine tool. CLASP agrees with this finding, and we would support more work being done in this Preparatory Study and by testing organizations and CECIMO to develop appropriate, accurate and repeatable energy measurement methods for this equipment." The authors of this study recommend that readers should crosscheck comments and statements on standardization in Task 1.

The definition of energy efficiency as the ratio of benefit and use of energy provides a possible approach to consistent determination and evaluation of energy consumption. Herein the benefit is represented for example by added value of a production line or turnover of a company depending on the observed object.¹⁵

¹⁴ Abele, E.; Kührke, B.: Impulsvortrag – Produktionsorientierter Umweltschutz im Maschinenbau und in der Metallbearbeitung. Fachtagung Hessen-Umwelttech 2009, 25.03.2009

¹⁵ Reinhart, G.; Karl, F.; Krebs, P.; Reinhardt, S.: Energiewertstrom – Eine Methode zur ganzheitlichen Erhöhung der Energieproduktivität. ZWF 105 (2010) H. 10, S. 870 ff

An alternative to quantify electrical energy consumption in the use phase is proposed by Gutowski et al.¹⁶, based on a more academic approach from the U.S.: The approach taken is based on thermodynamics to account for material transformations, including the conversion of raw working materials into products, wastes, and emissions, and the conversion of fuels into heat and usable work, wastes, and emissions. The concept can also incorporate all other energy sources. Machine tools include in addition to the basic function of shaping work pieces a wide variety of functions including tool and work piece clamping and handling, lubrication and chip removal. All these additional functions can often dominate energy requirements. This is shown in Figure 3-5 for an automotive machining line. In this case, the maximum energy requirement for the actual machining is only 14.8 % of the total. At lower production rates the machining contribution is even smaller.

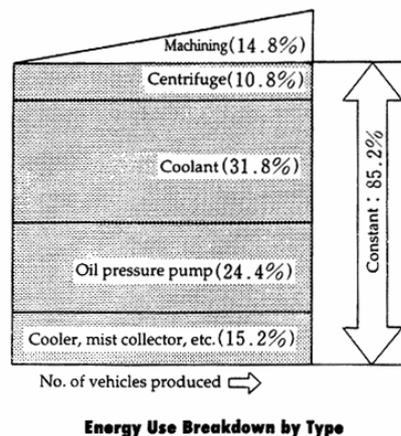


Figure 3-5: Energy used as a function of production rate for an automobile production machining line¹⁷

Other processes show a similar behaviour. In general, there is a significant energy requirement to start-up and maintain the equipment in a “ready” position. Once in the “ready” position, there is then additional power consumption proportional to the quantity of material being processed.

¹⁶ Gutowski, T.; Dahmus, J.; Thiriez, A.: Electrical Energy Requirements for Manufacturing Processes. In: Proceedings of the 13th CIRP Int. Conf. on Life Cycle Engineering, 2006.

¹⁷ Gutowski, T., Murphy, C., Allen, D., Bauer, D., Bras, B., Pivonka, T., Sheng, P., Sutherland, J., Thurston, D., Wolff, E.: Environmentally Benign Manufacturing: Observations from Japan, Europe and the United States, Journal of Cleaner Production 13 (2005), pp 1-17.

Gutowski et al. proposed the specific electrical energy per unit B_{elect} in kJ/cm^3 as calculated variable in order to determine the energy efficiency.

$$P = P_0 + k \cdot v'$$

with P total power in kW,

P_0 idle power in kW,

k constant in kJ/cm^3 , specific cutting energy, closely related to mechanical properties of material to be machined

v' rate of material processing in cm^3/s

the formula is transformed into $B_{\text{elect}} = P_0/v' + k$ [kJ/cm^3]

The relation of idle power and machining power is improved with an increase of the material removal rate. However, the throughput of material depends on frame conditions such as required precision, scale effects and the complexity of shape to be manufactured. These effects need to be taken into account for different manufacturing processes as depicted in Figure 3-6. The highest process rates at lowest electrical energy consumption are stated for injection moulding and machining¹⁸. As B_{elect} can be determined for a well-defined process and material, but not on a generic level for machine tools as such, a standardization of the process, work piece (type and quality), material would be required to make B_{elect} measurable in a comparable way. Such an approach might mean, that an exemplary process might be reflected, but not the real life application of a machine tool.

¹⁸ Gutowski, T.; Dahmus, J.; Thiriez, A.: Electrical Energy Requirements for Manufacturing Processes. In: Proceedings of the 13th CIRP Int. Conf. on Life Cycle Engineering, 2006.

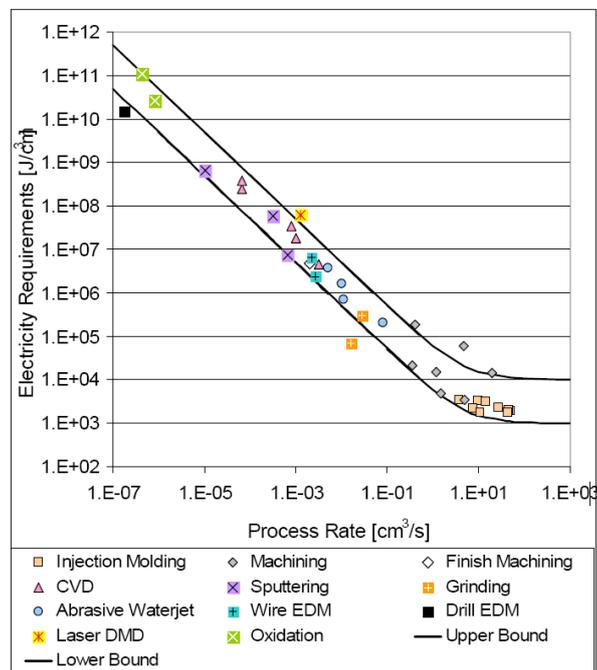


Figure 3-6: Specific electricity requirements for various manufacturing processes as a function of the rate of material processed (Source: Gutowski et al)

The scope of the ISO/TC39/WG12 Environmental evaluation of machine tools is the definition of the environmental performance of machine tools regarding design, use and end of life phases. Based on a list of positive environmental features which can be built into a machine tool, the performance of this product shall be evaluated to quantify the environmental improvements achieved over a defined period. The project will take care of environmental impacts like energy consumption, CO₂ output, materials used, and operating materials and precision tools during the use phase. Besides the design and engineering of machine tools also the utilization of these products will be addressed in this project¹⁹.

