European Commission

Technical assistance study for the assessment of the feasibility of using "points system" methods in the implementation of Ecodesign Directive (2009/125/EC)

TASK 4

Machine Tools Case Study

June 2017

EUROPEAN COMMISSION

Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs
Directorate Directorate C – Industrial Transformation and Advanced Value Chains
Unit Directorate C1 – Clean Technologies and Products

E-mail: grow-c1@ec.europa.eu

European Commission
B-1049 Brussels

Technical assistance study for the assessment of the feasibility of using "points system" methods in the implementation of Ecodesign Directive (2009/125/EC)

TASK 4

Machine Tools Case Study

Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs

LEGAL NOTICE

This document has been prepared for the European Commission however it reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

More information on the European Union is available on the Internet (http://www.europa.eu).

Luxembourg: Publications Office of the European Union, 2017

ISBN number 978-92-79-71411-5
doi:number 10.2873/211016

Printed in Belgium

Prepared by:
This report has been prepared by Clemens Rohde and Tim Hettesheimer of Fraunhofer ISI and Paul Waide from Waide Strategic Efficiency with comments provided by other members of the consortium comprising Waide Strategic Efficiency (technical leader of the study), VITO (contractual lead), Fraunhofer, Viegand Maagøe and VHK.

Project website: points-system.eu
Specific contract no.: 478/PP/GRO/IMA/15/1164 – SI2.722599
Implements Framework Contract: 409/PP/2014/FC Lot 2.

This study was ordered and paid for by the European Commission, Directorate-General for Growth.

Table of Contents

Methodological concept for a point system in the case of machine tools

After defining a generic Ecodesign points-system for complex products in Task 3, this case study applies this methodology to machine tools. The methodology is set out in the same steps that are described in the Task 3 report, but is applied to the specific use case of machine tools. Readers should note that the example given here, especially when considering Steps 7 to 9, is applied to a hypothetical type of machine tool in order to test the proof of concept. It is not intended to represent any specific category of machine tool nor are the values used intended to be representative of actual machine tool values (although the type of design options and configurations used are common to typical products).

This case study has been confined to addressing energy performance in the use phase because this is already a major challenge for machine tools and is the dominant environmental impact; however, it is certainly conceivable that other environmental impacts could be treated using this, or a similar methodology.

The Task 3 methodology has been tested in this case study for the energy performance of machine tools and in principle it has been established that the method:

- Seems to be suitable to assess energy performance
- enables complexity to be addressed
- recognises and rewards good ecodesign practice
- is designed to award points for design options in proportion to their expected effect on the impact parameter in question
- is as comprehensive and inclusive as possible and allows the option to extend the scheme's structure to include: the environmental impacts deemed appropriate (energy performance in this case), the product scope that is deemed most appropriate, the intervention phases deemed appropriate
- is capable not only of working at whatever application grouping levels are deemed to be appropriate but even for unique customised machine tool designs
- is adapted to address product modularity
- fits within the MEErP methodology, although it does not require some of the steps, and additionally does require detailed information on expected savings from using specific design options at the module level
- is capable of working with the Ecodesign and energy labelling regulatory process
- is technically feasible from a conformity assessment perspective, but will require a more elaborate procedure than is the case for simpler products.

Step 1 Assessment of key lifecycle stages

This step involves the assessment of the key life cycle stages of the product in question. The intention is not only to develop a points-system to assess the components of a complex product but also to integrate this methodology into the ecodesign development process and ecodesign thinking. Therefore, environmental aspects should also be considered in the design and development process as well as in the use phase. The schematic below illustrates these lifecycle stages from a product development perspective. In the case of machine tools, it can be asserted that there are important opportunities to influence environmental impacts at the early design, detailed design and use stages in the product lifecycle.

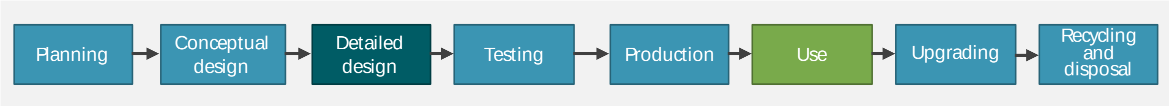

Figure 1: Product life cycle stages

Step 2 Assessment of product scope boundaries and associated impacts at the wider (extended product or product-system) level

The environmental impacts of machine tools are very sensitive to the product scope considered. Major shares of the energy consumption are determined not by the core machining process itself but by other components of the machine tool. The process periphery – including aspects like work-piece and tool handling, cleaning, heating, lighting and waste water conditioning - may also affect the environmental impacts of the overall product system (see Figure 2 for an overview illustration). Depending on the machine tool type, machine tools also often share loads with other products e.g. for compressed air use and cooling fluids and thus the energy flows considered need to take these into account. This makes it necessary to consider an extended product approach for machine tools.

Within a points-system approach, those impacts, which are determined by the product design, can be covered.

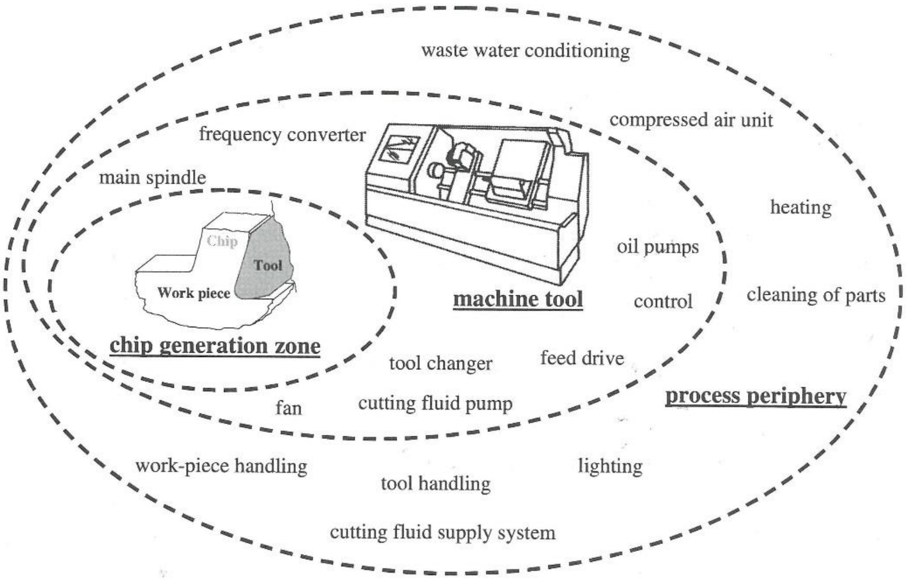

Figure 2: System boundary of the machining process [Abele et al. 2005]

Step 3 Selection of environmental impact criteria

The main environmental impact of a machine tool is the energy use in the use phase. Other impacts resulting from the use of chemicals (e.g. cutting fluids, lubricants) are usually regarded as being of comparatively minor importance. However, this has to be cross-checked via the results derived via the streamlined LCA "MEErP" (Kemna et al. 2011) process that is pursued in any "conventional" Preparatory Study related to Ecodesign product groups.

Material efficiency is another important impact factor. The reduction of scrap production, and reducing the proportion of rejected sub-quality finished end-product machined parts, will both lead to a lower energy use. The effect of reducing the embodied energy will also be taken into account, but as a further criterion in the checklist during the stage ("Stage 1") of product development, and hence on an ordinal scale rather than a cardinal scale, though not as part of the energy impact assessment ("Stage 2"). Figure 10, and the discussions in Section 8, give further details as to these proposals.

Given this, the majority of the case study focuses on the impact of energy in use, rather than a multi-criterion analysis encompassing different environmental impacts. Other important assessment criteria like cost, quality and productivity cannot be considered in these steps, as they would require the definition of a functional unit, which is virtually impossible for machine tools.

Step 4 Determination of the phases at which product design may influence lifecycle impacts

The earliest phases of product development have the highest impact on the final energy use. The selection of the working principle for the desired functionality as well as other general considerations impact the final energy use more than the decisions taken in the subsequent detailed design phase, where the components are selected and designed in detail, as shown illustratively in Figure 3.

Whilst on the one hand the earlier concept and design phases offer the greatest potential possibilities for design improvements, or product-service alternative ideas, on the other hand, the potential to concretely assess environmental impacts via measurement or simulation in those early stages is rather low.

However, at these earlier conceptual phases, modularity of design, the possibilities for modules to be upgraded in the future, and access to the machine's modules to facilitate reparability and ease of maintenance can be considered, and incorporated, as feasible and desirable.

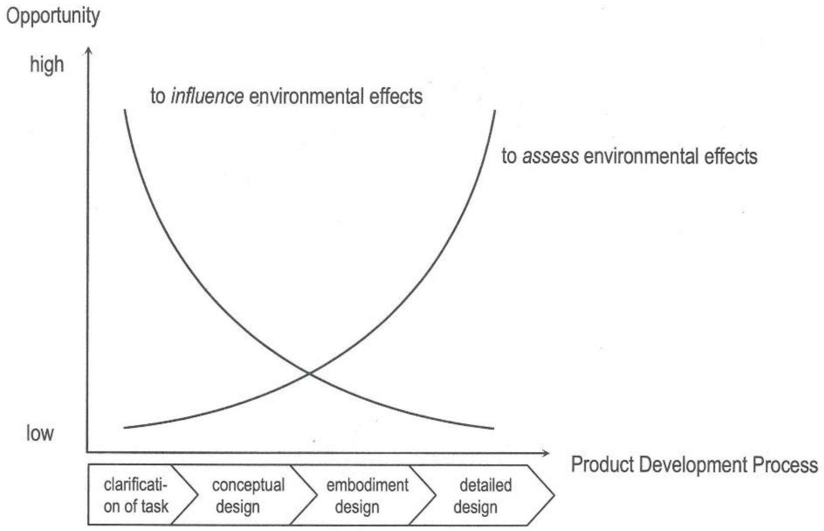

Figure 3: opportunities to influence and assess environmental impacts during the product development process [Atik 2001]

In the detailed design phase, the product designer has a very direct influence on the product's environmental impacts, as (s)he is selecting and designing the individual components of the product. The potential to assess those impacts in detail via measurement, iterative analysis and potential iterative design changes is very high, i.e. it is more straightforward to assess these lower magnitude impacts than it is for the potential (but ambiguous) possibilities to achieve higher magnitude design change impacts in the early design phase.

Furthermore, the way the product is subsequently used has a very significant impact on its energy consumption and thus measures that influence user behaviour are important and need to be taken into consideration. Nonetheless the potential for the designer to influence user behaviour is limited and subject to high uncertainty.

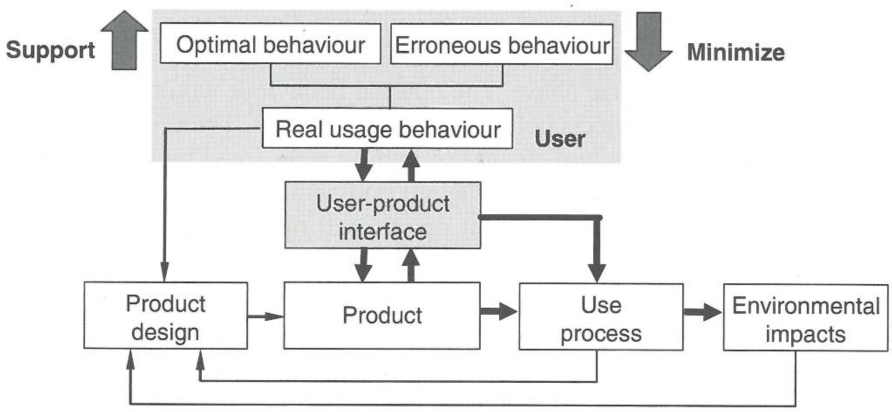

Figure 4: User-product interface [Abele 2005]

For the purpose of our analysis we distinguish three stages:

- product development (including testing, production and disposal)
- detailed product design
- the use phase.

Those stages are described in more detail in the following paragraphs.

