Concept Description for CECIMO's Self-Regulatory Initiative (SRI) for the Sector Specific Implementation of the Directive 2005/32/EC (EuP Directive)

CECIMO decided and applies for conducting a Self-regulatory Initiative (SRI)

> *(16) Priority should be given to alternative courses of action such as self-regulation by the industry where such action is likely to deliver the policy objectives faster or in a less costly manner than mandatory requirements. Legislative measures may be needed where market forcers fail to evolve in the right direction or at an acceptable speed*[1].

PE INTERNATIONAL GmbH (www.pe-international.com) supports CECIMO throughout the steps leading to the implementation of the machine tool sector self-regulatory initiative with:

- A Concept description (this document)
- An Evaluation scheme (method, included in this document)
- Presentation (preparative Consultation Forum (CF) meeting)
- Initial Project definition for the years 2009 – 2011 (Roadmap)

The concept is describing the procedure and method for CECIMO to meet the requirements of the nine points of Annex VIII of the EuP Directive (200732/EC).

Executive Summary

The concept allows the individual machine tool manufacturer to calculate environmental (energy based) improvements. Those data will be handed over by the machine tool builders to their national associations who will transfer them to the open CECIMO task force. The open CECIMO task force will then report the global European data to the European Commission showing that the industry sector reaches the targets on energy reduction, set jointly by the European Commission and CECIMO.

To support this calculation a simple calculator based on a spreadsheet program (Excel) has been foreseen. The list of improvements for machine tools is maintained as an open list by CECIMO or any other international organization like ISO/CEN. The improvement data is derived from a comparison with and without this feature and is represented as a relative value as well as absolute value of energy saving. Thus this calculator can be used for the administrative (EuP) obligations as well as for marketing.It allows showing to the customers that additional investment into energy saving measures can result in reduction of operational costs. Therefore the calculator also takes care for different operational structures, which can vary for different applications even for the same machine. This calculator has been developed so far and can be further tuned to specific needs as they might arise.

Goal of the SRI

The intended goal of the SRI of the machine tool branch is to increase the ecological performance of machine tools while maintaining the freedom of innovative development, minimizing administrative burdens and clear positioning of advanced manufacturing against copycat.

This is to be accomplished via the SRI by proposing improvements regarding environmental impacts. These improvements originate from machine tools in the future beyond the level of business as usual (BAU). Targets will be quantified supported from a sector/ branch commitment. The entire concept with focus on the method for quantifying the targets and environmental objectives is in "conformity"[1] with the nine points of Annex VIII of the EuP Directive (200732/EC).

The concept is intended to be implemented and practically in place ready for application until 2011. An accompanying roadmap defines also the action points necessary to be done between 2009 and 2011.

Scope of the SRI

The scope of the SRI is machine tools in general. This product group is very diverse and in-homogenously reflected by multitude of individual machines. The concept has been developed and proven by milling and turning machine tools intended for metal works. Nevertheless the principles of the concept are applicable to all machine tools and can be extended in mid to long term perspective to any machine tool after this initiation phase.

Basis is a modular view of the machine tool. Theoretically the machine tool is split into its modules, i.e. components with specific and defined functions.

In order to give an example Figure 1 reflects a milling machine tool. There are some main important modules given, typically a milling machine consists of.

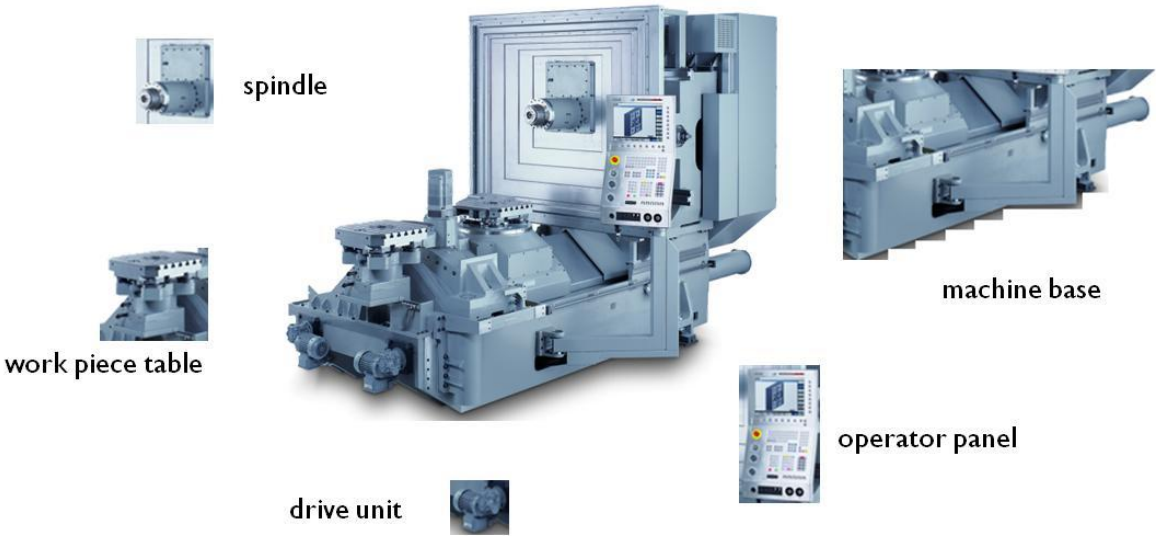


Figure 1: Example of a machine tool with some main important modules

[1] Conformity in the sense of compliance, the Annex VIII of the Directive 2005/32/EC is not a legal ordinance and rather points to an open political process related to proposal and acceptance

The complexity of the individual machine tool types within the given product group is challenging and not obviously definable. Figure 2 outlines three most important aspects to be considered when talking about energy efficiency or reduction of environmental impacts of machine tools.