3.1.2 Wood working machine tools

Although the wood working branch was invited to participate in the survey among users and manufacturers of machine tools and related machinery there was not sufficient feedback from this sector for a statistical evaluation. Anecdotally it is confirmed, that

¹⁹ Hagemann, D.: Stakeholder meeting Lot 5 EuP. Status of ISO/TC39/WG12. 02.07.2010

manufacturer of wood working machinery typically provide information on the technical specification, maintenance instructions and about spare parts availability, but not on environmental performance criteria or disposal instructions.

Resource efficiency has been one of the focal topics at the 2009 LIGNA trade fair, but refers rather to increasing productivity for on-site wood harvesting and technologies to minimize the resource consumption for furniture and other wood products rather than to the efficiency of the machinery as such.

There is no known joint marketing initiative for eco-efficient wood working machinery similar to the Blue Competence initiative for the metal working sector. However, there is a moderate tendency among individual manufacturers of wood working machinery to promote particularly energy efficient equipment, such as manufacturer Holzma, presenting their ecoLine technology for cutting processes in 2009.

▪ **Environmental requirements in purchase specifications**

Only very occasionally there are dedicated environmental purchase specifications – beyond legal compliance aspects - for wood working machinery. In the wood working and furniture manufacturing branch one of the examples where at least on a general level environmental aspects are specified is IKEA's IWAY standard "Minimum Requirements for Environment and Social & Working Conditions when Purchasing Products, Materials and Services"²⁰: This standard specifies, which criteria have to be met by suppliers of IKEA, i.e. the users of wood working machinery. Although it is an obligation to pass down these IWAY requirements also to sub-suppliers, those who "provide production equipment e.g. machinery or tools" are explicitly excluded from this requirement. However, there is a generic requirement to reduce environmental impacts of production constantly, including energy consumption: Suppliers "shall measure and record energy consumption for all buildings and processes. Targets for reductions shall be set annually." This requirement might be met by investing in energy efficient equipment, including wood working machinery. Furthermore, IKEA provides long-term strategic support for suppliers including²¹:

- Technical consultations to master new product-technology

²⁰ IKEA Supply AG: IWAY standard - Minimum Requirements for Environment and Social & Working Conditions when Purchasing Products, Materials and Services, edition 4, 2008

²¹ Ivarsson, I.; Alvstam, C.G.: Supplier Upgrading in the Home-furnishing Value Chain: An Empirical Study of IKEA's Sourcing in China and South East Asia, World Development, Volume 38, Issue 11, November 2010, pp. 1575-1587

- Provision, advice or financial assistance to obtain machinery and equipment
- Technical consultations to master new production-technology

As the major supplier basis of IKEA is in Europe, these supply chain requirements have a particular impact on a few hundred enterprises in the wood working branch in Poland, Italy, Sweden and Germany²².

3.1.3 Welding, soldering and brazing equipment

The growing need to pay attention to the energy consumption of most processing methods including thermal joining processes is shown in figure 3-7. It is obvious that most parts of the introduced overall performance are not used for the actual processing (e.g. heating to melting temperature T_S or fusing).

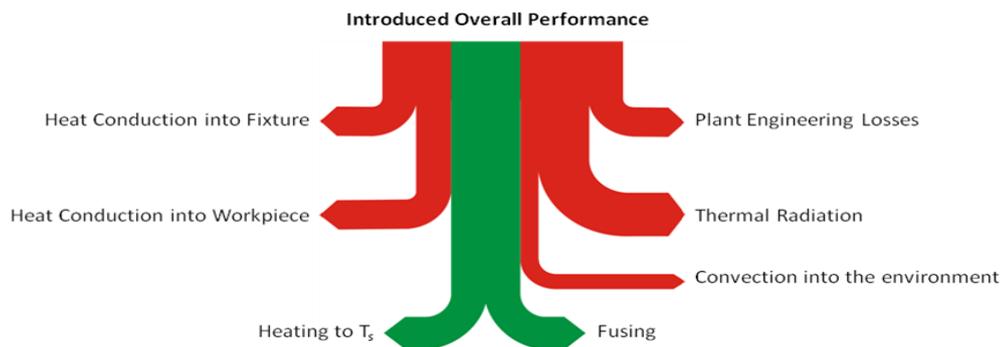


Figure 3-7: Thermal joining process

Some manufacturers of welding equipment promote environmental aspects of their products actively, pointing out e.g. energy efficiency and power factor correction²³ or following an approach called “Green Automation”, which is meant to allow in particular a much more efficient welding and cutting through robotics²⁴.

²² In 2009, almost two-thirds of IKEA’s global purchasing was in Europe. The top countries included Poland (18%), Italy (8%), Germany (6%) and Sweden (5%) according to IKEA, Facts and figures 2009. Total number of suppliers was 1,220 worldwide, a significant share of this likely to come from the wood working sector.

²³ See ESAB: Produktkatalog, 2010, www.esab.de/de/de/support/upload/Produktkatalog_PE_2010.pdf

²⁴ See Reis Robotics: Reis Robotics engagiert sich für Umweltschonung, press release May 10, 2010, <http://www.reisrobotics.cz>

Manuals for transportable units typically address worker safety aspects at length, including noise, fume emissions, electric shock and arc rays etc. As smaller non-stationary units fall under the WEEE directive disposal advices are given in the manuals. Stated technical data relevant for the environmental performance of the welding equipment typically are²⁵ (but not stated by all manufacturers in their manuals)

- Power factor at maximum current
- Efficiency at maximum current
- Constant A-weighted sound pressure

Anecdotally, there are some examples of closer B2B interaction to increase eco-efficiency of welding operations, such as Thermancut's refund and recycling system for used tungsten-based plasma cutting nozzles, which is economically motivated, but promoted as a measure for resource efficiency as well²⁶.

Looking at the German language daily journal of the 2009 "Schweißen & Schneiden" trade fair it is evident, that welding equipment and components are very occasionally promoted with pointing out the resource efficiency of a given product, which is typically related to higher productivity and better yield rates, but also material-reduced nozzles²⁷. Energy efficiency is occasionally a promotional argument for selling welding power sources. As the core business of some enterprises are the consumables – corresponding with the customers welding costs - and the equipment is just an add-on business also the marketing focuses on efficient use of consumables, tools and parts.