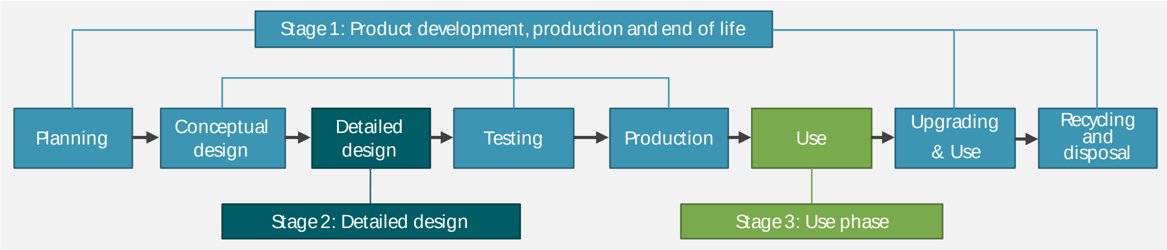

Figure 5: The three product stages (Stages 1, 2 and 3) that have most impact on machine tool energy consumption

The product development stage

Content of the stage:

This first stage is characterized by planning activities, conceptual thinking and the overall (environmental) management without going into the concrete design and specifications of the product. Furthermore, this stage also contains aspects of the subsequent phases after the stage of the detailed product design until the end-of-use, a potential upgrading and recycling of the product. The first stage contains those aspects which are not directly quantifiable, and which are more related to sustainable life-cycle-thinking. Criteria which might thereby play a role are quite heterogeneous, including, for example, considering issues such as the potential to: substitute energy-intensive materials; increasing material efficiency and reducing embodied energy, reduce friction; or "design for recycling", "design for upgrading", "design for light-weighting", etc. Taking different approaches for "design for x" into account assumes that the machine tool consists of different modules which might be replaced, repaired or recycled. Especially the upgrading of different machine modules offers the possibility to increase energy efficiency by adding more favourable modules or components at a later time. Since this effect is quite hard to determine ex ante and due to the high heterogeneity of components, such a future effects are not possible to include adequately in the present assessment. For that reason, there is no attempt to quantify this impact. Instead, it is proposed to reward this "design for x"-thinking in the early stages, in a qualitative manner.

Potential sources of good/ best practice for product and process design strategies:

A first set of criteria can therefore be derived from ISO 14955-1:2014 Annex A: "Overall machine concept", (ISO 2014) see *Figure* 6, or from Preparatory Study (ENTR Lot 5) (Schischke et al. 2012), from the Working Document for the Ecodesign Consultation Forum, May 2014 (EC 2014)[1] or via the "Blue Competence" publication by VDMA, Figure 7 (VDMA (Ed.) 2013)[2].

Additional criteria such as the use of virtual machining or the use of integrated ecodesign environments in the product development process can easily be included in the list of criteria.

[1] It should be noted that the Preparatory Study and the Working Document derive the measures from ISO 14955.

[2] Comparing Figure 7 to Figure 6, note that the features listed in Figure 7 are more related to overall (environmental) management rather than to direct design measures.

No.	Feature for improvemcnt	Description
1	Overall machine concept	
1-1	Minimization of moved masses	
1-2	Reduction of friction	Reduction of friction means less mechanical wear and higher quality and also should lead to energy reduction; various types of bearing possible (rolling bearing, sliding bearing, hydrostatic bearing): ecological aspect has to be considered by the choice of bearings as well.
1-3	Optimization of the electrical design	Check if the machine tool has been designed according to customer design requirements and operational range has been specified close to optimal working point; avoid adding up spare capacities (avoid over sizing/over-engineering).
1-4	Design for Instant machining without warm-up	Provisions for automatic temperature compensation.
1-5	Work piece clamping and tool clamping	Use best efficient technology
1-6	Multi-spindle/multi-work pieces machining	
1-7	Complete machining all sides	
1-8	Combination of various technologies (turning + milling + laser + grinding, etc.)	Combination of technologies in one machine, one-time mounting and adjusting may result in higher quality and higher yield and also causing less energy consumption
1-9	Axis clamping	Usage of axis clamping instead of active motor brake
1-10	Redundant axis	High acceleration with short-stroke axis reducing acceleration for long-range, heavy axis.
1-11	Increase output	Without utilization (production) or low output, the efficiency will be degraded.
1-12	Provide customer interaction to reduce consumption of resources	Give the operator provisions to interact when he expects downtime
1-13	Tool change during running spindle (milling machine tools used in a way to change tools very frequently)	Provision to allow a tool change during running spindle to avoid deceleration and acceleration of spindle.

Figure 6: Criteria from ISO 14955

	criteria
1	The company has defined goals for its products and staff that incorporate sustainability-aware action.
2	The design guidelines incorporate sustainability criteria that extend over all life phases of the product concerned.
3	The product documentation describes aspects of resource-economical operation and the relevant precautions taken with the product.
4	A concept is in place for professionally fit-for purpose disposal following the end of the useful lifetime.
5	The company's service capabilities include professionally expert consultancy on energy- and resource-economy during daily use of the product.
6	The company declares its willingness to quantify its measures for efficiency upgrading in its products as exemplified by at least one case study. This case study (or studies) may also be used by the participant within the framework of the Blue Competence campaign.
7	The company operates a management system in which sustainability-driven goals are also specified and monitored in the same way as quality targets and criteria. The commitment to continuous improvement (CIP) is a constituent part of this management system and also covers sustainability-related goals.
8	The issue of "sustainability" has for the company and its products been assigned to a person in the top management.

Figure 7: Criteria from Blue Competence

The detailed product design stage

Content of the stage:

The detailed product design stage focuses on the components of a product and how these can be selected and combined in the most energy-efficient way. To do so, first all the components have to be listed and then assessed with regards to their energy saving potential. Furthermore, it is necessary, or at least highly desirable, to avoid cases where features which increase the energy efficiency correlate with other features or components in a negative way (i.e., avoiding any unnecessary "trade-offs", wherever possible). Thus, combinations which would lead to those effects need to be detected and avoided.

Potential sources:

Potential opportunities and design options to improve machine tool energy-efficiency are set out in Annex A and B of ISO 14955-1:2014. As a first step, the saving potential of a machine tool design feature may be derived from the findings of the ENTR Lot 5 Preparatory Study (Schischke et al. 2012).

Measure	Cost effects (invest-ment) Increase in total ma-chinery invest (ten-dency)	Total ma-chinery sav-ings potential (tendency)
Option 1		
10.3 Minimise non-productive time	0%	5%
Option 2		
2.8 400V inverter systems to substitute 200V systems	0%	1%
Option 3		
2.1 Regenerative feedback of Inverter system (servo motor/spindle)	0%	0,5%
Option 4		
8.1 Controlled peripheral devices like mist extraction, chip conveyer, etc	0,2%	1%
Option 5		
7.10 Single master switch-off	1%	1%

Figure 8: Example of energy savings potentials from the use of machine tool design options as reported in ENTR Preparatory Study (Note option 1 should be considered to be associated with stage 3 [see later in this report], addressing the use phase)

The user guidance stage

Content of the stage:

The use phase follows on the product development and design process and therefore focuses on the energy-efficient operation of the product. This stage is of great importance because most of the measures previously discussed could be counteracted by deficiencies in how the product is used. Therefore, this third stage can be seen as accompanying the first stage, while explicitly concentrating on the use phase.

Potential sources:

Annex A & B of ISO 14955-1:2014 under point 9: “Guidance for energy-efficient use” contains a list of user guidance on the operation of machine tools that is an appropriate listing of relevant criteria, as shown in Figure 9.

9	Guidance for energy-efficient use	
9-1	Optimization of work piece processing by die tryout	Workpiece processing by tryout off-machine; avoidance of inefficient operating time; use also possible in conceptual phase of machine tool production.
9-2	Provisions to reduce scrap production	Die monitoring, in-process control, optimized use of raw material, minimize waste, zero-defect production.
9-3	Provide customer information to reduce consumption of resources	Training of operators leads to energy-sensitive handling of the machine tool.
9-3-1	Information to user on energy-efficient use of the machine e.g. on/off programming of auxiliary devices (users manual, instruction)	Give the operator information e. g. how to interact when he expects downtime.
9-3-2	Information to user on optimized movements of axis	Means for optimization of movements of multiple axis systems (feeders, robots) to follow energy-optimized moving curves
9-3-3	Information to user on usable exergy	Provide information about type of exergy carrier (e.g. water) and temperature of medium to choose optimal means for recovery.
9-4	Minimize non-productive time	Without utilization (production) or low output the efficiency will be degraded. Means of improving output may be automatic die change systems, condition monitoring to prevent component failures, good diagnostic for quick trouble shooting etc.
9-5	Optimize productivity by reducing cycle time per part	An improved productivity reduces the portion of required basic load per part.

Figure 9: Criteria from ISO 14955-1:2014 "Guidance for energy-efficient use"

Step 5 Assessment of whether a points system approach is potentially merited or not

Especially when considering the use phase and the early design stages, it is clear that there is a need to recognise a broad mix of qualitative criteria for good product design as well as the more quantitative criteria considered in the detailed design phase. The environmental impacts of the qualitative/ stages, as pointed out earlier in Steps 3 and 4, are difficult to estimate with any accuracy in a quantifiable (cardinal) manner. Still, they are of major importance for the productivity, functionality and final environmental impacts of the selected product design.

Furthermore, a rigorous performance assessment method cannot always be applied for machine tools, as the definition of the functional unit is often very challenging and the overall impact of specific technological requirements partly outweighs the saving potentials of individual measures.

All three questions laid out in the point system methodology can be answered positively:

a) There is a mix of quantifiable (cardinal) and more qualitative product ecodesign features, yet it is appropriate to also ascribe some value to the qualitative features because these are expected to bring environmental benefits.
b) The presence of specific ecodesign features is known to bring environmental benefits, but the relative importance of the benefit to a given environmental impact parameter is difficult to determine in a reliable manner, at the level at which the scope of a prospective regulation would be expected to apply.
c) It is too complex to apply a rigorous performance assessment method in practice, but a points-based approach (which awards points depending on the ecodesign features used) could provide an acceptable compromise that allows requirements to be set that encourage progress in a positive direction without being overly constraining.

Step 6 Assessment of the implications of product modularity

Machine tools are inherently modular. They consist of a variety of different components/modules, each with their individual function. Those components/modules can be assessed and optimized individually. The interaction of the modules has to be covered by the consideration of the early design stages in parallel with the process of optimising individual modules.

Thus, in this case study we propose to use "analytical modules". Those modules can represent two different aspects of the machine tool:

First, they apply to each machine component when assessed in the detailed design phase. Second, they can represent the impact on in-use energy consumption of the design process followed in the early design stage, and – separately - the quality of user guidance provided. This is a hybrid approach that combines modularity in component function with modularity in the phases at which product design may influence lifecycle impacts, and it is thus fully in line with the thinking expressed in the Task 3 methodology. Importantly, it also blends cardinal and qualitative inputs, as per Step 5.

For modules or parts already within the scope of existing ecodesign regulations (e.g., motors, fans, etc) the impact of going beyond the minimum requirements has to be assessed. If exceeding minimum requirements leads to an improved solution in the product context, they should be considered, otherwise they should be left out of consideration.

Step 7 Assessment of the implications of product performance sensitivity to the final application

A machine tool's environmental impact is highly sensitive to the use profile (duty profile) of the final application. In general it can be said that the share of the different operational states of the machine tool have an important impact on the final energy consumption, but are also sensitive to the final application.

While the energy consumed during unproductive modes is rather independent of the actual application of the machine (but not of the overall design itself), the energy consumed in the times of productive operation can vary substantially depending on the actual product being made and on the mode of production. For example, the same machine tool can be used for batch or single unit production, yet these different production modes are likely to have quite different energy requirements per machined workpiece produced. The workpiece characteristics also have an impact on energy use itself as well as the ratio between the operational and set-up/idle times, and these can vary from one job to another. Thus, heterogeneity in the machine tool design, the pieces being machined and the mode of production render it difficult to define generic duty profiles for many classes of machine tools. Furthermore, while it may be possible to map some classes of machine tool to some types of application, such that representative duty profiles could be established in these cases, it is beyond the scope of the current study to investigate this issue and to establish under what circumstances acceptable generic duty profiles could be defined. Nonetheless it is clear that there will also be many cases where the machine tools and their applications are too heterogeneous for adequately representative duty profiles to be established across the classes of machine tool and applications concerned.

Nevertheless, the designer of a machine tool will aim to optimize the product for a selected number of typical use cases. In addition, the intended application of a machine tool will generally be indicated during the design phase and before placing the product on the market. Thus any given machine tool designer can either be expected to know enough about the intended use of the tool to be able to define suitable duty profiles during the design process, or to be able to make use of generic duty profiles when the machine tool is destined for more generic (and predictable) applications. In both cases duty profiles will be assumed and hence could be used for Ecodesign assessment, provided that the working assumptions are documented and made available.

For those cases when the purpose of the machine tool is unknown, the uncertainty should be considered. The designer could at least state the main purpose for which the machine tool is designed, even though inherently accepting that it is unknown whether the customers will really use the machine tool for this purpose.

