Energy-Using Product Group Analysis - Lot 5

Machine tools and related machinery

Executive Summary – Final Version

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

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Executive Summary

Introduction

This Executive Summary covers an EC Product Group Study related to the Ecodesign of Energy-related Products (ErP) Directive 2009/125/EC (recast of the former EuP Directive 2005/32/EC) for ENTR Lot 5 Machine Tools and Related Machinery. This study has been contracted to Fraunhofer-Institut für Zuverlässigkeit und Mikrointegration (IZM) and Fraunhofer-Institut für Produktionsanlagen und Konstruktionstechnik (IPK).

This product group study aims to identify and recommend ways to improve the environmental performance of these energy-using products throughout their lifetime at their design phase based on the European Commission Methodology for Ecodesign of Energy-using Products (MEEuP). The information provided by the study will be used to prepare for subsequent phases, including undertaking an impact assessment on policy options and to prepare a paper for the consultation of the forum. Those phases are to be carried out by the European Commission.

Task reports are published at www.ecomachinetools.eu .

Main Findings

TASK 1 – DEFINITION

As there is a limited common understanding of a machine tool and as also standards and legislation do not provide an unambiguous definition of "machine tools", this study had to come up with a "machine tools" definition. This definition has been based on the engineering consideration that cutting, shaping and joining are typically those technologies employed by machine tools, together with economic classifications, standards on process technologies, and taking into account the existing legal framework (the Machinery Directive, 2006/42/EC). Hence, the definition proposed is as follows:

A machine tool is a stationary or transportable assembly, which is neither portable by hand nor mobile, and which is dependent on energy input (such as electricity from the grid or stand-alone / back-up power sources, hydraulic or pneumatic power supply, but not solely manually operated) when in operation, and consists of linked parts or components, at least one of which moves, and which are joined together for a specific application, which is the geometric shaping of workpieces made of arbitrary materials using appropriate tools and forming, cutting, physico-chemical processing or joining *technologies, the use of which results in a product of defined reproducible geometry, and intended for professional use.*

Examples of machine tools comprise those for separating/ cutting and forming of metals, including those using a laser beam, ultrasonic waves, plasma arc, magnetic pulse, electrolytic etching, etc., or for turning, drilling, milling, shaping, planing, boring, grinding etc., for soldering, brazing, or welding. Further examples are detailed in the Task 1 report.

Explicitly, machine tools for processing a variety of materials are covered, not only metal working machine tools, i.e. also wood working ones and those for other rigid materials such stones, plastics, glass etc. and welding equipment.

The scope of this study covers also “related machinery” which is *machinery for professional use, which contains components and modules of other machinery, which are similar to those used in machine tools.* In order to be clear, these components and modules might be used in machines which do not fall under the definition of machine tools as provided above.

This broader scope is meant to identify potentially a wider environmental improvement potential in industrial production than only with a focus on machine tools as such.

It is intended to follow a modular approach (i.e. machine modules) in the following environmental analysis, taking the machine tools as the starting point, but also covering through this modular approach other (“related”) machinery.

There are numerous standards which exist for machine tools, covering safety aspects. In Europe, a large number of these standards are implemented through the machinery directive (2006/42/EC). With respect to environmental aspects of machine tools there are only very few relevant standards to date, such as ISO 5170 on lubrication systems and ISO 11204 on noise test methods. The first standard specifically tackling machine tools with regard to environmental aspects is the planned ISO/NP 14955 - Environmental evaluation of machine tools. Taking the current status of approved and published standards as a basis, there are **gaps in standardisation** of machine tools specifically regarding the **eco-design process, marking/ labelling of materials/ components (e.g. identification of hazardous substances), power consumption measurements (machines and modules), power modes, power management, consumption of lubricants (measurements, assessment), consumption of compressed air (measurements), and process waste generation measurement including yield losses**.

The most relevant pieces of EU-level legislation regarding environment, health and safety issues for machine tools are:

- Directive 2006/42/EC on machinery
- Directive 2012/19/EU on waste electrical and electronic equipment (WEEE, recast of 2002/96/EC)
- Directive 2011/65/EU on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS, recast of 2002/95/EC)
- Commission Regulation (EC) No 640/2009 on ecodesign requirements for electric motors

Within the industry there is as yet no voluntary agreement, but CECIMO (Comité de coopération des industries de la machine-outil) initiated a Self-Regulation Initiative (SRI) in 2009, so far addressing metal working machine tools only.

TASK 2 – ECONOMIC AND MARKET ANALYSIS

The machine tools sales market is subject to huge fluctuations, depending on economic cycles. Due to their long lifetime, the stock (installed base) of machine tools shows much less fluctuation than the sales figures. PRODCOM figures were subject to an extensive plausibility check, and revisions were made accordingly, with the support of the following associations in particular: CECIMO (and member associations), EPTA (European Power Tool Association) and the European Welding Association (EWA). Whereas EuroStat states a production volume of nearly 600.000 metal working machine tools for 2009, our plausibility check shows that an estimated **216.000 metal working machine tools** are sold annually, falling under the definition provided in Task 1 is a much more likely figure. Similarly for wood working machinery, instead of 3.4 million production units sold per year - as stated by EuroStat - a more reasonable figure for wood working machine tools, according to the plausibility check by Fraunhofer, is **130.000** units (2009 data) for larger machinery. Note that these data overlaps with the annual market sales data of **220.000 for light stationary wood working tools**. The market of **welding, soldering, and brazing equipment** covers roughly **1.400.000 units** sold per annum of EU production, regarding units falling under the definition provided above.