3.1.4 Other machine tools

Given the fact, that other machine tools cover a broader spectrum of machines, partly niche markets, the user perspective can hardly be generalized. For some of the other machine tools the industrial worker is the typical user, such as glass and ceramics working machine tools. Stone working machine tools are used by both, industrial enterprises and in the construction sector, where craftsmen are among the users.

²⁵ See for example: ESAB Instruction manual, Arc 150i / Arc 200i, Origot A32, 0459 261 227

²⁶ Gießler, S.: Thermancut - Verdreifachte Standzeiten von Plasmaschneiddüsen, Welding and Cutting Today, September 19, 2009

²⁷ Trommer, G.: Fronius - Verschleißbedingte Einflüsse im Kontaktröhr beim MIG/MAG-Schweißen kontrollieren, Welding and Cutting Today, September 19, 2009

In the ceramics and glass processing industry energy is a highly relevant cost category, but this is related rather to other types of machinery, namely for glass melting and ceramics sintering ovens. See also the parallel DG ENTR Lot 4 Preparatory Study on Industrial and Laboratory Furnaces and Ovens²⁸.

For other machine tools used in industrial environments technical performance, such as throughput, i.e. productivity is of highest priority when deciding for a machine.

Other machine tools used in the construction sector, such as stone saws have to be very robust and durable when being used on-site, but also mobile. Safety aspects of such equipment used on construction sites is similarly important.

Instruction manuals for such smaller units typically include installation and operation instructions, safety guidelines, advice regarding suitable tools to be used with this machine and frequently also a components list and explosion drawing to facilitate repair and spare parts ordering.

3.2 User requirements in the use phase

As has been stated earlier in the report, it is expected that the energy related costs will increase considerably in relation to the total annual costs of producing companies²⁹. This trend is likely to draw more and more attention to energy saving measures. A calculation by AUDI for example compares the relation of energy costs for a transfer line and a table machine with tool costs while machining a swivel bearing. It is assumed that costs for electrical energy during primary processing time, down time and idle time as well as costs for pressurized air outperform tool costs of 0.19 € with 0.20 € of the table machine and 0.28 € with the transfer line³⁰. Energy saving measures are going to be more important in general and especially in the German machine tool sector in

²⁸ Reports for download at <http://www.eco-furnace.org/>

²⁹http://www.karlsruhe.ihk.de/produktmarken/innovation/Verborgene_Dateien_Innovation_und_Umwelt/Anlagen_Innovation_und_Umwelt/Umwelt/Energiepreise_und_Unternehmensentwicklung_in_Baden-Wuerttemberg.pdf. Access on 01/06/2010.

³⁰ E. Abele: Rahmenbedingungen und Lösungen für eine nachhaltige Fertigungstechnik. Proceedings of Symposium „Die energieeffiziente Werkzeugmaschine“ METAV Fair 2010, 24 February.

metal working production. The energy demand of these machines is estimated to be 15 % of the whole electric power consumption in Germany³¹.

The following figure underlines the percentage of energy costs of the value of manufactured goods for the production industry³².