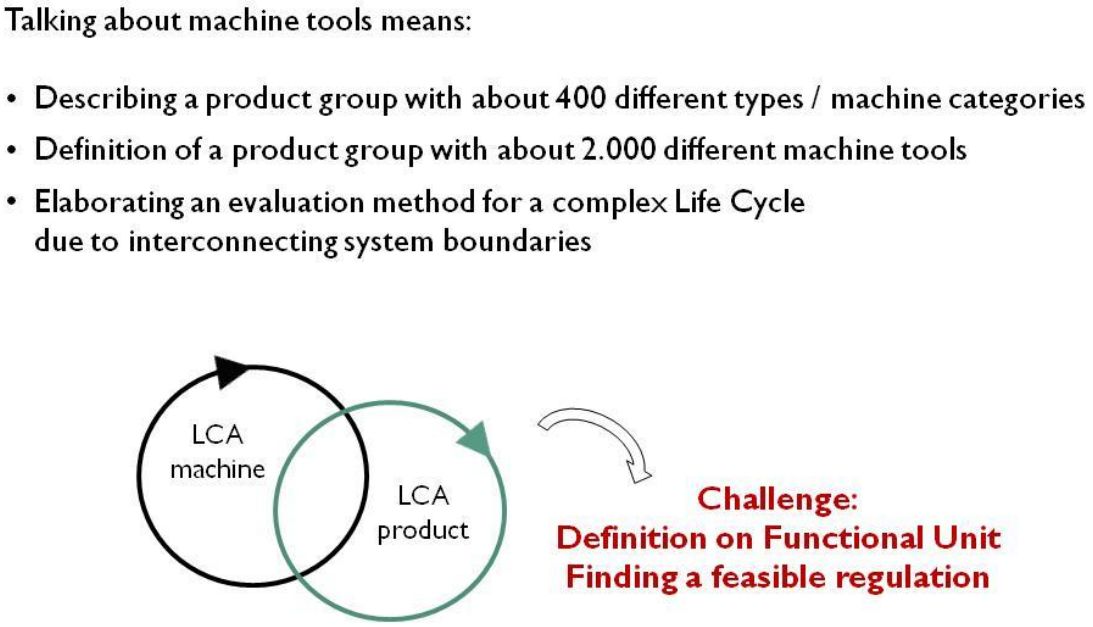


Figure 2: Complex and challenging situation for definition of a reference product

1. *Comparability between machine tools is limited*
   Machine tools are complex and very divers. Machine tool consists of a huge number of non-comparable modules, fulfil manifold functions and appear in a broad range of dimensions. The absolute amount of materials used for manufacture or the absolute consumption of energy and operation material (such as cooling agents, lubricants or tools), as well as End of Life aspects, depend on the individually intended function of the machine tool. Additionally quality aspects and economic efficiency have to be considered.

2. *A functional unit of a machine tool cannot be defined unambiguous*
   Machine tools consist of numerous modules, which can be optimised per se, but which also must be seen in the perspective of the entire machine tool as a product system, in which each module must fulfil the intended function in cooperation with each other module. There are no rules applicable, which allow identifying the optimum in the area of conflicts of quality, time, cost and environmental impact.

3. *Interlocking life cycles of products manufactured by machine tools*
   Machine tools are intended to manufacture products or part of products. These fulfil tasks in other products, which have their own life cycle and related environmental impacts. The quality of this product can have significant impacts on the life cycle, which may allow more effort during its manufacturing phase in order to provide an overall reduced environmental balance.

Considering these facts, this SRI bases on the concept that each machine tool must be seen as individual product with individual improvement potentials. This avoids the definition of general measures, which would have been applicable to any machine tool independently on the effectiveness. The individual application of measures, taken from a list of available, agreed and controlled options ensures the possibility of realising the biggest potential per machine; the implementation will be guided by an informed decision procedure.

The following concept description will summarise the entire SRI approach. It focuses in detail on the applied method for setting targets based on quantitative and staged objectives.

Identification of key indicators

First step of the concept development has been the conduction of life cycle assessments for two typical types of machine tools (milling and turning). The LCA considered the whole life cycle of several machine tools (manufacturing, use phase and end-of-life scenario). The study covered the data of nine machine tools from five European machine tool manufacturers. Considering ten impact categories (CML, 2007) and the primary energy demand, the results show a clear hot spot. The use phase dominates the environmental impact in all considered categories. In the use phase the most important influencing factor is the energy consumption.

The results of the conducted LCAs are enclosed in the annex.

Concept Description

Base of the concept is Figure 3. It consists of the following elements and aspects, which are described in detail below.

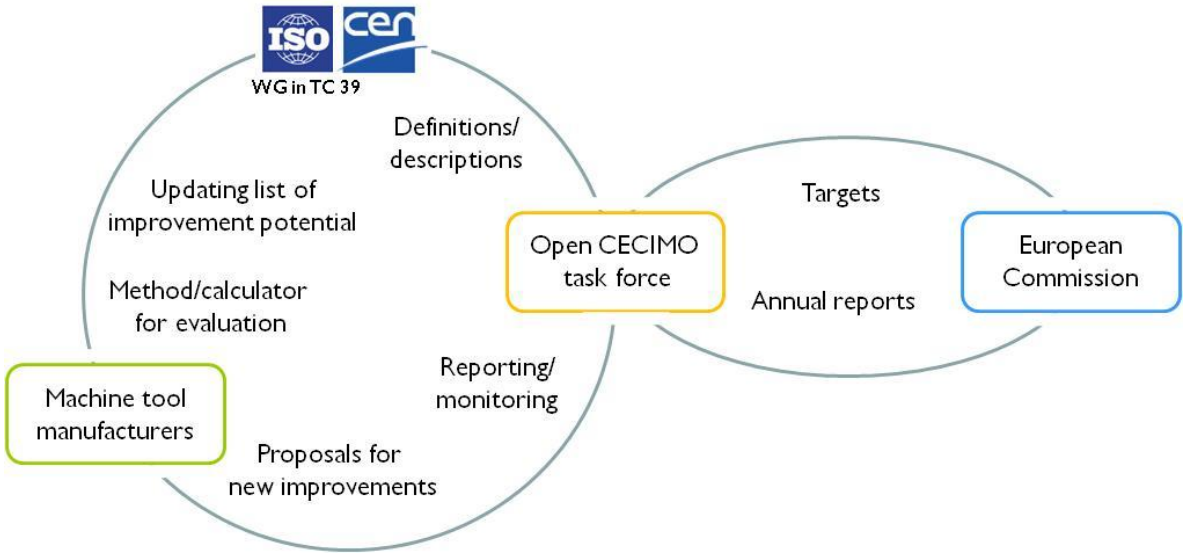


Figure 3: The concept for the SRI of the machine tool industry

(1) CECIMO and its members initiate the SRI, which ensures a **market coverage of at least 86%** - openness for non CECIMO members is ensured