A basic technical distinction of machine tools is, whether they are controlled and operated by support of any computer hardware and software (CNC, computerized numerical controlled, occasionally also called NC, numerical controlled, only), or just manually (referred to as non-NC, or non-CNC in this study).

A stock model set up by Fraunhofer for the major market segments covered by the definition of "machine tools" indicates that currently in the EU 27 there are in operation:

- **3,5 million metal working machine tools**, of which **750.000 are** Computerized Numerical Controlled **machine tools (CNC)**
- **5,8 million wood working machine tools**, of which **1,4 million are larger stationary machinery**
- **7,1 million units of welding, soldering and brazing equipment**, of which **1,5 million are stationary units.**

Due to the long lifetime of stationary machine tools, the stock remains very stable for wood working machine tools and no major changes are to be expected regarding the installed base in the mid-term future. The metal working machine tools market sees an ongoing shift from non-CNC machine tools to CNC: In 2025 a total stock of 2.8 million metal working machine tools is forecast, of which 800.000 are estimated to be CNC machine tools, with an increasing complexity and functionality.

The Life Cycle Cost (LCC) model for machine tools is subject to the broad variety of machine tools, and the fact that many more factors than only purchase price, consumables and spare parts play a role. Running costs over the lifetime in almost all cases seem to be higher than initial investment costs; the costs for electricity and (where applicable) consumables are very relevant, and maintenance costs often play an even more important role.

Reflecting the regions where machine tools are most prominently used, the size of the companies using them, and regional electricity costs, in approximate terms the "typical" electricity price for use of metal working machine tools is 0,11 Euro/kWh, for wood working machine tools it is 0,14 Euro/kWh, but it should be noted that these costs have a broad spread across the EU-27 countries.

The total sales volume for EU-27 for mineral oil-based non-water miscible and water miscible cooling lubricants was roughly 800 million Euros in 2008, indicating the high economic relevancy of coolants.

The total value of tools, workpiece holders and spare parts in 2008 for EU 27 production was **7,6 billion Euros**, compared to a sales volume (sold production) of 26,4 billion Euros for machine tools in the same year.

TASK 3 – USER REQUIREMENTS

Machine tools are **business-to-business products**. Recent survey results and stakeholder feedback show that “energy efficiency” – despite some outstanding initiatives - is only recently becoming important in the marketing of the machine tool manufacturers. The important facts are price, cutting speed and innovative equipment.

Although machine tools users’ interests regarding energy efficiency aspects is growing, technical features and performance criteria still dominate. The growing interest and related marketing initiatives do not yet result in a broad demand for, and implementation of, energy efficient modules in machine tools. This is the case particularly in the woodworking 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 of "green" issues, and interest among the automotive industry and its suppliers, but for most other market segments energy efficiency is not among the most 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. The main marketing aspects are still price, cutting speed and the innovative equipment of products. The Total Cost of Ownership approach is realised mainly in large-scale production branches, such as the automotive industry.

Nevertheless, machine tool users are aware of the growing importance of machine tools per se, in realising broader sector-specific environmental aspects, especially energy saving gains..

Retrofitting and refurbishment of machine tools after a certain time in use is very common and reported to take place typically 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.

TASK 4 – ASSESSMENT BASE CASE

Based on findings for the machine tools market, the **Base Case assessments**, meant to be conscious abstractions of reality, cover one typical type of machinery, for each of the following segments:

- **Base Case 1: Computer numerically controlled (CNC) machining centre,**

- **Base Case 2: numerically controlled (NC) deep drawing or bending machine tool,**
- **Base Case 3: laser cutting machine tool,**
- **Base Case 4: non-numerically controlled (non-NC) metal working drilling machine**
- **Base Case 5: machine tool for woodworking: light stationary table saw,**
- **Base Case 6: machine tool for woodworking; horizontal panel saw,**
- **Base Case 7: machine tool for woodworking: throughfeed edge banding machine,**
- **Base Case 8: machine tool for woodworking: CNC machining center; and**
- **Base Case 9: transportable welding equipment.**

The above choices were based on the rationale that the various levels of machine complexity should be addressed, and that the different processes applied, and the variety of materials processed, should be covered.

The assessments confirm the relevancy of use phase energy consumption. For some impact categories the production of the machine tools also has significance.

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 (36 PJ per year, represented by horizontal panel saws, throughfeed edge banding machines, and CNC machining centres), 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 c. **60 kWh is electricity.** Aggregated **Greenhouse Gas emissions** total **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 segments. Therefore, this approach leads to an underestimation of total impacts; however, the order of magnitude is plausible.