Note, as the energy budget calculations of Step 8 make use of the duty profiles, in theory it is possible to apply the same approach to determine the sensitivity of the points outcomes to the duty profile. Thus the methodology could provide a means of establishing the validity, or otherwise, of any prospective generic duty profiles being considered for the more predictable machine tool class and application combinations.

Regarding the criteria laid out in the methodology for most machine tools, the performance assessment is sensitive to the product application, and the intended application cannot be indicated at the time of first placing on the market; however, the actual application(s) can be added by a site-specific product designer or specifier.

Step 8 Determination of environmental impact budgets

As previously discussed in Step 4, the environmental impact budgets to be developed in this step (8) will need to take account of the product development stage, the detailed design stage and the use phase.

The Task 3 methodology requires each stage to be allocated a proportion of the total machine tool energy consumption in proportion to its impact on the overall energy consumption. For Stages 1 and 3 this is not measurable in any normal sense and hence a process would need to be agreed to decide what proportion of the total energy budget these would be allocated, noting that these Stages do not actually consume energy, but help to save it. Thus, these Stages would need to be awarded a part of the overall Step 8 energy budget that reflects their expected contribution to the whole machine tool’s energy performance.

Each of these is now considered in turn as if they were distinct modules in the environmental impact budget. In line with the Task 3 methodology these stages are then aggregated at the end of this step prior to normalisation in Step 9. In this case study we only consider energy performance in a cardinal manner, and thus all the stages address this specific environmental impact parameter However, we propose that other criteria, for example the reduction of embodied energy, be considered in an ordinal manner.

8.1 The product development stage

Assessment:

The objective during the product development stage is to encourage machine tool designers to adopt a design process that considers the environmental impact of their designs and systematically considers the means to reduce them.

A checklist methodology to be followed during the design process is probably the most straightforward means of promoting this. Defining exactly which criteria should be part of the list is something that would need to be established in a more detailed analysis of all the potential checklist elements and their potential application. However, if such a process is to be usable within an Ecodesign regulatory context, then it would need to be structured in such a way that the quality of the process followed can be verified by a third party as needed. Self-declaration, third party audit and the provision of additional material (such as detailed documentation) could all have a role to play, in order to satisfactorily demonstrate that the relevant aspects were truly considered, and have been achieved. ***In principle, the degree of credible evidence put forward as proof that the checklist methodology was followed and applied could also be incorporated into the points assessment for this stage, such that stronger documentation or a voluntary third party audit could be given a higher weighting than would weaker documentation and self-declaration.***

An illustrative checklist for determining the score regarding the consideration of ecodesign thinking in the stage of product development is depicted in the following table in the case of a machine tool (for example for a multifunctional milling centre).

The first column serves to register if the listed aspect can be taken into consideration or can be implemented. If it is not possible to implement a certain aspect, this will be considered regarding the achievable score. Then, the second column demands whether it has been realised, and to what extent. The stated extent can be rated according to an ordinal scale:

Table 1: Realisation of aspects and corresponding weightings

Realised to what extent	**Explanation**	**Weighting of activity/-ies**
Not realised	no activities undertaken	0
Poorly realised	minor activities undertaken	1
Moderately well realised	activities undertaken which offer a recognisable benefit	2
Well realised	activities undertaken which have a moderately high impact	3
Extremely well realised	Activities undertaken which have a high impact	4

The values assigned to the ordinal scale are used as weightings for the overall score achievable by these ordinal aspects. The decision and description should be briefly commented on in the third column and the action is verifiable via the additional information listed in column four. To pay attention to the different effort and evidence for the documentation, a weighting hierarchy is provided which is easy to understand and which does not compulsorily entail excessive documentation efforts for the manufacturers. Therefore, the following weighting is proposed. A simple self-declaration is rewarded with a weighting score of one. Providing evidence-based[3] documentation is taken into account with a weighting of two. Additionally, an external evaluation by a third-party audit is weighted with a score of three. By choosing this weighting, the greater effort required for an external audit receives a higher weighting. However, the additional score for third party auditing is not excessive, and as such, manufacturers would not be forced to have these audits performed for every aspect in order to be able to attain sufficient points for the required minimum final score. Based on the documentation provided, it is possible to cross-check to what extent an aspect really was realised and hence evaluate the accuracy of the assigned

[3] "Evidence-based" means that the information can be revised by a reviewer, based on a physical or digital source. The evidence provided must be complete and auditable, and must allow the reviewer to obtain a full, in-depth insight as to how the aspect is realised.

score. If all necessary information is provided and the aspect was realised to a high extent, a maximum of 12 points can be achieved (4 points for the degree of realization, multiplied by 3 points for the fullest and most reliable documentation, via a third-party audit). If additional information to support verification is not given, or the short description is missing, no points at all are given. Where an aspect is impossible to implement, or to be considered, an explanation has to be given why. If the argument put forward is valid, this aspect is not considered when calculating the maximum achievable score. By following this logic, a generic checklist can be used which also takes the uniqueness of most machine tools into account. A worked example of a checklist is shown in Figure 10 and explained in the text below.

General aspects for an eco-friendly product development:	Possible?	To what extent realized (0-4)[1]	Short description	Verifiable by:	Weighting Factor[2]	Points achieved
Sustainability criteria are taken into account during the whole product-life-cycle	✓	3	Checklist developed and used	Source [1]: Guideline	2	6
Main components that are susceptible to wear and tear have been well identified, and actions have been taken to prolong components' lifetime.	✓	0				
A concept for disposal of the product exists	✓	4	Guideline for disposal	Third party audit	3	12
Consultancy for considering energy-efficient aspects reagrding the intentended place of operation of the machine tool offered	✓	3	On-site consultancy	Self declaration	1	3
An upgrading of specific modules is feasible	✓	3	Modularity and interconnections taken into account. Components can be changed independently.	Source [2]: Blueprint	2	6
Machine tool specifc aspects for an eco-friendly product development:						
The complete machining all sides was considered			Not necessary, only working on one side			
The minimization of moved masses was considered	✓	4	Steel part substituted by an aluminium component. Further improvements not possible.	Source [3]: Blueprint	2	8
The reduction of friction was considered	✓	2	Partly: Would imply additional lubrication system. Low-friction bearings were implemented	Source [4]: Blueprint	2	4
Embodied energy was reduced	✓	2	By using a new processing method, the built-in materials were remarkably reduced. The use of the aluminium component increased embodied energy.	Third party audit	3	6
A multi spindle/multi work pieces machining was considered	✓	0			0	0
The combination of various technologies (turning + milling + laser + grinding, etc.) was considered	✓	1	Would increase complexity of the product.	Self declaration	1	1
Providing customer information to reduce consumption of resources was considered	✓	4	Personal instruction and information letter	Third party audit	3	12
					Max Points	Σ
					132	58

[1] 0 = not realized; 1 = poorly realized; 2 = moderately realized; 3 = well realized; 4 = extremely well realized
[2] 1 = Self declaration; 2 = internal documentation; 3 = third party verified documentation

Figure 10: Example machine tool checklist for the product development stage

In the above worked example, the first aspect regarding the consideration of sustainable criteria can be and was implemented based on a checklist (derived from the short description). However, it was well realized and hence this results in a score of three out of a possible four. This is documented by a provided guideline explaining the checklist. This type of documentation is given a weighting of a factor of two. This leads to a score for this aspect of 3 x 2 = 6 (as shown in the column on the right). The next aspect could also be implemented or considered. However, it was not considered, and no further explanation was given as to why this was not done. Hence, this aspect receives a score of 0, and is also taken into account, when calculating the maximum number of points achievable. On the other hand, the aspect "Complete machining all sides" was also not implemented, but a reasonable and tenable explanation was given as to why. Because this explanation seems clear and comprehensive, this aspect is not considered when calculating the maximum score. Thus, in the case of these 12 potential aspects a maximum of 132 (i.e. 11 x 12) points can be achieved in this specific case (Number of aspects (12 - 1 =11 [since one was not relevant]) x Max. Points per aspect (12)).

8.2 The detailed product design stage

The assessment of the environmental impacts of the components will be carried out using a cardinal scale, assigning deemed energy savings for the different design options which can be applied to the module.

To assess the energy performance of a machine tool all the core modules (e.g. drive unit, pneumatic system, etc.) of the product must first be listed and for each module a correlation matrix with the potential design options is created.

The modules are named and identified in accordance with ISO 14955-1:2014:

- Overall machine concept
- Drive units
- Hydraulic systems
- Pneumatic systems
- Electric systems
- Cooling lubrication system/Die cooling/lubrication system
- Cooling system
- Peripheral devices
- *Guidance for energy efficient use*[4]
- Control systems

The assessment within this step is comprised of several sub-steps:

1. Definition and population of the design option measure correlation matrix
2. Identification of the relevant operating states
3. Identification of generic energy saving potentials
4. Identification of the case for assessment
5. Identification of the reference case
6. Identification of the BAT case
7. Determination of relative performance of the selected design

Definition of the correlation matrix

For each of these modules, ISO 14955-1:2014 defines potential energy saving options. The implementation of those saving options may be exclusive. Thus a

[4] Not relevant for the detailed design phase, but considered for the use phase.

correlation matrix for all potential saving options has to be created to determine which options ***are*** mutually exclusive.

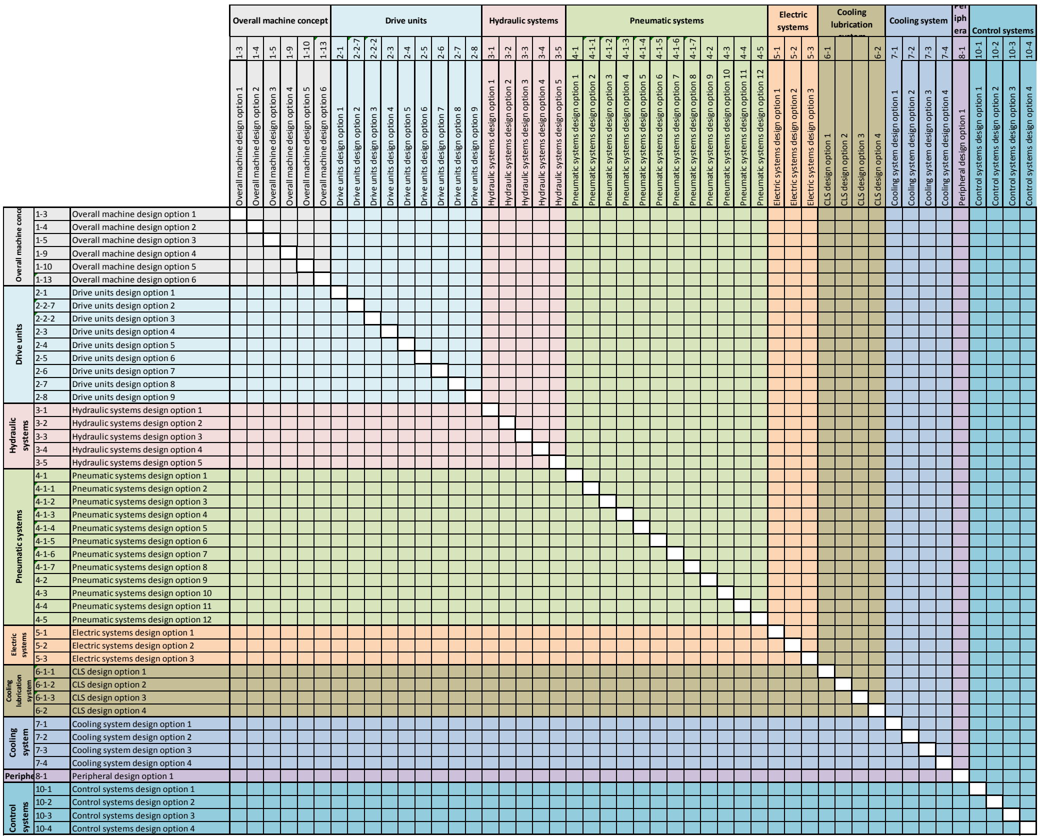

Figure 11: Empty example correlation matrix for a machine tool

Based on this correlation matrix a pairwise comparison of all features is conducted. The objective of this comparison is on the one hand the elimination of features which are not feasible or offer no benefit and on the other hand, to detect those features which are mutually exclusive. In the latter case, the option offering the higher saving potential should be considered.[5]

In the following figures and text, the descriptions focus on a single example module (drive units – see the coloured sections of the figure), however, the same process would need to be followed for other modules.

[5] This is under the assumption that no other features are excluded by the choice. Otherwise, the overall saving potential has to be determined considering all exclusions.