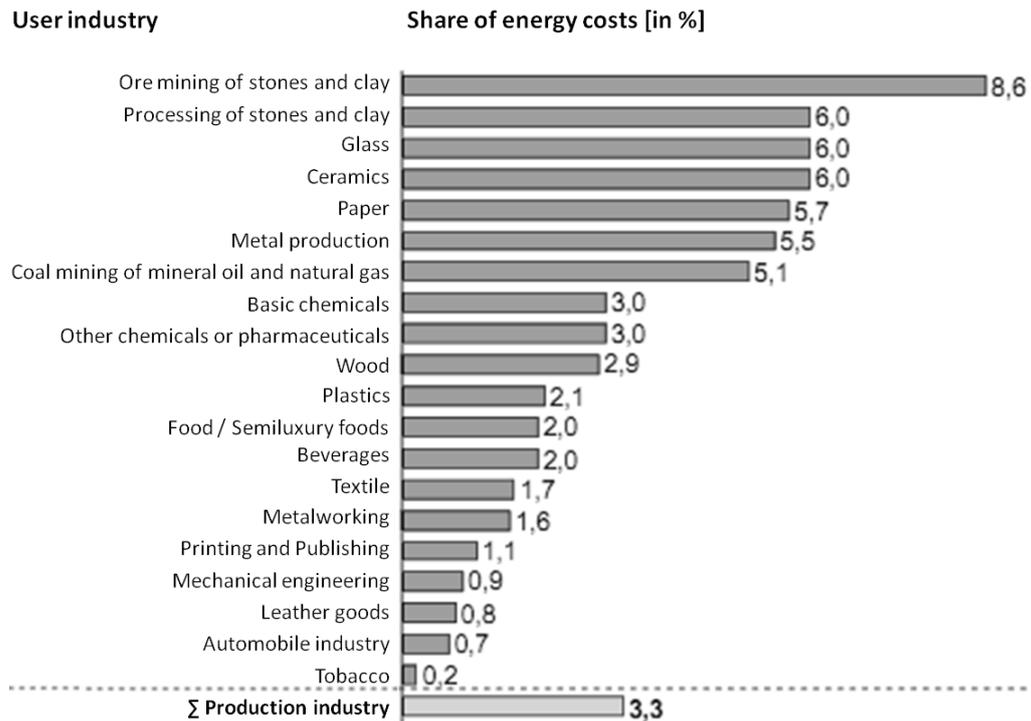


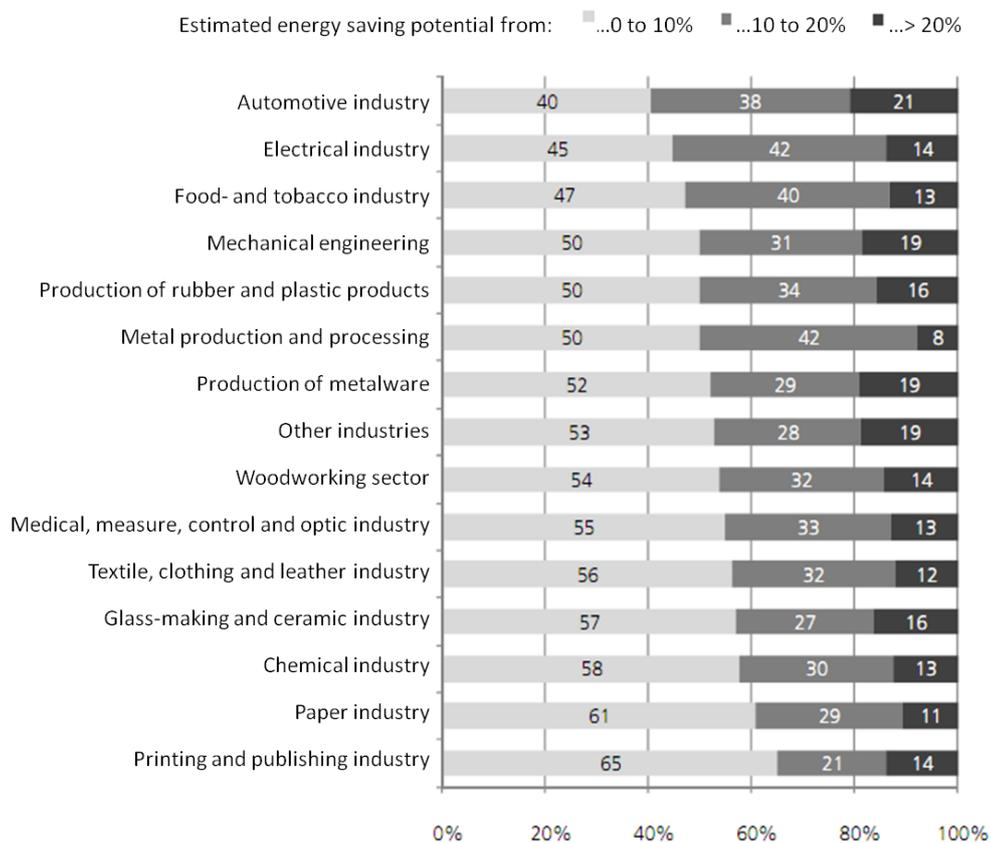
Figure 3-7: Share of energy costs in the production industry

In addition, according to a study undertaken by Thamling et al., the importance of energy efficiency is positively correlated with the company's size. The larger the company's size, the higher the significance of energy efficiency. Moreover, Thamling et al. state that especially bigger and more energy-intensive companies realize energy saving measures or see great potential in doing so. The reasons for implementing energy saving measures are to 93 % the reduction of energy costs and only to 21 % the opti-

³¹ Kuttkat, B.: Energiesparföhche sind am Werk. Sonderausgabe Maschinenmarkt METAV Journal 2010, p. 24-26

³² Henzelmann, T., Büchele, R.: Der Beitrag des Maschinen- und Anlagenbaus zur Energieeffizienz. Report of Roland Berger Strategy Consultants on behalf of VDMA, 2009

mization of processes and production³³. About 50 % of companies in mechanical engineering consider regardless of the size of the company the potential for energy savings in the production to at least 10 % (Figure 3-8). Mechanical engineering is thus in the first third of manufacturing firms that see a very high potential to reduce energy costs. Other branches of manufacturing industry that use machine tools see some significant energy savings potentials as well. The most energy-intensive companies, such as the chemical, glass and ceramic industry and the pulp, paper, printing and publishing industry, which mostly use a much smaller amount of machine tools, represent the last third in the survey. They see little or no energy saving potentials³⁴.



³³ Thamling, N.; Seefeldt, F.; Glöckner, U.: Rolle und Bedeutung von Energieeffizienz und Energiedienstleistungen in KMU. Report of Prognos AG on behalf of the KfW Bankengruppe, Berlin, 05/02/2010.

³⁴ Schröter, M.; Weißfloch, U.; Buschak, D.: Energieeffizienz in der Produktion –Wunsch oder Wirklichkeit? Energieeinsparpotenziale und Verbreitungsgrad energieeffizienter Techniken. In: Modernisierung der Produktion. Mitteilungen aus der ISI-Erhebung 51 (2009)

Figure 3-8: Energy saving potentials in the production industry

Furthermore, it is also stated that 61 % of asked companies realized energy saving measures in general in the last three years. 26 % of these companies are currently implementing energy saving measures. In total, 87 % of the surveyed companies were or are realizing those measures including not only in the production but also heating systems and insulation of buildings³⁵. It has to be mentioned that the highest potential in energy saving and in implementing energy saving measures is to be seen in the range of water heating systems, heating systems in general and insulation of buildings. These results however were essentially lower in the production and assembly (see figure 3-9)³⁶.

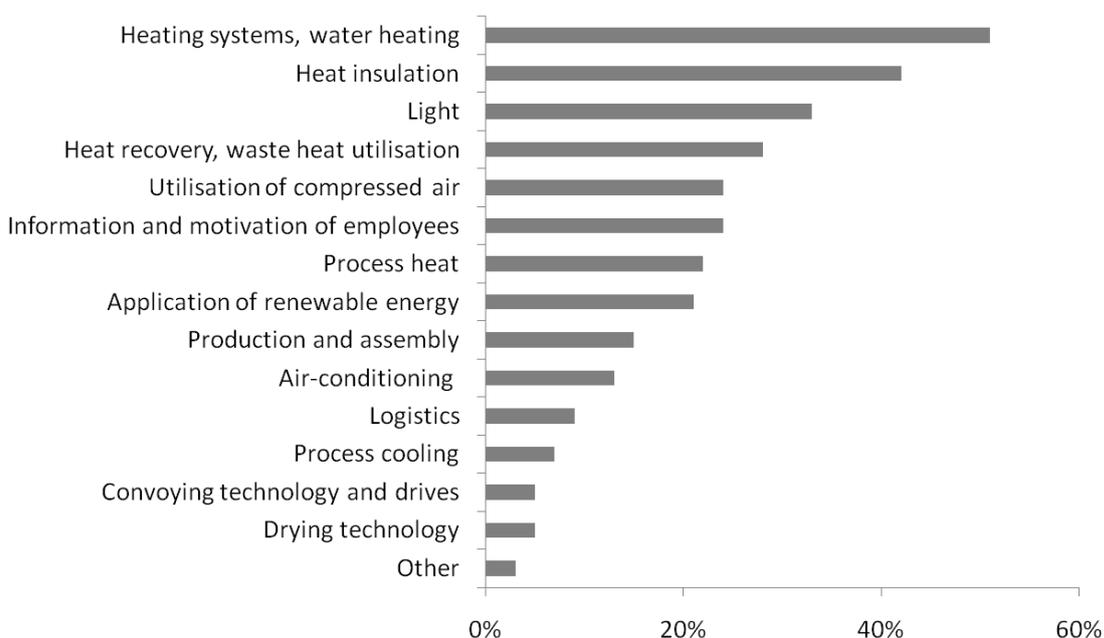


Figure 3-9: Realized implementation of energy saving measures, ordered by sectors

³⁵ Thamling, N.; Seefeldt, F.; Glöckner, U.: Rolle und Bedeutung von Energieeffizienz und Energiedienstleistungen in KMU. Report of Prognos AG on behalf of the KfW Bankengruppe, Berlin, 05/02/2010.