(2) The SRI is a transparent procedure allowing all stakeholders to follow, ask and comment; the to be founded '**open CECIMO task force**' organises, controls and reports as core group in the concept

(3) A **list of improvement potentials** will be defined and further fostered and extended on demand, based on information from LCA, technical aspects and innovative developments; it contains options machine tool manufacturers can select and apply to their individual machine tool.

(4) The method for evaluation the environmental improvement is based on a **calculator** taking into consideration individual aspects from the list of improvement potentials (see point (3)) and the intended application of the machine tool; the result of calculation shows the improvement of the individual machine tool in comparison to a business as usual (BAU) machine of the identical, individual application scenario.
The open CECIMO task force defines and controls the reference elements (BAU) and its development through time.

(5) Each machine tool introduced to the European market will be calculated from the persons responsible (manufacturers or importers), **showing the**

environmental improvement versus BAU and the absolute energy consumption[2].

(6) The gained relative improvements and the total absolute improvement in energy consumption will be **monitored by the open CECIMO task force** and reported yearly to the European Commission (EC).

(7) The **reporting** is a control mechanism for the EC whether the set improvement target is reached or even exceeded. The first **target setting** is foreseen within the installation phase. After first monitored results (supposed to be between 2010 and 2011), statistics will allow to define an objective for the industry sector.

The following chapters describe the individual aspects of the presented concept in more detail.

(1) Openness, Representativeness and Public Information

The concept proposes to achieve CECIMO member companies' commitment and invite non- CECIMO/ members to participate. CECIMO co-operates with other organisations representing machine tool manufacturers in third countries and is open to get them participating in the preparatory and the implementation phase.

CECIMO is active in the processes of **International Standardisation** and is going to expand these activities; CEN TC 143 (Safety of Machine Tools), ISO TC 39 (Machine Tools), NFPA 79/EN 60204

An exchange of information and economic data with also non-European associations for machine tools will be enabled by installation and fostering of a webpage, as well as networking with other associations.

The webpage and maybe meetings enables the participation of all interested parties and stakeholders.

This allows also gaining market coverage of theoretically 100% since the representativeness of member companies of CECIMO association have market coverage of 86%.

Statistics from CECIMO

Production of manufacturers associated in CECIMO:	44 % of global market	24,6 bn €
Export to non-European countries	37% of production	9,1 bn €
Sales in Europe of CECIMO members		15,5 bn €
Sales volume in Europe (including import)		18,0 bn €
Market coverage of manufacturers associated in CECIMO	**86 % of European market**	

Source: national indicator + Eurostat

[2] Energy consumption in use is recognized to be the main significant environmental aspect. In case this condition will change to another environmental aspect, the absolute energy consumption can be substituted or added by another environmental aspect, which needs proof by e.g. LCA study.

(2) The Open CECIMO Task Force

The open CECIMO task force will be a group, meeting regularly. It consists of experts from CECIMO member companies as well as external experts from technical research and development institutions, scientists and experts for environmental assessment, ecodesign and sustainability issues.

Means of communication may be web based tools or stakeholder meetings, publicly announced and open for all interested parties.

Industry's initiative is required and wished in this working group and should be in accordance with EC's expressions of requests. In any case, all arguments of interested stakeholders should be considered.

The open CECIO task force will be linked to other sections for public information relating to SRI and similar EuP related issues

(3) Pre-conditions and List of Improvement Potentials

As a pre-condition parts, components and modules a machine tool consists of or can consist of, must be defined. This reference text shall be based on a common agreed description all actors can refer to.

An example might be the definition of a spindle in a milling machine. It comprehends the motor, gear and dynamically moved masses/ materials.

Beside hardware description, different types of operating modes have to be defined. Measures regarding proper application and operation can have significant influence on the environmental performance. These definitions are an additional pre-condition of the method.

The list of improvement potentials describes the measures which can be implemented into a machine tool for a better environmental performance. Measures are either quantified and serve as base data for the calculator (see (4)) or show improvement potentials, which cannot be quantified yet, but are used as additional qualitative evaluation of the machine tool.

Quantifiable measures referring to single modules are classified into category 1 potentials; quantifiable measures referring to the overall machine are classified into category 2 potentials; measures, which cannot be quantified yet are classified into category 3 potentials.

The list needs the collection of as much as possible today known measures and options in order to allow a proper start of the concept. It is also matter of continuous extension and adaption in accordance to innovations and technical developments.

In order to ensure sustainability, the list must be updated regularly. This reflects the fact that developments become state of the art technologies. This leads to a continuous setup and adaptation of the BAU reference. The present list of improvement potentials developed throughout the conceptual base is enclosed in the annex and may serve as working paper for a first version.

All interested parties are invited for innovative ideas to be transferred into (quantified) measures by the open CECIMO task force during its regular meetings. As long as measures and the items in the list of improvement potentials refer to energy efficiency a further proof of relevance is not necessary. Nevertheless it might be possible that improvements are proposed, which go beyond energy efficiency or which do not clearly allow the reference to LCAs already done. Case specifically it will be necessary, decided by the open CECIMO task force to deliver such a proof via LCA.

In the long term the update intervals of the list of improvement potentials are recommended to take place annually. In the initial phase an additional update may be necessary and reasonable, in order to ensure proper conduction of the concept.

(4) Calculator for Quantifying Environmental Aspects and Impacts

The principle of the calculator is shown in Figure 4 and described below.