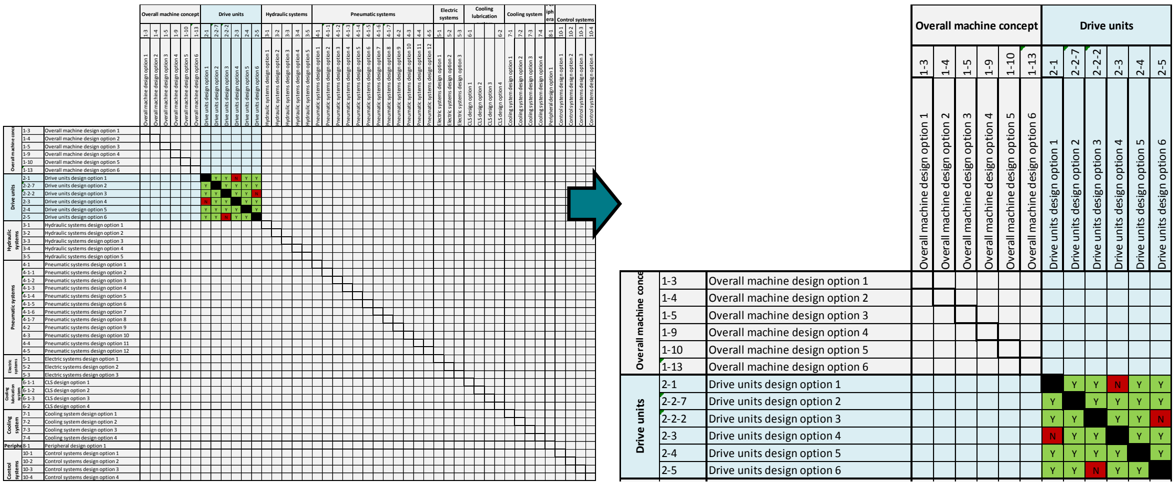

Figure 12: Population of the correlation matrix.

The compatibility of different combinations of energy efficiency design options is shown in the matrix below. For each combination of the different design option it is indicated, whether they can be combined in the product or not.

	Design option 1	Design option 2	Design option 3	Design option 4	Design option 5	Design option 6
Design option 1	n.a.	Possible	Possible	Not possible	Possible	Possible
Design option 2	Possible	n.a.	Possible	Possible	Possible	Possible
Design option 3	Possible	Possible	n.a.	Possible	Possible	Not possible
Design option 4	Not possible	Possible	Possible	n.a.	Possible	Possible
Design option 5	Possible	Possible	Possible	Possible	n.a.	Possible
Design option 6	Possible	Possible	Not possible	Possible	Possible	n.a.

Figure 13: Detailed view of the population matrix for one module

Identification of the relevant operating states

Next, for each module, the relevant operating states have to be identified. The operating states can be chosen in accordance with ISO 14955-1:2014, Annex D, but are not limited to this example. In the following tables, four operating states are used for illustrative purposes.

Identification of generic energy saving potentials

After defining the relevant operating states, generic energy savings need to be defined for each energy efficiency design option and for each operating state (preferably in accordance with ISO 14955). These energy savings should reflect a realistic saving potential, which can be achieved by the sound implementation of the respective energy saving measures. This results in a generic energy saving matrix for each module. Table 2 shows an example for a hypothetical drive unit.

Those savings are defined for the individual savings. It is assumed that the combination of the design options can be calculated by a linear combination of the individual savings. Figure 13 shows which of these combinations can be realized in the product.

Table 2: Energy saving potentials for design options compared to the reference case

	Off	Standby with peripheral units off	Warm Up	Processing
Reference case	0.0	0.0	0.0	0.0
Design option 1	0.0	1 %	2 %	1 %
Design option 2	0.0	3 %	-2 %	2 %
Design option 3	0.0	1 %	2.5 %	2.5 %
Design option 4	0.0	2 %	3 %	1 %
Design option 5	0.0	3 %	2 %	3 %
Design option 6	0.0	1.5 %	1.75 %	4 %

Note that savings may be negative (as for design option 2 during the processing) if a saving option leads to increased energy use in one operating state.

Identification of the case for assessment

For the design option actually selected for the machine tool in question, the power intake and annual energy consumption have to be determined for each of the identified load states. Those values could either be determined by measurement or derived from the design calculations. Table 3 shows an example for a hypothetical drive unit.

The fractions of time are derived from the operating hours of the product. The machine tool presented is off on most weekends leading to ~2200 off mode hours. During workdays, the machine tool is operative for ~6.5 hrs. per day, in warm-up for another ~3 hrs. and in standby mode for ~14.5 hrs.

Table 3: Annual Breakdown of Energy use of the selected design (for a hypothetical drive unit)

	Off	Standby with peripheral units off	Warm-Up	Processing	Total
Fraction of time	25% (~2200 hrs.)	45% (~3950 hrs.)	10% (~850 hrs.)	20% (~1750 hrs)	100% (~8750 hrs)
Power Intake (kW)	0.00	0.10	1.20	1.94	0.55
Energy use (MWh/year)	**0.0**	**0.8**	**10.5**	**17.0**	**4.8**

Identification of the reference case

For many Ecodesign assessments where an energy efficiency index is determined, the reference case is a product that is representative of the average energy performance on the market at a given time; however, whilst this is suitable for relatively uniform products, for which an energy efficiency index can be easily defined, it is much less suitable for highly heterogeneous products, whose performance is sensitive to the duty profile and task being set (i.e. nature of the workpiece and production run), such as machine tools. For machine tools, there are simply too many variables to have confidence in defining a generic energy efficiency index (as discussed in Step 7). Rather, it makes sense to use an approach using different energy savings design options, as listed e.g. in the standard ISO 14955-1:2014. By doing this a reference case may be defined to be the product which has none of these energy saving features (as per Table 2).

This can be done on a module–by-module basis, which reflects the reality of machines tools being assemblies of modules for which there is more predictability, with regard to the impact of using different design options to influence their energy performance.

The purpose of having a reference case product is that it defines a benchmark against which the performance (energy efficiency in this case) of other products can be compared[6]. If the reference case is considered to be the product which has no energy saving design options, then it represents the solution with the least energy efficiency for the given task, and hence defines the lower performance boundary. By contrast, the best available technology (BAT) is the product which incorporates all the available and mutually compatible high efficiency design options, and hence defines the other end of the spectrum from the reference case. It should be noted that, since the energy efficiency design options are simply expressed in terms of energy savings potentials then no reference energy consumption level has been defined (rather, we define relative energy efficiencies depending on the design options used). Thus for performance declaration and verification purposes it would be necessary to see which design options have been deployed in a given design to determine its relative efficiency.

To determine the energy use of the reference system, the deemed energy savings or the energy demand in relation to the reference case have to be used to perform a backwards calculation of the reference case power intake.

Using the deemed savings from Table 3, the relative energy use of each design option can be calculated (remaining energy use = 1 - energy savings). The product of the remaining energy use of all selected design options for the selected design represents the overall savings of the selected design for each operating state. Table 4 shows an example of this type of calculation for a hypothetical machine tool drive unit module, in which two design options are incorporated into the selected design. As a result of both design options being implemented, the “selected design” comparative energy design compared to the reference case is calculated via the resulting percentage - for each column below – from multiplying the design option 1 percentage by the design option 2 percentage.

Table 4: Comparative energy demand: Selected design options compared to the reference case

	Off	Standby with peripheral units off	Warm-Up	Processing
Design option 1	100%	99%	98%	99%
Design option 2	100%	97%	102%	98%
Selected design	100%	96%	100%	97%

Dividing the energy use of the selected design (which is determinable by measurement or design calculations) by the relative energy use values shown in Table 4 allows the energy use of the reference case to be calculated (as shown in Table 5). The values cited below are hypothetical, which would be derived from both the actual energy use of the selected design (which is known by measurement) and the (theoretical) deemed savings. This reference case has to be defined individually for each assessed product and load profile.

[6] A reference case is simply a product that can be used to define a benchmark performance level that is then used for comparison against other products having differing performance (energy efficiency in our case) levels.

Table 5: Energy use of the reference case hypothetical drive unit

	Off	Standby with peripheral units off	Warm-Up	Processing	Total
Fraction of time	25% (~2200 hrs.)	45% (~3950 hrs.)	10% (~850 hrs.)	20% (~1750 hrs)	100% (~8750 hrs)
Power Intake (kW)	0.00	0.10	1.20	2.00	0.57
Energy use (MWh/year)	**0.0**	**0.9**	**10.5**	**17.5**	**4.9**

The absolute energy savings of the selected design are calculated as the difference in energy consumption to the reference case.

Identification of the BAT case

By knowing all feasible design options as well as their savings potentials, the total sum of savings for different design options can be determined for each module and load profile. The maximum savings achievable are determined once the following two parameters are known:

- The individual duty profile of the machine tool
- The potential combinations of design options.

A specific case has to be defined for each potential combination of design options. For each case, the overall savings (from the combination of energy savings design options) are then determined by considering the duty profile and savings potentials under each phase of the profile.

Two general cases have to be considered in building the BAT cases:

1. All design options decrease the energy demand for all stages of the duty profile
2. One or more design options increase(s) the energy demand in at least the "on" stage of the duty profile.

For both cases, the cases are built from the matrix of all potential combinations of measures, compared to the possible combinations (Figure 13, as previous). For example, a combination of design options 1, 2, 4 and 5 is not possible, as the options 1 and four are incompatible. Figure 14 shows the potential combinations with all exclusions marked in red. The combination of all design options and of five design options is not possible due to the exclusions. Therefore, the maximum number of combinable design options is four. Four cases are possible using four design options.

All Design Options	1	2	3	4	5	6	not possible	
Five Design Options	1	2	3	4	5	n.a.	not possible	
	1	2	3	4	n.a.	6	not possible	
	1	2	3	n.a.	5	6	not possible	
	1	2	n.a.	4	5	6	not possible	
	1	n.a.	3	4	5	6	not possible	
	n.a.	2	3	4	5	6	not possible	
Four Design Options	1	2	3	4	n.a.	n.a.	not possible	
	1	2	3	n.a.	5	n.a.	possible	Case 1
	1	2	n.a.	4	5	n.a.	not possible	
	1	n.a.	3	4	5	n.a.	not possible	
	n.a.	2	3	4	5	n.a.	possible	Case 2
	1	2	3	n.a.	n.a.	6	not possible	
	1	2	n.a.	4	n.a.	6	not possible	
	1	n.a.	3	4	n.a.	6	not possible	
	n.a.	2	3	4	n.a.	6	not possible	
	1	2	n.a.	n.a.	5	6	possible	Case 3
	1	n.a.	3	n.a.	5	6	not possible	
	n.a.	2	3	n.a.	5	6	not possible	
	1	n.a.	n.a.	4	5	6	not possible	
	n.a.	2	n.a.	4	5	6	possible	Case 4
	n.a.	n.a.	3	4	5	6	not possible	

Figure 14: Combinations of four or more design options

In the first case (which is not applicable for the example), all the combinations that are a subset of another combination do not have to be considered, as they will lead to lower overall savings. If there were no negative savings, for example, case 5 in Table 6 overleaf (the combination of the design options 1, 3 and 5) will always have higher savings than all other combinations of the design options 1, 3 and 5. Therefore, those other cases would not have to be considered.

In the second case, design options that give negative savings for certain stages of the load profile exist. A case without them must also be considered. In our example, one design option (design option 2) has negative savings in one operating state (i.e. duty profile stage). Thus, case 5 is derived from case 1 by removing design option 2.

Figure 15 shows all combinations of three design measures. The design option with negative savings is marked in yellow. Only measures without this option are considered as cases, as all others are subsets of cases 1-4 with lower savings.

Three Design Options	1	2	3	n.a.	n.a.	n.a.	possible	subset of Case 1	
	1	2	n.a.	4	n.a.	n.a.	not possible		
	1	n.a.	3	4	n.a.	n.a.	not possible		
	n.a.	2	3	4	n.a.	n.a.	possible	subset of Case 2	
	1	2	n.a.	n.a.	5	n.a.	possible	subset of Case 1&3	
	1	n.a.	3	n.a.	5	n.a.	possible	subset of Case 1	Case 5
	n.a.	2	3	n.a.	5	n.a.	possible	subset of Case 1&2	
	1	n.a.	n.a.	4	5	n.a.	not possible		
	n.a.	2	n.a.	4	5	n.a.	possible	subset of Case 2&4	
	n.a.	n.a.	3	4	5	n.a.	possible	subset of Case 2	Case 7
	1	2	n.a.	n.a.	n.a.	6	possible	subset of Case 3	
	1	n.a.	3	n.a.	n.a.	6	not possible		
	n.a.	2	3	n.a.	n.a.	6	not possible		
	1	n.a.	n.a.	4	n.a.	6	not possible		
	n.a.	2	n.a.	4	n.a.	6	possible	subset of Case 4	
	n.a.	n.a.	3	4	n.a.	6	not possible		
	1	n.a.	n.a.	n.a.	5	6	possible	subset of Case 3	Case 6
	n.a.	2	n.a.	n.a.	5	6	possible	subset of Case 3&4	
	n.a.	n.a.	3	n.a.	5	6	not possible		
	n.a.	n.a.	n.a.	4	5	6	possible	subset of Case 4	Case 8

Figure 15 Combinations of three design options

Therefore, eight cases are relevant for the determination of the maximum savings in each operating state. The first four cases represent the potential combinations of the design options; cases 5-8 are their equivalents without design option 2.