³⁶ Thamling, N.; Seefeldt, F.; Glöckner, U.: Rolle und Bedeutung von Energieeffizienz und Energiedienstleistungen in KMU. Report of Prognos AG on behalf of the KfW Bankengruppe, Berlin, 05/02/2010.

3.2.1 Metal working machine tools

- **Energy efficiency**

The survey of this study supports the statements of Thamling et al. It reveals that for 87.5 % of manufacturers the energy consumption of designed metal working machine tools is relevant and for 62.5 % the energy consumption of machine tool production. The results show further that 83.3 % intend to plan measures to diminish energy consumption of designed machine tools and 71.4 % of the machine tool production. 85.7 % of machine tool manufacturers claim to already offer energy saving modes and modules such as sleep and stand-by modes or the use of synchronous motors (see Task 4 “Best Available Technology”). However, only 7.2 % of customers actually demand energy saving modes or modules.

Table 3-3: Energy consumption of machine tools

	Yes	No
Is the energy consumption of designed machine tools relevant?	87,5 %	12,5 %
Is the energy consumption of the machine tool production relevant?	62,5 %	37,5 %
Does your company plan measures to diminish energy consumption of designed machine tools?	83,3 %	16,6 %
Does your company plan measures to diminish energy consumption of the machine tool production?	71,4 %	28,6 %
Does your company offer energy saving modes or modules of designed machine tools?	85,7 %	14,3 %

The difference between the offered energy saving modules and the demand is founded in the structure of the relevant customer branch. Over 55 % of the costumers of the metal working machine tools are automobile manufacturers or suppliers³⁷. Additionally, more than 90 % of the companies of that branch are SME³⁸. Here, the actual energy saving of machine tools is not relevant (see table 3-9).

³⁷ VDW: “Die deutsche Werkzeugmaschinenindustrie im Jahr 2009.“ Annual Report of the German Machine Tool Builder Association (VDW), 2010

³⁸ Personal Information of Mr. A. v. Gersdorff, Press Office of the German Association of the Automotive Industry (VDA), 15/12/2010

Complementary to these numbers, the energy saving potential of German machinery and plant products is presented in a survey conducted by Roland Berger Strategy Consultants. According to manufacturers, 56 % of efficiency improvement will be realized through existing technologies and 44 % through new technologies. Similar numbers can be found in the machine tool sector³⁹, where 54 % of energy saving will be realized through already available technologies and 46 % through new ones. The use of energy efficient technologies for machinery and plants will increase by 27 % from 40 % to 67 % in the next ten years. Taking centre stage in this process will be the further development and improvement of existing technologies and their implementation. Therefore, the average possible energy efficiency improvement in the production industry will slightly increase⁴⁰.

When looking at the use phase of machine tools energy consumption has to be seen in close relation to productivity, availability and/or accuracy. The following example explains this matter in more detail: The comparison of a conventional turning lathe from 30 years ago to a today's numerical controlled turning centre shows that the weight of both machines is practically the same but the energy consumption of the modern machine is about 10 times higher. It should be clearly recognized that modern machine's productivity is 20 times higher in comparison to older models. Further, it has to be considered that a much higher productivity reduces also the energy consumption of the production facility for heating, air conditioning and lighting per produced unit. Even though most manufacturers apply energy saving measures, it can be stated that in the course of time the energy consumption of a single machine tool is continuously increasing. Nevertheless, the energy consumption *per produced unit* is significantly reduced.⁴¹

▪ **Materials and resource efficiency**

Additionally to energy consumption, the consumption of resources is important. Thus, every manufacturer stated within the survey of this study that resource consumption of machine tools (e.g. lubrication) is relevant and 87.5 % declare the relevance of resource consumption of the machine tool production (e.g. waste material).

³⁹ Henzelmann, T. et al. presumably refer to the metal working machine tools sector with this statement

⁴⁰ Henzelmann, T., Büchele, R.: Der Beitrag des Maschinen- und Anlagenbaus zur Energieeffizienz. Report of Roland Berger Strategy Consultants on behalf of VDMA, 2009

⁴¹ Expert opinion of a machine tools manufacturing stakeholder

- **Real life use patterns**

There are various reasons why machine tools are frequently not shut off at the end of a shift: One reason is to ensure thermal steady-state conditions with a specific thermal strain, which is very important for high accuracy of metal working machine tools, complex products and work pieces. Overnight shut off or other periods of non-operation of machine tools could result in processing temperatures to fall below desirable levels, and thus having an adverse impact on the process and manufacturing precision. Thus many users do not turn the machines off, keeping them in operational mode overnight to hold the thermal strain “constant” and to avoid lengthy start up times in the morning to bring the machines back to stable process conditions. In this example both aims, energy efficiency and accuracy, are contradictory to each other. On the other hand, this example also shows the playing field for eco-design. Fast reactivation technologies could lead to low power standby for machines. By that considerable energy savings could be realized as other industries (e.g. printing) as shown in past few years.

We have already touched the issue of measurement and comparison of energy consumption. A calculation of energy used as a function of material removal rate for a 3-axis milling machine is given in Figure 3-10.⁴² So the amount of electrical energy consumed without manufacturing remains constant, which is at least one third of the total used energy during maximum machining load.

⁴² Kordonowy, D.N.: A Power Assessment of Machining Tools, Massachusetts Institute of Technology, B.S. Thesis, Department of Mechanical Engineering, Cambridge, MA, USA.