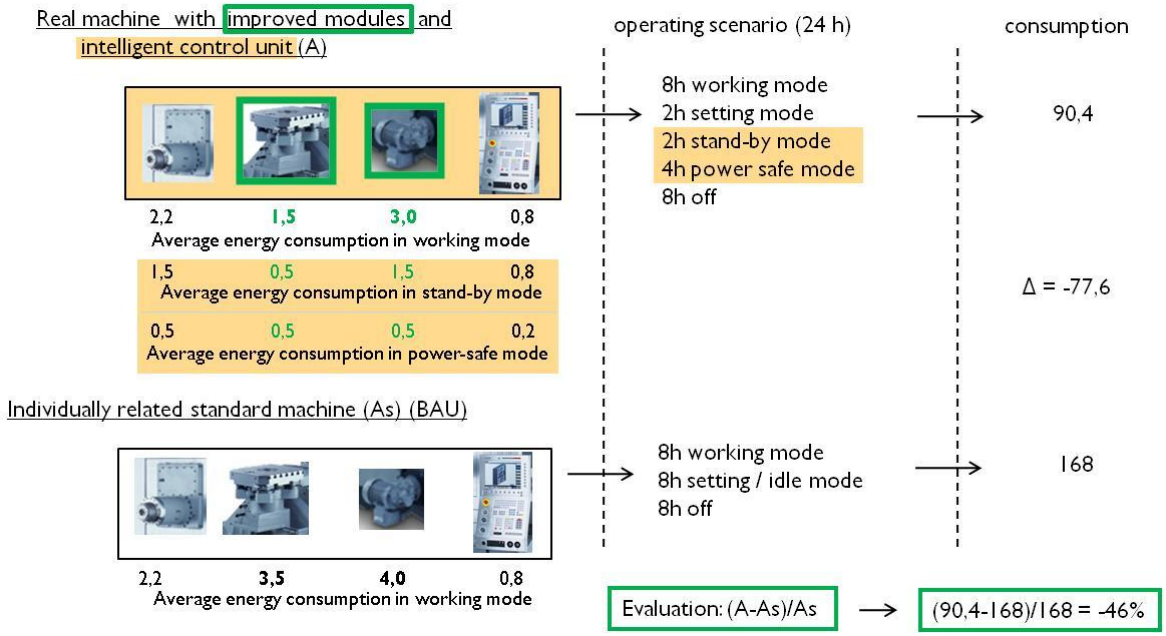


Figure 4: Principle of the calculator

In the above shown example the real machine tool (A) consists of four modules. Two of them are improved modules in regard to the list of improvement potential (marked by the green frame). The machine tool is featured with an intelligent control unit, which enables the operating modes stand-by and power safe (visualized by a yellow background).

The assignment of modules and operation modes and their definition will be fixed in the respective documents by the open CECIMO task force.

The determination of the average energy consumption in the different operation modes requires further investigations in the initial phase of the implementation of the SRI. It is recommended to develop this task iteratively, starting with available expert know-how and confirm the assumptions by measurements, statistics and mathematical algorithms.

In the example Figure 4 a virtual individually related standard machine tool (As) is shown. It consists of the same number of modules. These modules are assumed to be not yet improved and reflect the business as usual situation (BAU). The standard control unit of the machine tool do not allow the possibilities of different operation modes.

The consumption of electrical energy of both machines is calculated according to an operating scenario of 24h. Best case this scenario respects to the customer specific application the machine tool is produced for. If such a customer specific operating scenario is not known a certain number of typical pre-defined scenarios are applied for the calculation.

The calculation results in two figures of absolute energy consumption for the real machine tool (A) and the theoretical standard machine tool (As). The realized improvement is then expressed as percentage of absolute consumption saving related to consumption of the standard machine tool (BAU):

$$\text{Realized improvement} = (A-As) / As$$

According to this formula the realized improvement is stated as negative figure with the unit [%].

For practicable application of the calculator an excel-file or web-based version is recommended. In the annex screenshots of a first excel-version of the calculator are enclosed.

(5) Results from the Calculator

Results are relative to BAU but individually per machine tool. This procedure ensures improvement above BAU as long as the figure (in percentage) is less than zero.

The absolute consumption is also calculated, which shows the market effect, if the open CECIMO task force sums up all machine tool information sheets introduced to the European market each year. Monitoring of these data may be supported by computer aided tools, which will be established.

Correct application of the evaluation scheme will be controlled by the open CECIMO task force. A detailed procedure has to be developed in the initial phase of the SRI.

Once the method is implemented the industry sector needs to define a committed target. The target will become part of the monitoring and reporting. First statistics and feedback from the initial phase of the method will be necessary for a first target setting.

(6) Monitoring and Reporting

The evaluation is done by the machine tool manufacturer. This enables the companies to monitor their individual improvements. The reporting and target setting is related to the whole industry sector. The open CECIMO task force will collect the individual (absolute and relative) data of the environmental performance in the market.

(7) Ensurance of Sustainability and Continuous Improvement

The open CECIMO task force is the core working group of the network and concept shown in Figure 3. Regular updating of the necessary frame (definitions and descriptions) for the practical application of the method and its calculator will ensure the successful implementation and continuous improvement of the concept. Updating intervals for the list of improvement potential are essential.

The sustainability is ensured through the continuous procedure including adaptation and updating intervals. Also proof is given by the intended installation of a new job position within CECIMO secretary. Economic and social aspects (e.g. health and safety aspects) are regarded sufficiently from the concept.

ANNEX A:
Fulfilment of each Requirement of Annex VIII of EuP Directive

The Annex VIII of the EuP Directive shows the framework to be followed for a SRI (see http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32005L0032:EN:HTML). This chapter shows that the above described concept fulfils the nine points of the EuP Annex VIII.