Table 6: Considered combinations of the design options for the BAT case

Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8
Design option 1	Design option 2	Design option 1	Design option 2	Design option 1	Design option 1	Design option 3	Design option 4
Design option 2	Design option 3	Design option 2	Design option 4	Design option 3	Design option 5	Design option 4	Design option 5
Design option 3	Design option 4	Design option 5	Design option 5	Design option 5	Design option 6	Design option 5	Design option 6
Design option 5	Design option 5	Design option 6	Design option 6				

For each case (which might be the BAT case for our machine tool), the cumulative savings can be calculated by the multiplicative combination of the individual options (as already shown for the reference case in Table 5).

The reference case always has 100 % energy use. For example, case 5 includes design options 1, 3 and 5. They have savings of 1%, 1% and 3%.

The energy demand of case 5 in standby mode compared to the reference case is therefore calculated as the product of the three design options:

(100% - 1%)*(100% - 1%)*(100% - 3%) = 95 %

The calculation is in principle the same for all other design options using the respective values and combination of design options.

Table 7: Energy demand of the potential BAT cases compared to the reference case

	Off	Standby with peripheral units off	Warm Up	Processing
Case 1	100%	92%	96%	92%
Case 2	100%	92%	96%	90%
Case 3	100%	91%	95%	92%
Case 4	100%	92%	96%	89%
Case 5	100%	95%	94%	94%
Case 6	100%	95%	94%	92%
Case 7	100%	94%	93%	94%
Case 8	100%	95%	94%	91%

In our example, the maximum savings depend on the duty profile. In Standby mode, Case 3 has the highest savings, while Case 7 does in warm up and Case 4 does in full (processing) load. This means that the maximum savings can only be determined depending on the shares of operating states (duty profile stages) and the energy budget of the various operating states.

Therefore, the individual duty profile has to be included in the selection of the BAT case. Table 8 shows the potential energy use of the cases for the duty profile and energy use of the different load states. The fraction of time spent in each load profile mode is taken from Table 3.

Table 8: Potential energy use of the hypothetical drive unit cases

	Off	Standby with peripheral units off	Warm Up	Processing	Weighted Total
Fraction of time	25%	45%	10%	20%	100%
Energy use (MWh/year)					
Case 1	0.0	0.8	10.0	16.1	4.58
Case 2	0.0	0.8	10.1	15.8	4.54
Case 3	0.0	0.8	9.9	16.1	4.57
Case 4	0.0	0.8	10.1	15.6	4.49
Case 5	0.0	0.8	9.8	16.4	4.64
Case 6	0.0	0.8	9.9	16.2	4.60
Case 7	0.0	0.8	9.7	16.4	4.63
Case 8	0.0	0.8	9.9	15.9	4.54

In total, case 4 has the lowest total energy consumption and is selected as the BAT case.

From the above analyses it is now possible to define the energy use in each phase of the duty profile of the reference case, the BAT case and the selected design, as shown in Table 9 for the hypothetical drive unit. Therefore, the values for the reference case are derived from Table 5, values for the selected design from Table 3 and the values for the BAT from Table 8.

Table 9: Energy use of the reference case, selected design and BAT – example of a hypothetical drive unit

Energy use (MWh/year)	Off	Standby with peripheral units off	Warm Up	Processing	Weighted Total
Reference case	0.0	0.9	10.5	17.5	4.9
Selected design	0.0	0.8	10.5	17.0	4.8
BAT case	0.0	0.8	10.1	15.6	4.5

Treatment of additional machine tool modules

Exactly the same process can be repeated to determine the energy consumption of other modules. For example, if we consider that the same machine tool also has some peripheral devices then this could have a set of energy savings potentials by design option as shown in Table 10.

Table 10: Energy saving potentials for design options compared to the reference case for a hypothetical peripheral device module

	Off	Standby with peripheral units off	Warm Up	Processing
Reference case	0%	0%	0%	0%
Design option 1	0%	2.0%	3.0%	1.0%
Design option 2	0%	3.0%	2.0%	3.0%
Design option 3	0%	1.50%	1.75%	4.0%

For the design option which is actually selected for the machine tool in question, the power intake and annual energy consumption have to be determined for each of the identified load states. Those values could either be determined by measurement or derived from the design calculations. Table 11 shows an example for the hypothetical peripheral devices unit.

Table 11 Energy use of the selected design (for a hypothetical peripheral device module) for overall 8750 total annual hours in different operation modes

	Off	Standby with peripheral units off	Warm Up	Processing	Total
Fraction of time	25%	10%	60%	5%	100% (8750 hrs)
Power Intake (kW)	0.00	0.05	3.62	7.51	1.89
Energy use (MWh/year)	**0.0**	**0.4**	**31.7**	**65.8**	**16.5**

Using the deemed savings from Table 10, the relative energy use of each design option can be calculated (remaining energy use = 1 - energy savings). The product of the remaining energy use of all selected design options for the selected design represents the overall savings of the selected design for each operating state. Table 13 shows an example of this type of calculation for a hypothetical machine tool drive unit module.

The relative energy demand of the selected design is calculated by a multiplication of the percentages of the individual design options (in this case "Design option 1" and "Design option 2" are implemented in the product, Design option 3 is only relevant for the BAT case.).

Table 12 Energy demand of the selected design compared to the reference case for a hypothetical peripheral devices module

	Off	Standby with peripheral units off	Warm Up	Processing
Design option 1	100%	98%	97%	99%
Design option 2	100%	99%	98%	96%
Selected design	100%	97%	95%	95%

By dividing the energy use of the selected design (which is determinable by measurement or design calculations) by the relative energy use values shown in Table 11, the energy use of the reference case is calculated, see Table 13. This value is a hypothetical value, derived from the actual energy use of the selected design (which is known by measurement) and the (theoretical) deemed savings. This case has to be defined individually for each assessed product and load profile.

Table 13 Energy use of the reference case hypothetical peripheral devices module (reference case)

	Off	Standby with peripheral units off	Warm Up	Processing	Total
Fraction of time	25%	10%	60%	5%	100%
Power Intake (kW)	0.00	0.05	3.80	7.90	1.98
Energy use (MWh/year)	**0.0**	**0.4**	**33.3**	**69.2**	**17.4**

The absolute energy savings of the selected design are calculated as the difference in energy consumption to the reference case.

The next step is to define the BAT case and this requires the compatibility of the design options to be assessed in the correlation matrix,Table 14. In this case there are less design options than for the hypothetical drive unit and all the design options are compatible, so a single BAT case emerges which is the simple combination of all the design options i.e. of design options 1, 2 and 3.

Table 14 Design option correlation matrix for the hypothetical peripheral devices module

	Design option 1	Design option 2	Design option 3
Design option 1	n.a.	Possible	Possible
Design option 2	Possible	n.a.	Possible
Design option 3	Possible	Possible	n.a.

For this BAT case, the cumulative savings can be calculated by the multiplicative combination of the individual options (as already shown for the reference case in Table 13), see Table 15. The data is based on information from Table 10.

Table 10 illustrates that the energy demand of the BAT case (case 1) in standby mode compared to the reference case is therefore calculated as the product of the three design options:

(100% - 2%)*(100% - 3%)*(100% - 1.5%) = 94%

Table 15 Energy demand of the potential BAT case compared to the reference case (extraction of data from Table 10)

	Off	Standby with peripheral units off	Warm Up	Processing
Case 1	100%	94%	93%	92%

As there is only one case, the duty profile and the power intake in the different operation states can simply be applied to determine the weighted energy consumption for the BAT case, Table 16. The duty profile is taken from Table 11.

Table 16 Potential energy use of the hypothetical peripheral devices module (BAT case)

	Off	Standby with peripheral units off	Warm Up	Processing	Total
Fraction of time	25%	10%	60%	5%	100%
Power Intake (kW)	0.00	0.05	3.55	7.28	1.83
Energy use (MWh/year)	0.00	0.41	31.09	63.80	16.1

From the above analysis it is now possible to define the energy use in each phase of the duty profile of the reference case, the BAT case and the selected design, as shown in Table 16 for the peripheral devices module. Therefore, the values for the reference case are derived from Table 13, values for the selected design from Table 11 and the values for the BAT from Table 17.

Table 17 Energy use of the reference case, selected design and BAT – example of a peripheral devices module

Energy use (MWh/year)	Off	Standby with peripheral units off	Warm Up	Processing	Weighted Total
Reference case	0.0	0.4	33.3	69.2	17.4
Selected design	0.0	0.4	31.7	65.8	16.5
BAT case	0.0	0.4	31.1	63.8	16.1

Combining modules to get the overall Stage 2 energy budget

At this stage the energy budgets of the machine tool are combined to derive an overall Stage 2 (detailed design stage) energy budget as shown in Table 18. The data is based on the previous Table 9 (for the drive unit) and Table 17 (for the peripheral devices).

Table 18 Combined energy budget for the detailed design stage (Stage 2) – hypothetical example of a machine tool with just two modules

Stage 2	Selected design energy budget (MWh/year)	Reference energy budget (MWh/year)	BAT energy budget (MWh/year)
Module 2.1 – drive unit	4.8	4.9	4.5
Module 2.2 – peripherals	16.5	17.4	16.1
Total	**21.3**	**22.3**	**20.5**

8.3 The user guidance stage

As user behaviour has a significant impact on energy in use and in theory it is possible to improve machine tool operator actions by providing good guidance. This phase is intended to recognise the impact that such guidance can have on the product's final energy consumption.

The eco-design criteria in this stage are of a qualitative character and hence are very challenging to put on the same basis as the quantitative data considered in the previous stage (detailed design stage). However, they are of a very similar nature to those considered in the product development stage, and hence a checklist seems to be the most fitting method to assess these criteria.

This situation is a classic example of why a points system can be helpful because it can recognise degrees of progress towards an eco-design objective (in this instance reduced energy consumption) of both a quantifiable and qualitative nature and organise them within a common framework that allows some flexibility as to how the goal is achieved.

An example checklist for the case of a mechanical servo-press or mechanical presses, is shown in Figure 16 and is structured in the same manner as the one shown for the product development stage.

Accordingly, the means of completing the form and allocating the distribution of points also happens in the same way. The first column serves to register if the listed aspect can be realized at all, while the second column demands to what extent the aspect has been realized. The decision and description should be briefly commented on in the third column, and the action is verifiable via the additional information listed in column four. In the final column the points are awarded in accordance with the agreed structure. In this example, if all necessary information is provided and the aspect was realized to a high extent, a maximum of 12 points can be achieved (up to 4 points for the degree of realization, multiplied by up to 3 points for a fully documented case via a third-party audit). If additional information to support verification is not given or the short description is missing, no points at all are given. In the case where an aspect is not possible to be implemented or considered, an explanation has to be given why. If the argument put forward is valid, this aspect is not considered when calculating the maximum achievable score. By following this logic, a generic checklist can be used, which also takes into account the uniqueness of most machine tools. Figure 16 shows an example of such a checklist with a worked case study.

The aspect "provide customer information" is divided into three sub aspects. The points achieved for this criterion the average of the three sub-criteria.