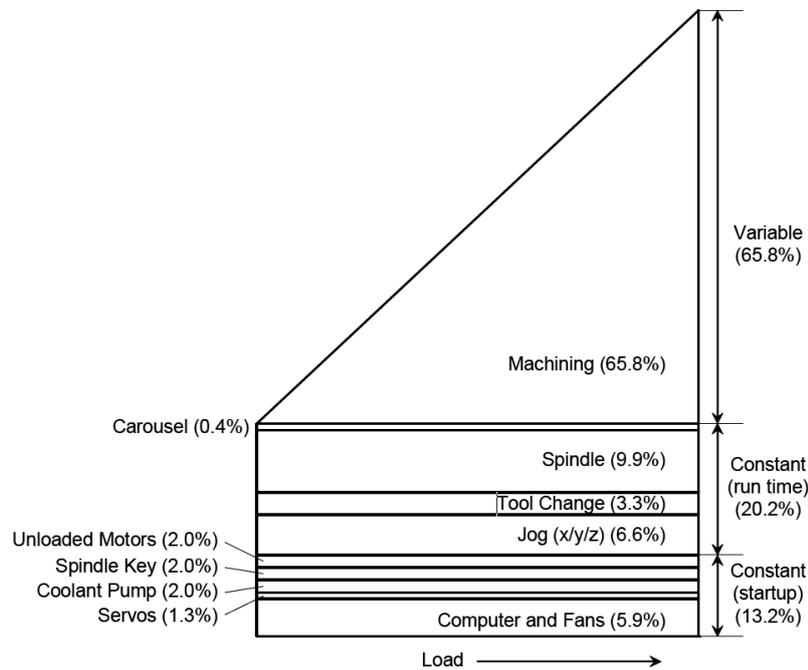


Figure 3-10: Energy used as a function of production rate for a 3-axis CNC milling machine⁹

The evaluation of “typical” use patterns are challenging due to the very different machining cycles in manufacturing processes. In automotive industry machine tools are deployed for 24 hours a day, whereas in workshops operational times of 8 hours a day with intermitting operation cycles are typical. Thus, the broad spectrum of use patterns includes one or more shifts operation and permanent or occasional usage.

Very expensive machine tools are likely to be operated close to maximum capacity to allow for a timely Return-on-Investment (ROI), unless the machine tool is intended to be used for very specific tasks, which mean a high added value for the work piece. In this case even for a very costly machine tool occasional use might be the case.

Machine tools for mass production or for very large and/or for complex work pieces are working in five-shift-operation (24 hours at seven days a week). An opposing example is simple vertical drilling machines. These machines are operated often only for a few minutes a day.

The UK Manufacturing Technologies Association (MTA) estimated the typical annual operating hours for metal working machine tools, making a distinction between “small”,

“medium” and “large” machine tools⁴³ as stated in Table 3-4. “Large” machine tools are, for example, machining centres. Annual operating hours of 4.416 roughly correspond with a two-shift pattern of operation. Smaller machine tools, which also cover the non-CNC range, are stated as having 1,820 annual operating hours, which is a little more than a 1-shift operation.

Table 3-4: Metal working machine tool annual operating hours (source: MTA)

Size	Hours per annum.
Small	1,820
Medium	2,897
Large	4,416

Another important aspect for determining use patterns for metal working machine tools are the type of batch production: large-batches typically mean a high share of productive time, whereas the share of set-up times and tool change times increases with smaller batch sizes. Kührke⁴⁴ states some typical profiles for usage of machine tools, meant to be used for calculating usage scenarios (see Table 3-5).

Table 3-5: Production type related time-split of metal working machine tools usage

	Lot size	operational	idle	standby	set-up time, tool change
single-part production	1 ... 10	40 %	5 %	20 %	35 %
small-batch production	10 ... 100	55 %	10 %	15 %	20 %
Medium-sized batch production	100 ... 1,000	63 %	3 %	27 %	7 %
large-batch production	1,000 ... 10,000	70 %	3 %	23 %	4 %

This range of use patterns has to be considered in the definition of base cases for the environmental assessments in task 4 of this study. Moreover, it has to be considered, that under real life conditions for the sake of thermal stability metal working machine tools might run in operational mode during free shifts without processing any work piece. Here, thermal compensation via CNC might be needed to reduce energetic effort.

⁴³ SKM Enviro: Estimating the Energy Saving Potential from Small Motors and Machine Tools, Report on Machine Tools Research & Modelling, 11 July 2011, p.19

⁴⁴ Kührke, B.: Ansätze zur Optimierung und Bewertung des Energieverbrauchs von Werkzeugmaschinen, Proceedings of Symposium „Die energieeffiziente Werkzeugmaschine“ METAV Fair 2010, 24 February

Table 3-5 displays typical assumed use patterns for selected machine tools categories. 50 % of the most relevant machine tools are used without switching-off during idle time and so energy is wasted with basic load.

Table 3-6: Use patterns for selected types of metal working machine tools

PRODCOM Code	Label	Use patterns				
		Workshop	Industrial plant	1 or 2 shifts	3 & more shifts	Switch-off
28412235	Non-numerically controlled drilling machines for working metal (excluding way-type unit head machines)	y	n	y	n	y
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	y	y	y	y	n
28412470	Sawing or cutting-off machines for working metal	y	n	y	n	y
28411220	Horizontal machining centres for working metal	y	y	y	y	n
28412223	Numerically controlled tool-milling machines for working metal (excluding boring-milling machines, knee-type machines)	y	y	y	y	n
28412395	Machines for deburring or polishing metal (excluding gear finishing machines)	y	y	y	y	y
28412375	Non-numerically controlled sharpening (tool or cutter grinding) machines for working metal	y	n	y	n	y
28412490	Planing, shaping or slotting machines and other machine-tools working by removing metal or cermets, n.e.c.	y	y	y	y	n
28413160	Non-numerically controlled bending, folding, straightening or flattening machines for working flat metal products (including presses)	y	n	y	n	y

▪ **Maintenance and repair**

Maintenance and repair practice depend on failure modes. Typical failures of metal working machine tools are as follows⁴⁵:

- Drive axes (38 %)
- Spindle and tool changer (26 %)
- Electronics (23 %)
- Fluidics (13 %)

⁴⁵ Fleischer, J., Schopp, M., Broos, A., Wieser, J., 2007, Datenbasis für lastabhängige Prozesseingriffe – Modularisierung und Analyse von Ausfallursachen zur Erhöhung der Verfügbarkeit von Werkzeugmaschinen. wt Werkstattstechnik online, Jahrgang, 97/H.7/8: 491–497.

The resulting repair cycles and expenses need to be investigated. In some cases failures might not even lead to repair, but disposal of equipment. For example, 20-year old machines run with 20-years old electronics assemblies, which might not be available on the market anymore. Meaning, instead of repairing the whole machine tool or major parts the machine would be scrapped.

3.2.2 Wood working machine tools

Table 3-7 displays typical assumed use patterns for selected wood working machine tools categories.