1. Openness of participation

> "Self-regulatory initiatives shall be open to the participation of third country operators, both in the preparatory and in the implementation phases." (Citation from EuP Directive 2005/32/EC)

- Transparency and public information ensures the possibility of participation of all stakeholders
- Openness in participation is given to all machine tool manufacturers and importers; proof is also given by the intended ISO/CEN activities

2. Added value

> "Self-regulatory initiatives shall deliver added value (more than 'business as usual') in terms of the improved overall environmental performance of the EuP covered." (Citation from EuP Directive 2005/32/EC)

- The method for target setting and calculation of the environmental improvements focuses on a relative description and assessment of the improvement in comparison to the business as usual situation
- Significant environmental aspects are identified through LCA to ensure coverage of all possible environmental aspects beyond the so far identified energy consumption during use phase

3. Representativeness

> "Industry and their associations taking part in a self-regulatory action shall represent a large majority of the relevant economic sector, with as few exceptions as possible. Care shall be taken to ensure respect for competition rules." (Citation from EuP Directive 2005/32/EC)

- Statistics (2008) proof the coverage of 86% of CECIMO of machine tools introduced to the European market (i.e. produced, imported and not exported machines used in Europe)
- Openness in participation allows reaching a theoretical coverage of 100%

4. Quantified and staged objectives

> "The objectives defined by the stakeholders shall be set in clear and unambiguous terms, starting from a well-defined baseline. If the self-regulatory initiative covers a long time-span, interim targets shall be included. It must be possible to monitor compliance with objectives and (interim) targets in an affordable and credible way using clear and reliable indicators. Research information and scientific and technological background data shall facilitate the development of these indicators." (Citation from EuP Directive 2005/32/EC)

- The method with the calculator and evaluation scheme bases on quantitative values
- The target setting in regard to the intended and committed improvement of the market sector machine tools is quantitative and scalable in absolute terms of consumption to entire European market level.

5. Involvement of civil society

> "With a view to ensuring transparency, self-regulatory initiatives shall be publicised, including through the use of the Internet and other electronic means of disseminating information. The same shall apply to interim and final monitoring reports. Stakeholders including Member States, industry, environmental NGOs and consumers' associations shall be invited to comment on a self-regulatory initiative." (Citation from EuP Directive 2005/32/EC)

- The intended web page and other public initiatives such as stakeholder meetings ensure transparency and will provide options for participation of stakeholders

6. Monitoring and reporting

> "Self-regulatory initiatives shall contain a well-designed monitoring system, with clearly identified responsibilities for industry and independent inspectors. The Commission services, in partnership with the parties to the self-regulatory initiative, shall be invited to monitor the achievement of the objectives. The plan for monitoring and reporting shall be detailed, transparent and objective. It shall remain for the Commission services, assisted by the Committee referred to in Article 19(1), to consider whether the objectives of the voluntary agreement or other self-regulatory measures have been met." (Citation from EuP Directive 2005/32/EC)

- The open CECIMO task force ensures a monitoring procedure, which is given by the nature of its definition of work and responsibility within the concept
- It also manages the reporting

7. Cost-effectiveness of administering a self-regulatory initiative

> "The cost of administering self-regulatory initiatives, in particular as regards monitoring, shall not lead to a disproportionate administrative burden, as compared to their objectives and to other available policy instruments." (Citation from EuP Directive 2005/32/EC)

- Existing infrastructure in communication and web presentation can be used to a reasonable extend
- The company or importer individual data input is computer supported and needs only lean effort
- The centralised work for organisation and management within CECIMO is related to less than a full employee count

8. Sustainability

> "Self-regulatory initiatives shall respond to the policy objectives of this Directive including the integrated approach and shall be consistent with the economic and social dimensions of sustainable development. The protection of consumers' interests (health, quality of life and economic interests) shall be integrated." (Citation from EuP Directive 2005/32/EC)

- The option of updating the list of improvement potentials and thus adaptation of the evaluation according to future developments guarantee continuous improvement
- The consolidation of ecological, economical and social dimensions is possible and documented in the CECIMO Environmental/ Sustainability Principles

9. Incentive compatibility

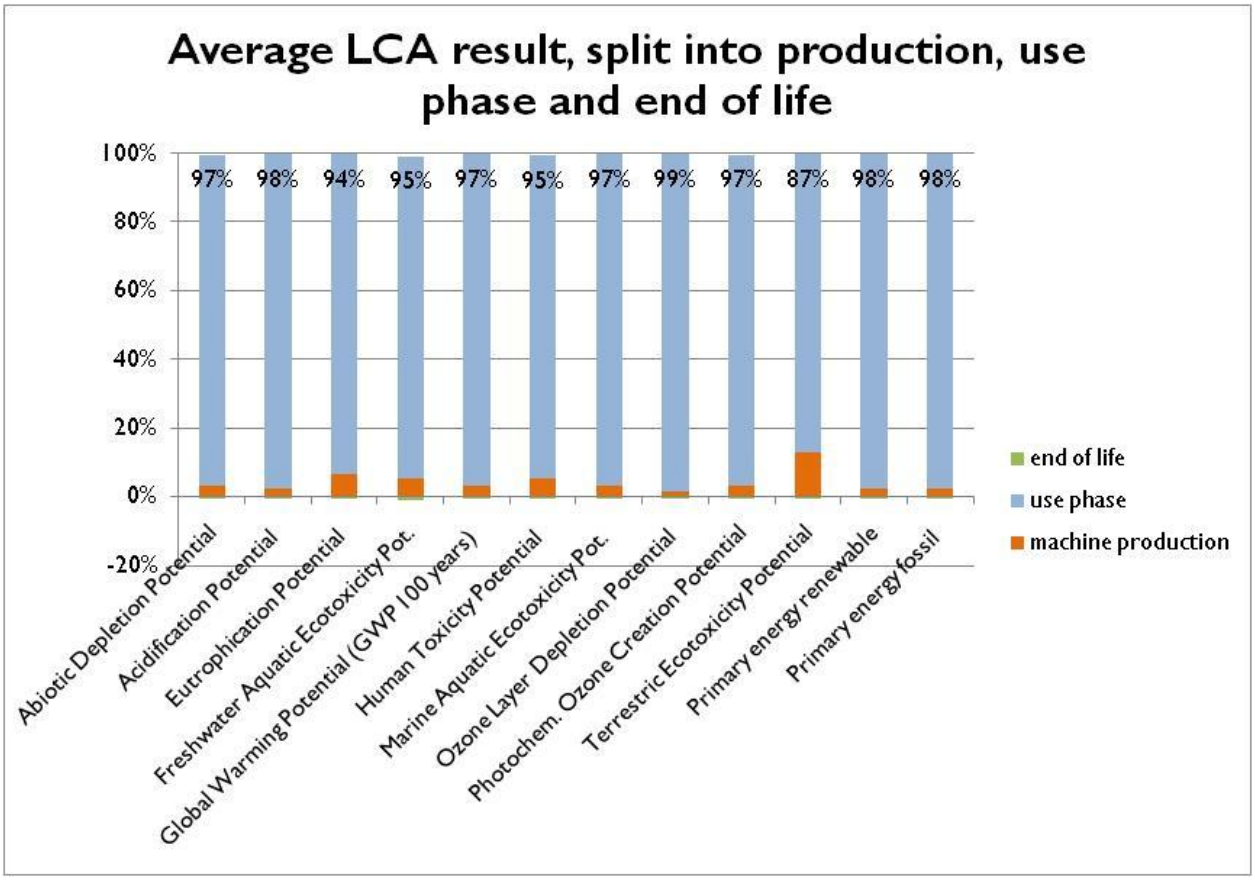
> "Self-regulatory initiatives are unlikely to deliver the expected results if other factors and incentives — market pressure, taxes, and legislation at national level — send contradictory signals to participants in the commitment. Policy consistency is essential in this regard and shall be taken into consideration when assessing the effectiveness of the initiative." (Citation from EuP Directive 2005/32/EC)