General aspects for an eco-friendly product development:	Possible?	To what extent realized (0-4)[1]	Short description	Verifiable by:	Weighting Factor[2]		Points achieved (sub criteria)	Points achieved
Provisions to reduce scrap production	✓	4	Die monitoring as in-process control	Third party audit	3			12
Provide customer information to reduce consumption of resources (3 sub criteria)								
Information to user on energy-efficient use of the machine e.g. on/off programming of auxiliary devices (user manual, instruction)	✓	2	Not necessary, only working on one side	Source [1]: Manual	2		4	4
Information to user on optimized movements of axis	✓	0	Steel part substituted by an aluminium component. Further improvements not possible.				0	
Information to user on usable energy	✓	4	Partly: Would imply additional lubrication system. Low-friction bearings were implemented	Source [2]: Blueprint	2		8	
Minimize non-productive time	✓	4	By using a new processing method, the built-in materials were remarkably reduced. The use of the aluminium component increased embodied energy.	Self declaration	1			4
Optimize productivity by reducing cycle time per part	✓	3	Personal instruction and information letter					0
						Max Points		Σ
						48		20

[1] 0 = not realized; 1 = poorly realized; 2 = moderately realized; 3 = well realized; 4 = extremely well realized
[2] 1 = Self declaration; 2 = internal documentation; 3 = third party verified documentation

Figure 16 Example machine tool checklist for the user guidance stage

Defining exactly which criteria should be part of the list is something that would need to be established in a more detailed analysis. However, if such a process is to be usable within an Ecodesign regulatory context then it would need to be structured in such a way that the quality of the process followed can be verified by a third party as needed. Self-declaration, third party audit and the provision of additional material (such as detailed documentation), to demonstrate that the relevant aspects were truly considered, could all have a role to play. In principle, the degree of credible evidence put forward as proof that the checklist methodology was followed happens in the same way as already described in the case of the checklist for the product development stage. In addition, the weighting regarding the degree to which an aspect was realized occurs in the same manner.

The depicted example consists of 4 different aspects, while the aspect "Provide customer information to reduce consumption of resources" consists of three sub-aspects. In such a case, each aspect is assessed separately and the results of all aspects aggregated. In this case this would mean, that the sub-aspects achieve a score of 4,0 and 8 which leads to a sum of 12. For all the criteria a maximum of 36 points can be achieved. So the score for this aspect is: 12/36 x 12 = 4

Based on this example checklist a maximum score of 48 points can be achieved. The score attained is therefore 20 (12 + 4 + 4 + 0).

8.4 Step 8 summary

Under the Task 3 methodology, Step 8 entails establishing environmental impact budgets for each impact criterion and application group being considered. For this case study we have only considered energy consumption that occurs in the use-phase of the machine tool as this dominates the environmental impact of machine tools and is quite complex in its own right. As the energy consumption in use is known to be affected by the product development stage (i.e. the early design phase), the detailed design phase (where the technical design options for each machine tool module are decided), and the use phase (which is sensitive to user behaviour, which in turn can be affected by the quality of guidance provided on the optimal operation of the machine tool) then it is appropriate to structure the energy budget in a modular manner where there are three broad stages (one for the product development stage (qualitative), one for the detailed design stage (quantitative), and one for the user guidance offered (qualitative). To be consistent with the Task 3 methodology each of these broad stages needs to be allocated a share of the overall energy budget in proportion to their expected impact on the overall energy performance of the product.

Adjustment to Task 3 methodology

There is one significant adjustment to the Task 3 methodology and this concerns the treatment of the relationship between the duty profiles and the application groups. The task 3 methodology imagined that application groups would be defined based on the identification of whatever combination of product type and usage application would result in sufficiently stable representative duty profiles to enable an energy budget, akin to an energy efficiency index, to be defined. If no application groups with a stable duty profile could be defined, it proposed that the product was possibly therefore not suitable for a points-system approach for the environmental impact criterion being addressed.

In the case of machine tools there is so much heterogeneity that it may only be possible to identify a limited number of such application groups, and these may not cover a large part of the machine tool market. However, the method put forward here based on ISO 14955-1:2014 avoids this problem, because the methodology defines the efficiency of individual modules via an assessment of the array of energy-saving design options that they have used. Thus, for any machine tool, even if it is completely customised and made to order, it is sufficient for the designer to specify and document the duty profiles that were envisaged during its conception (which will have been informed by the client's brief) and document the design options which were utilised, for the efficiency of each module to be determined. Then, if the energy consumption of each module is measured or calculated when tested under the designated duty profile, the energy budgets can be determined. This provides all the information required to follow the Task 3 methodology without needing the definition of application groups. To also avoid possible negative interactions between the specific modules right from the start, the development of a correlation matrix (as shown in Figure 11) on a module level might help to identify possible interferences. Whether this is really necessary depends on the complexity of the machine tool.

Assembling the energy budget

The final energy budget will thus comprise:

- a first stage to cover the product development stage (Stage 1)
- a set of stages that cover the detailed design stage (Stage 2)
- a last stage that covers the impact of the user guidance stage (Stage 3)

The number of modules in the detailed design stage is a function of the number of modules used in the machine tool design, and can address up to 8 areas within the ISO 14955-1:2014 methodology[7]. These can be designated as Module 2.1, Module 2.2, Module 2.3 etc. The Task 3 methodology requires each stage to be allocated a proportion of the total machine tool energy consumption, in proportion to its impact on the overall energy consumption. For Stages 1 and 3 this is not measurable in any normal sense, and hence a process would need to be agreed on, to decide how much

[7] Drive units, hydraulic systems, pneumatic systems, electric systems, cooling lubrication system/die cooling/lubrication system, cooling system, peripheral devices, control systems

of the total energy budget would be allocated to Stages 1 and 3, noting that these Stages do not consume energy in reality, but instead help to save it (via prospective design, and use-phase guidance, respectively. Thus, these Stages would need to be awarded a part of the overall Step 8 energy budget that reflects their expected contribution to the whole machine tool's energy performance. The actual energy budget is then calculated by the relative performance of the product calculated previously. Where reliable performance data and information exist, it is possible to use this assembly of information to increase the reliability of these estimates. However, for some Stage 1 and Stage 3 features, it may be largely a matter of engineering judgement. As such, these would seem to be areas where a panel approach or, for example consulting experts via a pairwise Analytical Hierarchy Process (AHP) would be appropriate, to help to reach a weighted decision. In this case study, we assume that Stages 1 and 3 are both assigned 20% each of the energy budget consumed by Stage 2, which addresses the detailed design stage and is the part of the energy budget that is directly measurable. This means that Stage 2 accounts for 71.4% of the total energy budget from all three stages added together i.e. from 100%/(20%+100%+20%) = 71.4%; however, a panel or expert decision-making group charged with making these determinations would be free to allocate whatever proportions to Stages 1 and 3 that they saw fit, based on the evidence at their disposal. Within Stage 2 the energy budgets allocated to each sub-module can either be measured directly (for each module), or, if it were more practical, the whole machine energy use could be measured under the designated duty profile, and design calculations used to allocate the proportions of the measured consumption associated with each sub-module.

Putting all this together to obtain an overall energy budget, as a precursor to the normalisation process of Step 9, results in the values shown in Table 19, for the specific hypothetical machine tool considered in this case study. Note, as previously discussed, the Stage 1 and Stage 3 energy budgets of the reference case are both simply 20% of the corresponding Stage 2 energy budget. The energy budget for the BAT case in Stage 1 and Stage 3 is set to zero, assuming that all proposed measures are implemented (i.e., the maximum feasible identified energy savings possible have been achieved). The energy budget for the selected design is calculated based on the relative performance of the selected design compared to the reference energy budget.

Table 19 Combined energy budget for all three stages (Stages 1, 2 and 3) – hypothetical example of a machine tool with just two modules

	Selected design energy budget (MWh/year)	Reference energy budget (MWh/year)	BAT energy budget (MWh/year)
Stage 1	**Product Development Stage**		
Module 1	**1.86 MWh**	**4.46 MWh**	**0.00 MWh**
Stage 2	**Detailed Design Stage**		
Module 2.1 – drive unit	4.83 MWh	4.95 MWh	4.49 MWh
Module 2.2 – peripherals	16.52 MWh	17.37 MWh	16.05 MWh
Sub-total	**21.35 MWh**	**22.32 MWh**	**20.54 MWh**
Stage 3	**User Guidance Stage**		
Module 3	**1.96 MWh**	**4.46 MWh**	**0.00 MWh**
Total	**25.17 MWh**	**31.24 MWh**	**20.54 MWh**

Step 9 Normalisation and awarding of points

Issues of principle

The Task 3 methodology requires the values indicated in the energy budget to be normalised by comparison with a reference case product. This is then used to establish a performance indicator that can be converted into an overall point score.

In the specific application of the methodology set out above for machine tools, the energy budget first has to be assessed for the detailed design stage (Stage 2) and then the allocations for the product development stage (Stage 1) and for the user guidance phase (Stage 3) are scaled from that. Hence, if a machine tool was found to have an energy consumption of 10 MWh/year when tested under the designated duty profile, its Stage 2 consumption would be 10 MWh/year, while its Stage 1 and Stage 3 energy consumption would be 2 MWh/year each (assuming they account for 20% each of the total of all the stages). The chosen approach covers the principal components as well as the auxiliary components (e.g. cooling, ventilation, etc.), since they are covered by the modules in accordance with ISO 14955-1:2014. In this example, only a limited number of modules/components are considered. Module 2.2 represents peripheral units.

Note, what this implies is that optimising the product development process in line with the procedural checklist could save up to 2 MWh/year in the product's final energy consumption, and that providing consumer guidance fully in line with the checklist could save a maximum of another 2 MWh/year. It would be useful for a panel charged with setting the Stage 1 and 3 weightings to explicitly consider the proportion of savings they would expect to occur from these measures, as this helps to concentrate the thought process and encourages it to be more rigorous.

In addition, in this illustrative example, if Stage 1 and Stage 3 both counted for 20% of Stage 2 in the potential overall points allocations, then Stage 2 would count for 71.4% of the potential total points (71.4% = 100/(20+100+20)). Stages 1 and 3 would then each account for 14.3% of the potential total points once 'normalised' to an overall total of 100% (14.3% = 20/(20+100+20)).

The point's allocation process defined in the Task 3 methodology is given on a scale of 0 to 100, and is related to the reference product which receives a score of 0. In this machine tool case study, whatever the points allocations that are given for the checklist assessments for Stages 1 and 3, they would have to be subsequently scaled to be out of a maximum of 100 (in %) and then multiplied by their stage's allocated weighting of the total points (14.3% each in this example). Similarly, the maximum potential points score for Stage 2 is also 100 but then multiplied by 71.4% to account for its share of the total points-allocation.

The detailed design stage, Stage 2, needs to be processed exactly as set out in the Task 3 methodology to establish the points to be allocated to that section.

Application in a worked example

The above outline is now applied to the worked example considered in this case study. In line with the Task 3 methodology, the first step is to normalise the energy budgets compared to the reference case by dividing them by the reference case, and then expressing the values as a percentage, as shown in Table 20. Those values are a 'percentage-ratio' normalization of the values already seen (in actual kWh) in Table 19.

Table 20 Normalised combined energy budget for all three stages (Stages 1, 2 and 3) – hypothetical example of a machine tool with just two modules

	Normalised energy budget for the selected design	Normalised reference case energy budget	Normalised BAT energy budget
Stage 1	**Product Development Stage**		
Module 1	**41.7%**	**100.0%**	**0%**
Stage 2	**Detailed Design Stage**		
Module 2.1 – drive unit	97.6%	100.0%	90.6%
Module 2.2 – peripherals	95.1%	100.0%	92.4%
Sub-total	**95.7%**	**100.0%**	**92.0%**
Stage 3	**Use Guidance Stage**		
Module 3	**43.9%**	**100.0%**	**0%**
Total	**80.6%**	**100.0%**	**66.0%**

Note, the approach described below only really uses this information for the Stage 2 point's allocation calculation – the Stage 1 and 3 points calculations are done in a slightly simpler but equivalent manner as described below.

The points are then calculated as follows:

Stage 1 – Product development stage

If we imagine that the specific product in question scored a total of 58 out of a maximum potential score of 132 points for this stage, in line with the approach discussed in section 8.1, then the points allocated for Stage 1 would be (58/132)*(100)*0.143 = 6.3.

Stage 2 – Detailed design stage

The selected design has a normalised Stage 2 energy budget of 95.7% (compared to the reference case of 100%) while the best available technology has a normalised energy budget of 92.0%. Under the Task 3 methodology, the reference case product scores 0 points and the best attainable product scores 100. The choice is open to the designer of the points scheme as to whether they set the high-performance end-point of the points scale at the BAT energy budget level or at an energy budget of zero. In the present case study for machine tools it makes sense to use the BAT as the high-performance end-point of the points scale. This is because the methodology does not enable savings to be allocated which are higher than the identified BAT ("BAT" being based on using a published list of energy savings potentials per design option, and not an actual performance measurement under reference conditions, etc). Thus, if the BAT scores 100 points and the Reference Case scores zero points, the specific product in question will score = 100*(100-95.7)/(100-92) = 53.75. However, this is the score within Stage 2 itself and this needs to be multiplied by 0.714 (=100%/(20%+20%+100%)) to get the points score that is to be added to the other Stages i.e. 0.714*53.75 = 34.3 points for Stage 2.