Table 3-7: Use patterns for selected types of wood working machine tools

PRODCOM Code	Label	Use patterns				
		Workshop	Industrial plant	1 or 2 shifts	3 & more shifts	Switch-off
28491233	Band saws for working wood, cork, bone and hard rubber, hard plastics or similar hard materials	y	y	y	n	y
28491263	Grinding, sanding or polishing machines for working wood, cork, bone, hard rubber, hard plastics or similar hard materials	y	y	y	n	y
28491279	Machine tools for working wood, cork, bone, hard rubber, hard plastics or similar hard materials, etc.	y	y	y	n	n
28491237	Sawing machines for working wood, cork, bone, hard rubber, hard plastics or similar hard materials (excluding band saws, circular saws)	y	n	y	n	y
28491235	Circular saws for working wood, cork, bone, hard rubber, hard plastics or similar hard materials	y	y	y	n	y
28491250	Planning, milling or moulding (by cutting) machines for working wood, cork, bone, hard rubber, hard plastics or similar hard materials	y	y	y	y	n
28491287	Presses for the manufacture of particle board or fibre building board of wood or other ligneous materials, and other machines with individual functions for treating wood or cork	y	y	y	y	y

3.2.3 Welding, soldering and brazing equipment

Welding, soldering and brazing equipment is rather used as auxiliary equipment. Hence the actual usage times are typically much lower than working shifts. According to an expert's estimate⁴⁶ hours in productive operation per working day are roughly as stated in Table 3-8 (allocation to PRODCOM categories).

⁴⁶ P. Couderc, Air Liquide

Table 3-8: Use patterns and characteristics of welding, soldering and brazing equipment

PRODCOM Code	Label	CNC controlled yes/no	average use scenario: hours in productive operation per working day
27903118	Electric brazing or soldering machines and apparatus (excluding soldering irons and guns)	Yes	8h
27903145	Electric machines and apparatus for resistance welding of metal	No	8h
27903154	Fully or partly automatic electric machines for arc welding of metals (including plasma arc)	No	2h
27903163	Other for manual welding with coated electrodes	No	1h
27903172	Other shielded arc welding	No	1h
27903181	Machines and apparatus for welding or spraying of metals, etc.	Yes	5h
27903190	Machines and apparatus for resistance welding of plastics	Yes	5h
27903199	Machines and apparatus for welding (excluding for resistance welding of plastics, for arc and plasma arc welding, for treating metals)	Yes	5h
28297090	Machinery and apparatus for soldering, brazing, welding or surface tempering (excluding hand-held blow pipes and electric machines and apparatus)	Yes	5h

In the specific segment of soldering equipment for printed circuit board assembly⁴⁷ similar observations are made as for metal working machine tools: Although manufacturers offer energy saving modules and features, such as power management, this is rarely asked for when purchasing decisions are made⁴⁸. On the other hand, there are (few) assemblers considering in particular following aspects when specifying and purchasing equipment⁴⁹:

Generic requirements:

- Energy efficient machinery controls such as

⁴⁷ this industry typically uses soldering ovens (reflow, wave, induction ovens) , which are considered to be covered under the Product Group Study Lot 4 - Industrial and Laboratory Furnaces and Ovens, www.eco-furnace.org

⁴⁸ Friedrich, J. at Expertenforum SMT Hybrid Packaging 2010, Nissen, N.F.; Friedrich, J.; Husemann, J.: Energieeffizienz in der Baugruppenfertigung – June 10, 2010

⁴⁹ Husemann, J. at Expertenforum SMT Hybrid Packaging 2010, Nissen, N.F.; Friedrich, J.; Husemann, J.: Energieeffizienz in der Baugruppenfertigung – June 10, 2010

- Static power management
- Dynamic / smart power management

Requirements specific to SMD (surface mount devices) assembly:

- Housing of machinery (reducing heat losses)
- Optimized heat transfer
- Specifying machine design according to contact pad geometries
- Selection of optimal technology for a given soldering task / adaptation to the products to be soldered

This list of requirements indicates, that for the printed circuit board assembly industry among the specific requirements oven related aspects dominate.

3.2.4 Other machine tools

The ceramics industry, where cutting tools are used, is characterized by a rather large share of energy costs (see Figure 3-7, p. 22). This is due to the thermal oven processes applied in this industry, and not related to the machine tools used in this sector.

Table 3-9 displays typical assumed use patterns for selected machine tools categories.

Table 3-9: Use patterns for selected types of other machine tools

PRODCOM Code	Label					
		Workshop	Industrial plant	1 or 2 shifts	3 & more shifts	Switch-off
28951140	Other cutting machines for paper or paperboard	y	y	y	y	n
28491170	Machine-tools for working stone, ceramics, concrete, asbestos-cement or like mineral materials or for cold working glass (excluding sawing machines, grinding or polishing machines)	y	y	y	n	n
28491130	Sawing machines for working stone, ceramics, concrete, asbestos-cement or like mineral materials or for cold working glass	y	y	y	n	n

3.3 End-of-Life behaviour

Due to the B2B characteristics of this product group it can be assumed, that disposal of end-of-life machine tools largely happens under well controlled and state-of-the art

conditions. Furthermore, most of the machine parts represent a remarkable intrinsic value due to the scrap metal values, so high down-stream recycling quotas can be anticipated. However, this has to be verified. Under certain circumstances recycling might be hindered by contaminations (for illustration: semiconductor manufacturing equipment sometimes has to be treated as hazardous waste due to inflammable gases diffusing into metal parts and being released over time, but in explosive concentrations).

▪ **Retrofitting cycles and end-of-life**

A survey of the German Machine Tool Builders' Association (VDW)⁵⁰ unveils the conditions of retrofitting⁵¹ and refurbishment⁵² measures of the most top-selling machine tool companies. According to Figure 3-11 this survey covers mainly machine tools for cutting purposes with medium or large dimensions. It has to be considered that refurbishing and retrofitting costs of machine tools with small dimensions compared to the investment costs are in percent higher. So, the overhaul of that category of machines is energetically and economically of less interest compared to machine tools with medium and high dimensions.