- Obstacles are not recognised

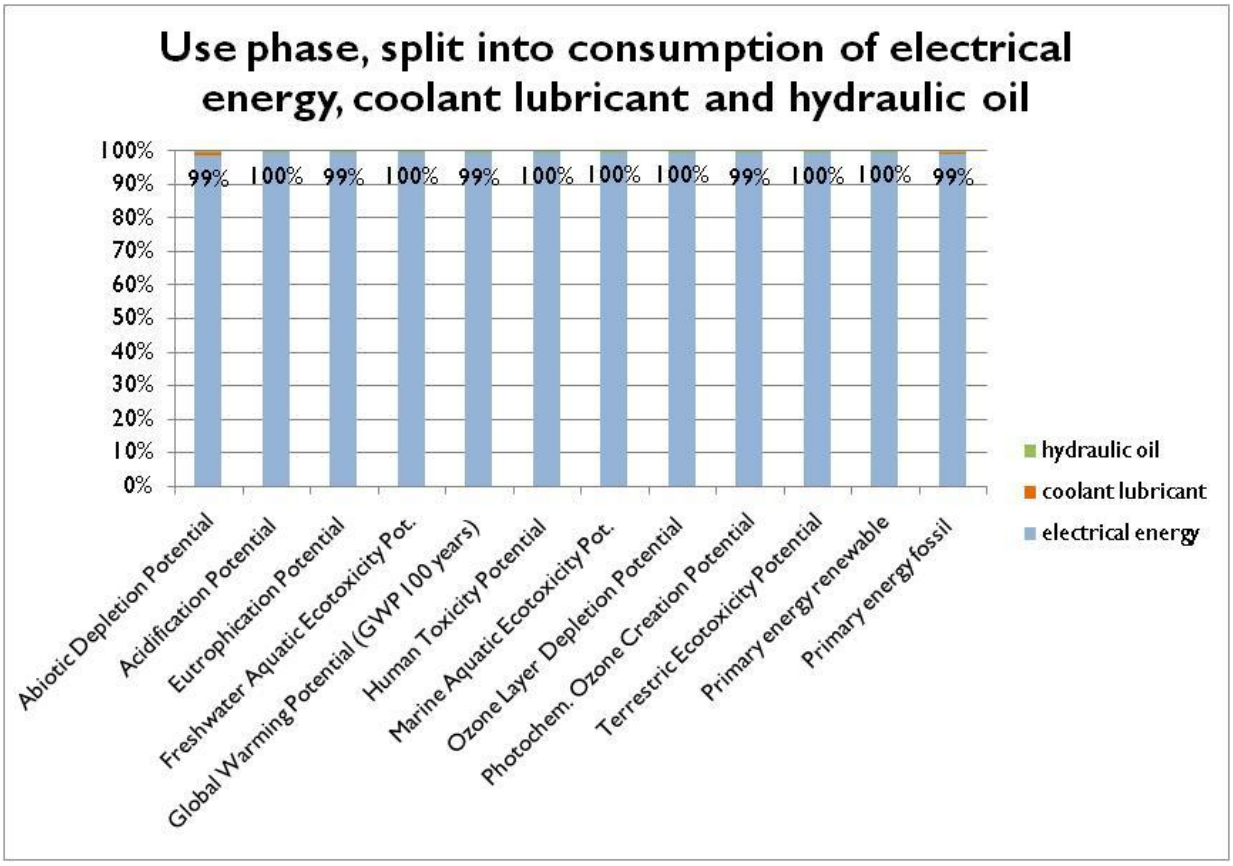
ANNEX B:
Results from the Conducted LCAs of machine Tools

The LCAs have been conducted according to the following system boundary conditions:

- Materials for production of the machine tool with average consumptions for machining
- 100.000 hours productive operating with specific average energy consumption (20h/d, 250d/a, 20a)
- Consumption of 4.000 kg coolant lubricant in 20 years (assumption)
- Consumption of 400 l hydraulic oil in 20 years (assumption)
- End-of-Life scenario with credits for recycling of metal and incineration of plastics
- According the methodology of the Institute of Environmental Sciences, University of Leiden, NL, 2007



This diagram shows the LCA results over the entire life cycle as average from the 9 individual LCA studies