Stage 3 – Use guidance stage

If we imagine that the specific product in question scored a total of 20 out of a maximum potential score of 48 points for this stage in line with the approach discussed in section 8.1, then the points allocated for Stage 3 would be (20/48)*(100)*0.143 = 6.0.

Total points

Summing the three sets of points for Stages 1, 2 and 3 gives a final points-score (out of a possible 100) for the specific product considered in this case study of 46.6 (=6.3+34.3+6.0).

Other considerations and conclusions

This case study has been confined to addressing energy performance in the use phase, because this is already a major challenge for machine tools, and has been previously identified - in the 2012 Preparatory Study for this product group - as the dominant environmental impact; however, it is certainly conceivable that other environmental impacts could be treated using a similar methodology.

As already mentioned in the beginning, the Task 3 methodology has been tested in this case study for the energy performance of machine tools, and in principle it has been established that the method:

- seems to be suitable to assess energy performance
- enables complexity to be addressed
- recognises and rewards good eco-design practices
- is designed to award points for design options in proportion to their expected effect on the impact parameter in question
- is as comprehensive and inclusive as possible, and allows the option to extend the scheme's structure to include: the environmental impacts deemed appropriate (in addition to energy performance, in this case), the product scope that is deemed most appropriate, and the intervention phases deemed appropriate
- is capable not only of working at whatever 'application grouping levels' are deemed to be appropriate, but also for unique customised machine tool designs
- is adapted to address product modularity
- fits within the MEErP methodology, although it does not require some of the steps, and does require the input of detailed information on expected savings from using specific design options at the module level
- is capable of working with the Ecodesign and energy labelling regulatory process
- is technically feasible from a conformity assessment perspective, but will require a more elaborate procedure than is the case for simpler products.

Nonetheless there are many areas that will still require further development and confirmation before this method could be deemed to be suitable to be applied to machine tools for Ecodesign regulatory purposes.

With regard to the savings potentials which are used, the existing preparatory study has some information on design options and savings potentials, while the ISO 14955-1:2014 standard has more, but both are thought to be incomplete. Thus, additional work is needed to develop suitable lists of options and savings potentials, if these were to be applied in a points system for machine tools. In practice, there are also likely to be some interactions between modules, which add an additional layer of complexity to the derivation of such a list. As the method works on a module-by-module basis, any additional study charged with investigating these potentials in detail would need to not only conduct the assessment for each module of interest, but also examine the interactions between them. In the case study presented here it is assumed that there is full confidence in the savings potentials ascribed. However, if that is not the case, then the Task 3 methodology includes a possible approach for discounting less certain energy savings, which could be applied to address this issue. This approach could also be used to discount uncertain savings due to interactions between modules.

With regard to the checklists to be used for the product development stage (Stage 1) and the user guidance stage (Stage 3), work would be needed to verify which elements should be included in these lists (building on the ISO 14955-1:2014 work) and to determine the relative magnitude of the points that should be allocated to each element. The points allocation would also need to address the calibre of the supporting evidence that could be provided, to demonstrate that the criterion under scrutiny was really met, and to determine how to weight the points allocations accordingly. This is not an action within a MEErP study, but could be added in as a component of a later possible study, the aim of which would be to specifically investigate the design option savings potentials at the module level. Inputs to such a step could potentially comprise experts from standardisation Technical Committees (TCs), academics etc. An early integration into the process would ensure an intensive discussion with the stakeholders.

The consultants could assemble the information to inform this and present it to the stakeholders and Consultation Forum, prior to the Commission drafting a proposal that would be scrutinised by the Consultation Forum and Regulatory Committee. Although from a "streamlined" regulatory mandate perspective, it might seem ideal if the Regulatory Committee formed the Panel to decide (by voting if necessary) on the criteria and points allocations to be used within these two stages, in practice this might not function well, or be sufficiently independent or transparent. Such a process as decided by the Regulatory Committee might either come too late in the process to be viable, or would require the Regulatory Committee to meet more than once, with its mandate consisting of different tasks. Given these constraints, it is likely the Commission would need to find another means of establishing a panel and then ask the Regulatory Committee to scrutinise and approve/ reject/ query the findings of this panel, in much the same way as they currently undertake for draft regulations.

The Ecodesign regulatory process would also need to consider the weightings to be applied to Stages 1 and 3. In practice, this would probably require some supporting technical investigations, and preparation of a draft proposal for consideration by the Consultation Forum and subsequently the Regulatory Committee, who would ultimately be responsible for the decision made on this topic.

The Ecodesign directive requires MEPS to be set to the energy efficiency level that produces the least life cycle cost. However, if the Commission refrains from setting MEPS, and instead requests generic measures, or solely information requirements in the ecodesign context, a full detailed economic assessment sensu stricto may not be necessary. In the latter case, it would then be out of the scope of the 'standard' MEErP methodology per se.

Conformity Assessment

Compared to products, where the Market Surveillance Authorities (MSAs) test the actual products' energy performance values, the approach for conformity assessment according to the presented methodology is different. The requirements set out are either procedural (for stages 1 and 3) or technical (stage 2). The conformity assessment therefore will be of an audit type.

The machine tool supplier would have to provide evidence on the following:

- The checklists followed in Stages 1 and 3 with supporting evidence
- The duty profile(s) that the machine tool is designed to satisfy
- The energy consumption of the machine tool when tested under those duty profile(s)
- The list of energy savings from the relevant design options, completed to show which options were excluded and why, and which options were selected for each module, with their predicted (and/ or measured) effects
- A documentation of the calculations, preferably in a pre-defined format.

Regarding the checklists for stages 1 and 3, each MSA would only check whether the evidence provided was appropriate and correct. For selected cases, the MSA could also check whether the procedural requirements had actually been implemented in the company concerned. Regarding selected issues in stage 3, such as the user information, the MSA is able to readily check whether this information has actually been provided.

For the calculations carried out for stage 2, the MSA would first have to check plausibility, completeness and accuracy of the information provided by the manufacturer. The MSA would then need to enter the information into the appropriate algorithms (ideally using a software tool) to check the points calculation. This is evidently a more complex process than is followed to verify compliance for less complex product types, but it is technically feasible.

It is also clear that applying such a methodology could be relatively time-consuming from the machine tool designers' perspectives, if done for a complex machine tool comprising many modules. Explaining the algorithms used is certainly possible but would be susceptible to human error. Hence, it might be preferable if software were developed to support the machine tool design process where the required informational inputs and algorithms were embedded in the program. The input files could be automatically updated each time there was a revision to the savings potentials options permitted by the method. Sharing the files could also facilitate any verification process.

Lastly, the methodology developed shows that a points systems approach could be beneficial, because it allows qualitative and quantitative ecodesign benefits to be incorporated into the same accounting framework and this both rewards good eco-design practice, and gives flexibility to the machine tool designer/supplier to decide how to meet any given points level. However, much of the methodological approach set out could also be used in a conventional Ecodesign regulatory approach where specific and generic requirements are specified. In principle, the specific requirements could be set around the Stage 2 (detailed design stage) performance levels using the methodology put forward to relate any actual machine's performance to the equivalent reference case and BAT for the same machine. Generic Ecodesign requirements could be set for Stage 1 (product development stage) and Stage 3 (use guidance stage). Apart from the added flexibility, the advantage of the points system approach is that it can also be tuned to address uncertainty, which is harder to do within a conventional

Ecodesign approach. As there is still a great deal of uncertainty surrounding many of the elements applicable to machine tools, a softer and more flexible approach to promoting good ecodesign practice has a number of potential merits to further the advances in innovation in this important facilitating industry sector for achieving further enhanced design product and process solutions.

References

Abele,E.; Anderl, R.; Birkhofer, H. (2005) Environmentally-Friendly Product Development – Methods and Tools, Springer, 2005

Atik, A. (2001) Decision support methods for the development of environmentally friendly products, Shaker, Aachen, 2001

ISO (2014) 14955-1:2014 Environmental evaluation of machine tools-Part 1: Energy-saving design methodology for machine tools. *International Organization for standardization, Geneva, Switzerland*.

European Commission (2014) Working Document for the Ecodesign Consultation Forum on Machine Tools and Related Machinery. Brussels (2014)

Kemna, R., Azaïs, N., van Elburg, M., van der Voort, M., & Li, W. (2011) Final report: Methodology for Ecodesign of Energy-related Products: MEErP 2011: Methodology Report: Part 1: Methods.

Schischke, K., Hohwieler, E., Feitscher, R., König, J., Nissen, N. F., Wilpert, P., & Kreuschner, S. (2012) Energy-Using Product Group Analysis-Lot 5 Machine tools and related machinery-Task 5 Report – Technical Analysis BAT and BNAT.

VDMA (2013) Nutzungsvereinbarung für die Marke Blue Competence zwischen Träger, Teilnehmer und Partner. Online http://kug.vdma.org/documents/105897/2333238/BC_Nutzungsvereinbarung_KuG.pdf/3d738752-15a1-4d7b-a30f-a02ba2086b9e, zuletzt geprüft am 18.01.2017

Annex 1: Technical assistance study on "points system" methods – Stakeholder comments on Task 4 Machine Tools Case Study

Organization: SST (Association of Engineering Technology) & RCMT (Research Center of Manufacturing Technology)	Name: Jiri Vyroubal	Date: March 29nd, 2017

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
4	2nd par	4	This case study … in the use phase …	This is true only for one very specific combination of machine, used manufacturing technology, workpiece, user behavior etc. Can't be used as general approach	No change possible. This method can't be used for machine tools as general methodology	In this study it was only intended to demonstrate the feasibility on one generic example. Of course this differs from case to case.
4	Fig. 1	5	Not complete scheme	Next "use" should be after the box "Upgrade". Without this, the Upgrade does not make sense	Add new box "Use"	Completed
4	2nd par.	6	Given this …	Energy impact is only one criterion. Costs, production time and quality of production are crucial for the machine users and cannot be neglected. Otherwise we can go back to the manual machines.	Combination of costs, quality and productivity should be considered as well	Costs, quality and productivity were not considered in this Task 4 assessment, as they would require a set Functional Unit. However, the methodology proposed is neutral from a quality and productivity perspective and could be adapted to integrate economic considerations.
4	2nd par.	7	Influence to the user behavior	How this can be done if the user behavior can't be known during the design stage? The uncertainty is not high, but extremely high	This cannot be done. (No proposed change to this paragraph)	There are likely to be means e.g. via a worksheet or through written instructions, where guidance with regard to optimising energy efficiency can be offerred that reflect reasonable assumptions concering user behaviour.

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
4	3rdLast par.	11	Those components/modules can be assessed and optimized individually …	How do you want to consider the interaction between components/modules during the design stage, if this interaction depends on the machine usage and what the machine will do during production time?	Some "assumed" consideration can be very far from the real situation and thus can bring wrong results. Explanation how assumption can be used is required	This is the reason why a correlation matrix at the components level might be favourable.
4	3rd par.	12	Thus any given machine tool designer can either be expected to know enough about the intended use …	This is wrong. Some real statistics for large and middle-size machines sold to the whole prom CZ:	This main idea is unfortunately wrong and should be modified	Thus it can be considered to be appropriate for the cases when the purpose is known. For those where it is unknown, an acceptable way has to be found rearding how to deal with it and how this uncertainty can be managed; however, clearly MT designers have notions of user needs and behaviour in mind when they design their products and this is likely to be sufficient.
				10-20% machines sold with knowledge of the machine will do -> duty profile during production life is known		The MT designer could at least state the main purpose for which the MT is being designed. Even accepting, that he can't know for sure if his customers are really using it for this purpose.
				Aprox 30% sold with knowledge of requested technologies (not workpieces) -> duty profile during production life is not known		
				50% sold without ANY knowledge of the user behavior		

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
				This statistics is valid only for 2-5 years. After that, nobody knows, what the machine will do. Machine tools are used up to 30-40 years.		
4	8.1	13	Table 1	Who will decide the weighting of activities during development stage? This should do someone independent, but during this stage, ideas of development are highly secret.	Please, explain how to do this	If a points system were to be implemented it is imagined that the weighting would be elaborated via a panel approach. The activities to improve energy efficiency in the product development stage are on a rather generic level so that it shouldn't be a problem with regard to Intellectual Property.
4	1st par.	15	… because the explanation seems reasonable, …	Who will decide, what seems reasonable or what does not? This is very much fuzzy and can't be used for precise points calculation.	More exact decision procedure is required	Clarity and comprehensibility and common criteria which can be assesed by the surveillance bodies.
4	8.2	16	The modules are named …	Due to the high customizing of machines, list of components can't be done in this stage. This information is not known.	No change proposed. This method is not suitable for machine tools	For different types of machine tools specific components are needed to enable its functions and these should be known.