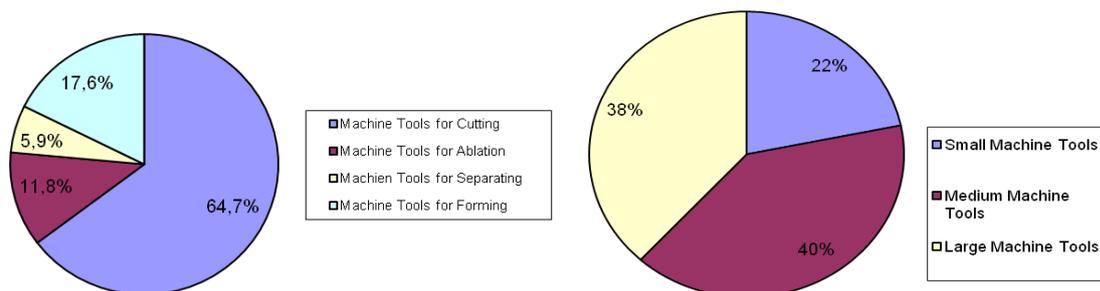


Figure 3-11: Survey among machine tools users: Machine tool purpose (left), Machine tool size (right)

⁵⁰ Personal Information of Mr. Detlef Hagemann, Systems Engineering and Automation of the VDW, 09/03/2010.

⁵¹ Modifying existing equipment or structures with additional or new components or members [http://www.businessdictionary.com/definition/retrofitting.html]

⁵² Servicing and/or renovation of older or damaged equipment to bring it to a workable or better looking condition. Refurbished goods are of older model and usually in worse condition than reconditioned goods. [http://www.businessdictionary.com/definition/refurbishing.html]

The machine tools' age at first retrofitting/refurbishment measures is mainly between 5 and ten years. 80 % of the machine tools are retrofitted and refurbished between 5 years and 15 years as to be seen in Figure 3-12.

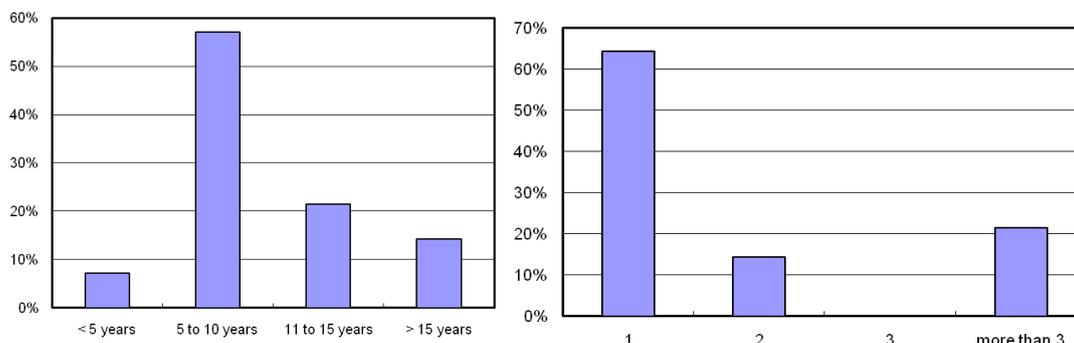


Figure 3-12: Survey among machine tools users on retrofitting/refurbishment: Age of first measures (left), Number of cycles (right)

End of life of a machine tool is reached after at least ten years (Figure 3-13):

- 55 % of the machine tools have a maximum life span of 25 years.
- 45 % of the machine tools have a life span of more than 25 years,

Average amortization time is eight years with a range of five to ten years of amortisation period for survey related CNC controlled machines tools⁵³.

As measures for retrofitting/refurbishment the mechanical and electrical maintenance is dominating. Renewal and extension are of secondary importance.

⁵³ <http://www.urbs.de/afa/change.htm?afa101.htm>. Access on 07/05/2010.

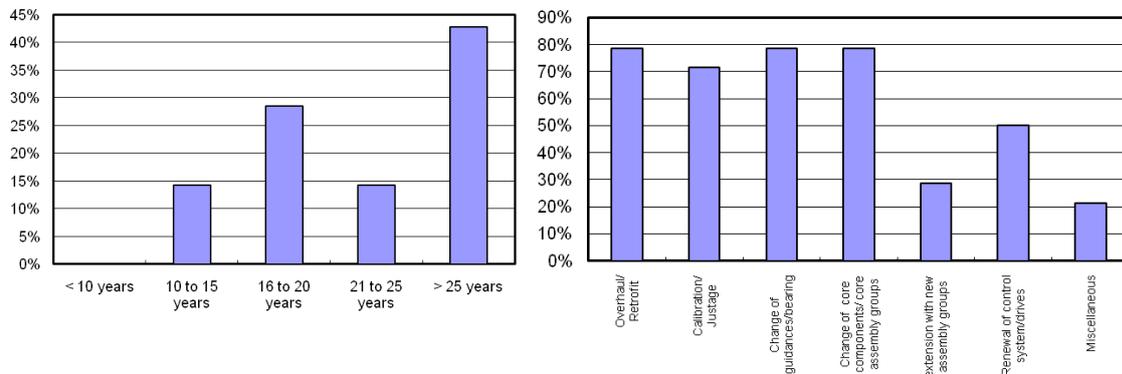


Figure 3-13: Survey among machine tools users: Age of machine tool run-out (left), Retrofitting/refurbishment measures in detail (right)

62.5 % of the companies of the study provide ecological information which mainly concerns the recycling of machine components. To realize the recycling of machine components, machine tool manufacturers mainly apply recyclable materials.⁵⁴

▪ **Third country exports**

In 2003 a study for the German Council for Sustainable Development stated⁵⁵: “The transfer of second-hand machinery and equipment has now evolved to become an important business sector - almost unnoticed. Enterprises in developing countries and emerging markets have recognized that second-hand machinery and equipment from industrialized countries represent a low-cost and fast solution to the problem of replacing outdated machinery and/or building up new capacities. At the same time machinery dealers from industrialized countries have discovered the market gap and are now extremely active in this field. The import of second-hand goods in the machinery and equipment sector has therefore become a daily reality in developing countries and emerging markets. At the time the study was published, the proportion accounted for by second-hand machinery in the total sales of machinery in Germany was estimated by experts to be 3 to 5 %. For wood working machines, machine tools or machinery for plastics 15 % and more are stated, including domestic sales and abroad. Although

⁵⁴ Questionnaire result

⁵⁵ Janischweski, J.; Henzler, M. P.; Kahlenborn, W.: The Export of Second-Hand Goods and the Transfer of Technology – An Obstacle to Sustainable Development in Developing Countries and Emerging Markets? May 2003

second-hand machinery in many regions might be the only affordable solution to ramp up production, the implications are as follows:

- Life time of machinery of low efficiency is extended, resulting in proportionally higher power consumption in the destination countries
- Once the machine tools reach their end-of-life controlled disposal of the very minor amount of potentially critical components is questionable.