TASK 5 – TECHNICAL ANALYSIS BAT AND BNAT

Task 5 identified numerous Best Available Technologies (BAT), including options which are mostly already introduced on the market. In addition, several very generic Best Not Yet Available Technologies (BNAT) were identified and examined. The presented solutions do not claim certain machine tools as the most energy efficient, and thus the best available, or best not yet available technology. Instead, **there are a large number of energy efficient solutions at the component level** for BAT and potentially as BNAT. Here, the modular system architecture of machine tools has to be taken into account for any eco-design measures. Many of the components are manufactured by suppliers and implemented by the machine tool manufacturers. There are some approaches, which address **non-energy related improvements, including media consumption, mass reduction, and productivity increases**. The energy savings to be realised largely depend on the combination of measures, and the savings potential cannot solely be aggregated, when more than one option is implemented.

The assessment of the various technical eco-design measures has been based on a survey among machinery and component manufacturers, which was complemented by research on technical options. The assessment shows that there is a multitude of options, each with a small energy savings potential in the range of 1%, and that it may be anticipated that a combination of several options could lead to significant total savings. However, the large spread of answers given for most of the options once again confirms that the feasibility and suitability of any option has to be assessed carefully for the intended application.

TASK 6 – IMPROVEMENT POTENTIAL

The analysis of improvement potentials calculates the effects of these design options being implemented consecutively, in terms of their monetary consequences via Life Cycle Costs (LCC) for the user, comparing their environmental costs and benefits, and pinpointing the solution with the Least Life Cycle Costs. This analysis builds on the Base Cases. Although the implementation of options now refers each to “one unit of machine tool”, these are hypothetical cases, and are not meant to represent real-world machine tools. Note that the analysis already includes a consideration of market penetration rates.

For each of the Base Cases a consecutive order of design options between 1 for simple non-NC machine tools up to 22 for highly complex machine tools was identified. The analysis showed that the combination of options can lead to moderate **Total Energy savings potentials at the point of Least Life Cycle Costs**, **in the range of 3%-5% for the most relevant Base Cases**, among them the highly-relevant Base Case 1 on CNC machining centres, but also the Base Cases from the wood working sector. For **welding equipment** a **Total Energy savings potential of 12,2% at Least Life Cycle Costs** was calculated. The sensitivity analysis (variation of use patterns, shift models, lifetime, energy costs) largely confirms the trends identified in the baseline analysis.

In general, there is no single option with a large environmental improvement potential. **Moderate savings** as stated **can only be realised with the implementation of several individual options, and what could be called "good machinery design"**. As this analysis was meant to address certain archetypal machine tools on a very generic level, it should not be ignored that there might be a much larger savings potential for some machine tools under certain conditions, e.g. for specific applications.

TASK 7 – POLICY AND IMPACT ANALYSIS

For the various market segments covered by this study, several targeted policy options apply. For less complex machine tools, specific requirements can be defined. However, for more complex machine tools, policy measures need to reflect the multitude of improvement options identified, the systems aspect, and productivity considerations. A proposed requirement is the mandatory usage of **Good-design-practice Checklists**, making it obligatory to assess the feasibility of improvement options. The final judgement, whether an option is suitable for a given application would remain with the machinery developer.

Besides such a checklist approach (and closely related to it), **power management and information/ declaration requirements** can be defined. Whereas power management addresses the aspect of reducing power consumption in non-productive times without hampering productivity, standardised information/ declaration requirements create transparency and comparability regarding environmental performance and life cycle costs. In particular, the latter is assumed to have an influence on purchase decisions.

Such measures could be introduced either through an ecodesign **implementing measure** or through one or several **Voluntary Agreements (VAs)**. No such Voluntary Agreement is currently in place, and for both options several standards are still lacking, which – if in force - would allow the unambiguous implementation of such VAs.

Three policy option, assumed to yield a change in the market from 2014 onwards, are assessed against a Business-as-usual-scenario (BAU), to examine their energy savings potentials:

(1) Implementation of a good-design-practice-checklist, accompanied by power management requirements and declaration obligations, leading to machinery improvements which correspond to the point of **Least Life Cycle Costs**. This scenario yields a moderate **saving of minimum 31 PJ in 2025 or nearly 4% compared to BAU**.

(2) An alternative **“optimistic scenario”** anticipates higher savings of good-design-practice. **Fiscal incentives** furthermore are assumed to pay off part of the additional machinery costs for implementing even more improvement options than in the scenario above. This option results in **savings of minimum 38 PJ in 2025** compared to BAU.

(3) A **Voluntary Agreement** with a hypothetically target that all machine tools sold in 2014 and thereafter should be, on average, 10% less energy-consuming than in 2010 in combination with an effective **Product Carbon Footprint label** for light-stationary machine tools, yields a total **saving of 74 PJ in 2025**, or **9% compared to BAU**.

Note that the actual savings potential of all scenarios might be higher, because the Base Cases chosen do not fully cover the scope of the study.

Given the typically long lifetime of the machinery considered, any implemented measure is projected to yield significant overall savings results only over the **medium- to long-term**.