This diagram shows the LCA results of the use phase as average from the 9 individual LCA studies

average result of 9 data sets for 6 milling and 3 turning machines	proportion of use phase related to whole life cycle	proportion of influence of power consumption in use phase
Abiotic Depletion Potential [kg Sb-Equiv.]	97,1%	98,8%
Acidification Potential [kg SO2-Equiv.]	97,7%	99,8%
Eutrophication Potential [kg Phosphate-Equiv.]	93,5%	99,4%
Freshwater Aquatic Ecotoxicity Pot. [kg DCB-Equiv.]	95,4%	99,8%
Global Warming Potential (GWP 100 years) [kg CO2-Equiv.]	96,8%	99,5%
Human Toxicity Potential [kg DCB-Equiv.]	94,9%	99,9%
Marine Aquatic Ecotoxicity Pot. [kg DCB-Equiv.]	96,9%	100,0%
Ozone Layer Depletion Potential [kg R11-Equiv.]	98,7%	99,9%
Photochem. Ozone Creation Potential [kg Ethene-Equiv.]	97,0%	99,4%
Terrestric Ecotoxicity Potential [kg DCB-Equiv.]	87,2%	99,8%
Primary energy renewable [MJ]	97,5%	100,0%
Primary energy fossil [MJ]	97,8%	99,3%

Summary of the relations from the LCA results according to diagrams above.

ANNEX C:
Screenshots of Excel-calculator foreseen for evaluation the realized improvement

MACHINE MANUFACTURER:	XYZ
MACHINE NAME:	ABC
MACHINE TYPE:	milling
MACHINE IMPROVEMENTS REALIZED FOR:	
main spindle	
main axis	
fan for control cabinet cooling	
pump for spindle cooling	
pump for coolant lubr. System	
pump in chip cleaning module	
intelligent control system with standy-by mode and power safe mode	

Template for general information of the machine tool, manufacturer and realized improvements

average power consumption [kWh]			
	productive mode		
component/module	realized improvement	real machine	standard
main spindle	30%	5	7,14
main axis	30%	1	1,43
automatic tool changer	0%	0,3	0,30
fan for control cabinet cooling	10%	2	2,22
pump for spindle cooling	10%	2,8	3,11
hydraulic pump	0%	0,025	0,03
pump for coolant lubr. System	10%	1	1,11
pump in chip cleaning module	10%	2,2	2,44
chip conveyor	0%	0,25	0,25
exhaust for oil mist	0%	0,8	0,80
energy consumption kWh/h		**15,38**	**18,84**

Template for entry of average energy consumption and realized improvement per module according to the list of improvement potential

stand-by real machine	
loss	0,2
loss	0,2
loss	0,2
100%	2
20%	0,56
0%	0
20%	0,2
20%	0,44
0%	0
100%	0,8

power safe mode real machine	
loss	0,2
loss	0,2
0%	0
100%	2
loss	0,2
0%	0
loss	0,2
loss	0,2
0%	0
0%	0

Template for entry of energy consumptions in different operation modes

scenario description		productive mode proportion	productive mode hours in productive mode	stand-by proportion	stand-by hours in stand-by mode	power safe mode proportion	power safe mode hours in power safe mode
customer specific	24 h	50%	12,00 h	0%	0,00 h	0%	0,00 h
customer specific with modi	24 h	50%	12,00 h	20%	4,80 h	20%	4,80 h

Template for entry of a customer specific scenario

EVALUATION OF MACHINE

calculation formula: (real machine - standard machine) / standard machine

real machine: all improved modules + intelligent control system
standard machine: standard modules, excl. intelligent control system

considered scenarios:			improvement as absolute figure [kWh/h] ref. 24h scenario:	
3-shift, productivity > 90%:	(B-As)/As	-19,9%	B-As	-3,66 kWh/h
3-shift, productivity 80%:	(D-Cs)/Cs	-24,7%	D-Cs	-4,40 kWh/h
3-shift, productivity 80% + simulation:	(E-Cs)/Cs	-28,0%	E-Cs	-5,00 kWh/h
1-shift, productivity 30%:	(G-Fs)/Fs	-24,4%	G-Fs	-1,71 kWh/h
1-shift, productivity 20%:	(I-Hs)/Hs	-36,3%	I-Hs	-2,37 kWh/h
customer specific:	(K-Js)Js	-37,3%	K-Js	-5,83 kWh/h

Display of results for operating according to pre-defined and customer specific scenarios

ANNEX D: List of improvement potential (status September 2009)

No	Requirements on	description	vision	Category 1, single modules	Category 2, overall machine	Category 3, machine concept	improvement potential	comment 1	comment 2
1	**drive units**							**In general: All facts depends on the operation cycle of the machines and the size oft the machine (so for the size of the drives)**	Siemens
1-1	regenerative feedback of Inverter unit (servo motor/spindle)	the infeed unit is capable to feed back the braking energy to the mains power supply	-	x			ca. 10%	10% of energy saving compared to non regenerative feedback infeed units related to servo axes and spindles axes	
1-2a	minimisation of reserve capacity/customer specific layout of **motors**	Substituting the motor with a bigger motor at the same current level results in increased energy efficiency due to reduced ohmic losses.		x			ca. 3%	3% of energy saving compared to motors with original size. related to servo axes and spindles axes	
1-2b	minimisation of reserve capacity/customer specific layout of **motors**	reducing the maximum acceleration in the setpoint signal results in a better exploitation of the motors' efficiency. In this case, the overload capabibilty of the motor is not utilized.		x			up to 15%	up to 15% of energy saveing due to the reduction of the maximum acceleration. related to servo axes and the rampup/rampdown of spindles axes. The production time will be increased !	
1-2c	minimisation of reserve capacity/customer specific layout of **inverter unit**	check, if the machine tool has been optimally layouted regarding costumer needs; operation in optimal working point; avoidance of reserves' oversizing		x			up to 10%	up to 10% power losses can be saved by choosing the appropriate infeed and motor modules and line side components (reactor and filter) related to the overall inverter unit.	

1-3	use of energy efficient motors	declaration of energy efficiency class and size of the motors (EFF / capacity)		x			up to 12%	up to 12% due to usage of EFF1 motors compared to EFF3 motors (at 3kW motors) related to auxiliary units that are line connected.	
1-4	high efficient gear unit	declaration of energy efficiency; not applicable for direct drives usage of energy efficient gear boxes		x			up to 40%	up to 40% by using a planetary gear box (eta=0,9) compared to a worm gear box (eta=0,5). related to axes with gear boxes.	
1-5	mass free compensation of load for vertical axes	in case of vertical spindle: compensation of weight force (e.g. spring type mounting)		x			?	% of energy saving compared to mass compensation?	
1-6	use of break for non moving axes	the feed axes that are not involved in the interpolation during the part program are switched off (pulses deleted) and clamped by a brake.		x			up to 3%	up to 3% due to avoiding switching losses in the IGBT. only related to servo axes.	Deckel-Maho, 2009-07
1-7	inverter controlled motors for auxiliary units	substituting line connected motors by inverter motors			x			up to 40% by using inverter motors compared to line connected motors. related only to auxiliary motors, depends on the load cylce.	
1-8	400V inverter units to substitute 200V units (see also 6-1)	substitunging 200V inverter units by 400V inverter units leads to a higher enery efficiency due to reduced ohmic losses.		x			ca. 15%	400V units exhibit 15% less power losses compared to identical (spindle powert, feed axes' torques) 200V units.	
1-9	spindle-design without belt and pulleys	integrated motor in the spindle housing		x			?		Mazak, 2009-08-26
2	**overall machine**								
2-1	minimisation of moved masses	short term high accelaration results in		x			?	reduction of x kg results in y kWh of energy saving?	

		power peaks, but allow high productivity; still energy minimisation has to be considered							
2-2	reduction of friction	avoidance of friction means less mechanical wear, higher quality and also should lead to energy reduction; various types of bearing possible (rolling bearing, sliding bearing, hydrostatic bearing, magnet bearing); ecological aspect has to be considered by choose of bearing as well				x		general information available?	
3	**hydraulic unit**								
3-1	control coupled hydraulic pumps	active mode of hydraulic unit dependend on operating mode			x		-> 1-7	to be calculated in scenarios	see 1-7
4	**cooling lubricant unit**								
4-1	control coupled cooling lubricant unit	active mode of cooling lubricant unit dependend on operating mode			x		-> 1-7	to be calculated in scenarios	see 1-7
5	**cooling unit**								

5-1	thermal management regarding control cabinet	optimized concept for thermal management of the control cabinet; 1. minimisation of waste heat; 2. if waste heat is not avoidable, it has to be dissipated (air cooling, water cooling); further use of waste heat has to be checked/discussed with customer				x		general information available?	
5-2	thermal management regarding machine tool itself	optimized concept for thermal management of the control cabinet; 1. minimisation of waste heat; 2. if waste heat is not avoidable, it has to be dissipated (air cooling, water cooling); further use of waste heat has to be checked/discussed with customer				x		general information available?	
5-3	cooling of components depending on process				x			to be calculated in scenarios	
6	**power electronics**								
6-1	avoidance of transformers by use of voltage-proof converter (see also 1-8)	avoid power losses in the transformer.			x			Typically the energy efficiency of a transformer is 96 %. So it is possible to save 4% losses of a inverter unit witout a transformer.	
6-2	high efficiency transformer	substituting a conventional			x			% of energy saving compared to standard transformer?	

		transformer by a high efficiency transformer.							
6-3	connection power comprehends only units possibly operating concurrently	connection power comprehends all energy consumers, which can possibly run at the same time; consideration of cucurrently driven units			x			to be calculated in scenarios	requirement not clear
6-4	converter with power factor correction	power factor factor in the inffed unit for feed operation and regenerative feedback saves power losses.			x			1% power losses can be saved with the PFC	needs to be verified.
7	**machine concept**								
7-1	thermal management regarding motors	optimized concept for thermal management of the control cabinet; 1. minimisation of waste heat; 2. if waste heat is not avoidable, it has to be dissipated (air cooling, water cooling); further use of waste heat has to be checked/discussed with customer				x		general information available?	
7-2	switching valves with low Watt technology / alternative control via pulse width modulation (PWM)			x			?	typical reduction factor?	
7-3	alternative work piece clamping					x		avoidance of hydraulic unit?	

7-4	combination of various technologies (turning + milling + laser etc.)	combination of technologies with one time of work piece adustjusting may result in higher quality and higher yield and so also less energy				x			
7-5	dismantling ability of machine / recyability of materials	choose of material and way of construction/dismantling ability has to be considered already at state of planning				x			
7-6	optimised compressed air unit with minimal losses				x			% of energy saving / typical loss of compressed air in standard machine?	
7-7	critical assessment of wished options of machine concept	critical questions regarding customer requirements/wishes				x			
7-8	dry processing	dry processing is only possible in special processing modes; check for minimizing of lubricant			x			to be calculated in scenarios	
8	**peripheral devices**								
8-1	control coupled oil mist exhaust unit	active mode of oil mist exhaust unit dependend on operating mode			x			to be calculated in scenarios	
8-2	minimisation of loss of cooling lubricant by carryover with work pieces and chips			x			?	information available?	

9	**simulation**								
9-1	simulation of thermal management		development necessary			x			
9-2	optimisation of work piece processing by simulation off-machine; avoidance of inefficient operating time	work piece processing by simulation off-machine; avoidance of inefficient operating time; use also possible in conceptual phase of machine tool production	existing + development necessary			x			
10	**control**								
10-1	energy optimized NC-program	a post processing tool is required to assess the energy consumption of a part program. With this tool, the mechanical engineer can optimize the part features.	development necessary			x			
10-2	default setting for operating modes (costumer specific unit switch-off)	possible operation modi: standby, hot running, operating break/ste-up time, operating mode high productive mode - energy efficient mode (for phases with reduced utilisation ratio)				x			
10-3	display and balancing of energy consumption	display of energy consumption serves as tool for awareness raising of the operator; information as input for reporting and optimisation of industry site				x			

10-4	screen saver and work space lighting switch-off			x				For a 15 inch display up to 150W energy can be saved by switching off the screen.	