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
4	8.2	16	Definition of the correlation matrix	The correlation matrix can possibly have tens of variants of design options because the interaction between components/modules and due to the modulating control of some components. This will be a monster table with some unknown or known but indescribable variants	This is almost impossible to do. Please, propose the procedure, how to make the matrix smaller (like prescreening) Otherwise this matrix can't be done properly and there will be massive administrative burden.	Here further future work would need to be done to enable simplification. A software based solution might provide some helpful support.
4	Table 3	20	Fraction of time	Fraction of time CAN'T be defined during the design stage. The designer don't know, what the machine will do for next 1-40 years (the productive life of standard machine tools). The same for Power intake.	This methodology is not suitable for machine tools. Such calculation can be highly manipulated to have good results.	Might be true. But reasonable assumptions or estimations for the MT could be given. Nevertheless, this would also be a subject for future investigation.
4	Table 3	20	Energy use	This is the average energy use in the column "Total"? The power intake is usually calculated as average value, but Energy use is usually calculated as a sum.	Recalculate the Energy use as a sum of energy consumption during the year	See related hours in revised table. If it is confusing in the sum, this listing appears more reasonable when concentrating on the different operating states.
4	2nd par	21	Reference case	What is the reference case? How to define it? This can be the machine from 19th century, from 2010 or whatever.	Please ad more precise definition of reference case	It is described in the text. It is the MT without any energy saving features.

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
4	5th par.	21	This reference case has to be defined individually for …	There can be unlimited number of load profiles of the machine due to its usage by customer, used technologies, interaction between components etc. See comments above.	More specific description of reference process is required	If the future purpose of the MT and the load profile is known, this can be used. If not, reasonable assumptions have to be made by the MT designer. These could be flanked by sensitivity analyses. Nevertheless, this point concerning how to deal with a completely unknown purpose offers an interesting point for future investigation.
4	Table 5	22	Energy use	Same as comment above about average/sum of energy	Recalculation of energy use as a sum	See revised table. This listing is more reasonable when concentrating on the different operating states.
4	BAT case	22	2nd bullet – The individual duty profile	How to define individual duty profile?	More specific definition is required	Same as for the designed MT
4	3rd par.	23	The following Table 6 …	This should be linked to the Figure 16, not Table 6.	Correct the link to the Figure 16	Corrected
4	Table 6	24	Case 2, Case 3	The obvious mystake. 2nd column is for Case 3, the 3rd column is for Case 2	Correct the Table 6	Corrected

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
4	3rd par.	24	The reference case always …	The calculation goes from Table 2 (I guess), but it is valid only for Stand-by.	Add to the text, that this example is only for Stand-by	The text has been edited. The example is only for standby, but illustrative for all modes.
4	1st par.	25	This means, that the maximum saving ..	How to define shares of operating stages (duty profile)? See comments above	This can't be done -> proposed methodology is not suitable for machine tools	See comment above. Task 4, 5th para. Page 21.
4	1st par. (in the middle)	33	In this case study, we assume …	Assumption is highly manipulative and risky and can be used for negative competitive fight. Real data have to be consider in this methodology.	Avoid assumption and propose technical/measurement-based procedure	A real data case study would be an interesting point for further investigations and a necessary step, if the point system should ever be implemented

Organization: Daikin Europe	Name: Durca Pathmanathan, Takahiro Oki, Els Baert	Date: 28/03/2017

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
4 MT	Step 1	5	Use of "phases" and "stages"	Figure 1 are the key life cycle stages and not phases	"Figure 1: Product key life cycle stages"	Completed
4 MT	Step 2	5	System boundary	It is not clear if : b)".. the product have impacts at an extended product level?" Or c)"… the product design have impacts at the wider product system level?"	Explain by putting bullets as in the Task 3 and explain by putting examples.	Completed
4 MT	Step 3	5 / 6	Environmental impact criteria	Taking energy efficiency as the only one environmental impact criteria is not explained.	Give explanation for choosing the energy efficiency as an environmental impat criteria.	Energy efficiency is the most dominant one. For the purpose of this study to simply demonstrate the feasibility of a points system, this concentration on one criterion is sufficient. But further criteria could also be included.
4 MT	Step 4	7	Product stages	The term "stage" is used and it's	It could be called "phase".	Nomenclature is harmonized; stage is

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
				confusing as it is also used on Step 1.	Ex: Phase 1: "Product development, production and end of life" includes three stages: "Planning", "Upgrading" and " Recycling and disposal".	used for the three considered stages, phase is used for the more detailed breakdown.
4 MT	Step 5	11	Points system approach merited or not	The three points(a), b) and c)) that are exposed on Task 3 are not clearly explain on this example. The point b) doesn't seem to be achieved.	For each point, say that the anwer is positive and explain with examples.	Can be added
4 MT	Step 7	12	Step 7 link with the definition on Task 3	It seems to be no link between the explanation of the Step 7 in Task 3 and the explanation here on the Task 4.		Yes, it is not exactly the same due to the specific character of MTs.
4 MT	Step 8 .1	13	Weighting of activities	The points are ranked from 0 to 4 but this weighting is very subjective . It will be difficult for market surveillance to check this kind of values as it's not a value that can be measured or calculated.		We chose this quite common five-point scale because it is quite intuitive. Were a points system ever to be implemented then the weighting should be elaborated, presumeably via a panel approach. Sensitivity analyses could also help to inform this.

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
4 MT	Step 8 .2	16	Sub steps	The point "7. Determination of relative performance of the selected design" is not treated on the document.		Yes, it is. See e.g. table 9 on page 26
4 MT	Step 8 .2	20	Reference case	On the "Identification of generic energy saving potentials" part, individual savings are shown. What is disturbing is that the energy savings of a design option is shown without defining the reference case (cf Table 2). If a design option can reduce 2% of energy consumption on standby mode, it should be 2% from the reference case.		Yes, that's correct and also what the table says.
4 MT	Step 8 .2	20/21	Selected design and actual design	- Is the "Selected design" from the Table 3 the same that the "Actual design" from the Table 4?	If so, it should be "Table 3: Energy use of the actual design (for a hypothetical drive unit)" And "Table 9: Energy use of the reference case, actual design and BAT – example of a hypothetical drive unit" Can be	Harmonized

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
					haminzed	
4 MT	Step 8 .2	26	Editorial	Mistake for the number of the Table.	"Table 4" has to be "Table 12".	Corrected
4 MT	Step 8 .4	33	Selected design energy budget	It is not clear the way to get the values of 3.20 MWh for the Module 1 and 3.42 MWh for the Module 3.	Explain the calculation.	Modules 1 and 3 in this example are hypothetical but the calculation is explained in the text.
4 MT	Step 9	35/36	Normalised energy budget for the selected design	For the Stage 1, an imaginary value of 46 is used. It should be the 58 points obtained on the figure 10. For the Stage 3; the 20 points obtained on the figure 16 shoud be used.		Can be completed.In this case the values were only used to demonstrate the calculation. But it is right, that it may be somewhat confusing.
4 DS	5.9. Ste 8	31	Estimated weightings	The weightings on the Table 6 are based on the team's assumption (from experience and judgement). In that case, the values should not be accurate to the nearest decimal.	- Values should be accuarte to the unit.	True, subjectivity will alway play a role and there have to be measures defined with respect to how to deal with them.

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
				It will be very difficult for Market Surveillance to evaluate that because of the subjectivity.		
4 DS	5.9. Ste 8	36/37	Excluding the 10% highest performing products	The 10% highest performing products are excluded due to cost-effectiveness.	Instead of taking into account the cost effect in an abrupt manner, an economic impact had be integrated and assessed on Step 8 during the assessment of environmental impact budget.	

Organization: CECIMO	Name: Kamila Slupek	Date: 28 Feb. 2017

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
4	General		Title: case study	Title of the Task 4 says that is supposed to be a case study. Unfortunately, there is no case study on a real existing machine tool presented. Only an example for a hypothetical component, called a "module" is given. This is not sufficient for a case study.	Execute the case study/apply the methodology to a real existing machine tool or even better on several types/technologies of machine tools, e.g. metal working machining centre, metal working grinding machine tool, etc.	The focus of this study was to show the feasibility of a point system. A real case study on a specific MT would be an interesting point for further investigation, but would be too narrow to demonstrate the principle being considered here.
4	General		Effort	The effort of analysing an entire machine tool by way of the proposed method is extremely high and puts a great burden on the machine tool manufacturers. For SMEs, the induced disadvantage is even higher.	Abstain from proposing this method as an input to any regulatory context.	Yes, the method deals with complex products. Accordingly there is a comparatively high level of effort necessary to analyse these products.
4	General		Application	As the task 4 report does not demonstrate an example of a full real-life complex machine tool, it misses an approach how to deal with variants of a machine tool. If any variant of the machine tool (e.g., different spindle power, modified drive system, different coolant units, etc.) is to be analysed in the presented way, the effort for machine tool builders who build standardized but customable machine portfolios increases exponentially.	Introduce how variants should be treated with respect to minimizing market distortion.	This study was only concerned with the demonstratation of general feasibility. Examination of specific MTs would be an interesting point for further investigation.
4	General		Efficiency increase by productivity increase	Successful machine tool builders provide efficiency to their customers, in the sense of efficient production cost per part, which includes energy cost. Customers analyse the solution of the competing machine tool builders with respect to that property, i.e., this is a strong market force. The task 4 report doesn't mention at all that a high productivity increase in combination with a mild increase in energy consumption can increase energy efficiency (i.e., savings per part	Explicitly demonstrate how a reduction of energy consumption per part will be considered when evaluating the energy savings.	Productivity is not explicitly linked to the ecodesign process. Therefore an increased productivity per part may increase efficiency but is not taken into account in the evaluation. Note too, that the methodology normalises for productivity and thus the productivity of the machine tool is unaffected by its energy performance.

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
				produced) dramatically, more than many technical measures. Certainly this is feasible only where there is a defined part, e.g., specified in the contract.		
4	General		Effort vs. savings	The method lacks the assessment whether a feature that improves energy efficiency is worth the technical and economic efforts.	Implement a system to judge effort vs. additional increased energy efficiency to the methodology.	Economic efforts are not additionally considered in the ecodesign assessment in the Task 3 methodology. The LLCC considerations would be addressed in the Preparatory Study and subsequent IA and standardisation investigation refinements, in a real application of the points study method.
				Many features may be possible and contribute to increased energy efficiency from a pure technical point of view. However, the level of additional increased energy efficiency is outweighed by the efforts to implement such features.		
4		General	Assessments to be carried out	The whole method and all calculations are based on the fact, that modules have to be assessed (via measurement). As measurement or other valid and reproducible assessment is often not possible in these stages, the whole method is not applicable in the field.	Accept that the method is not applicable for the product group of machine tools.	Yes, it is difficult and before bringing this method to the point of real implementation, this has to be further examined.
				E.g. see page 6, last sentence, see page 20, 2nd § of Identification of the case for assessment…		
4	Introduction	4	Methodological concept	With a hypothetical type of machine tool it is not possible to execute a "proof of concept".	Apply the methodology to a real machine tool to demonstrate the proof of concept.	A real case study would be an interesting point for further investigation.

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
			… is applied to a hypothetical type of machine tool in order to test the proof of concept.		As the product group "machine tools" is extremely heterogeneous it would be even better to execute the proof of concept on several types/technologies of machine tools, e.g. metal working machining centre, metal working grinding machine tool, etc.	
4	Introduction	4, 2nd par.	*“This case study has been confined to addressing energy performance in the use phase […].”*	This is true only for one very specific combination of machine, used manufacturing technology, workpiece, user behavior etc. Can’t be used as a general approach.		True, it was only intended to demonstrate feasibility for one generic example. Of course this differs from case to case.
4	Introduction	4	3rd bullet point: *“Recognises and rewards good eco-design practice”.*	This is only true if the individual use / application and infrastructure is known.	No change possible as this method is not able to have information on this is early development stages.	Might be known in most cases, by information from Key account managers or desired product specifications. But there will surely be cases where it is unknown and within future work means will need to be identified witn respect to how to deal with that.
4	Step 1	5	Not complete scheme of the Fig. 1	Additional “use” box should be added after the box “Upgrade”. Without this, the Upgrade does not make sense.	Add a new box “Use” after the “Upgrade” box.	Completed
4	Step 1	4-5	Assessment of key lifecycle stages	Assessment of the key lifecycle stages for the addressed case study "machine tools" is missing.	Execute an assessment of key lifecycle stages for the addressed product group.	Such an holistic assessment was not a focus of the project, but might be an interesting area for further research. It was also addressed quite extensively in hte 2012 Prepartory Study report re. Machine Tools.
				There are only assertions about which lifecycle stages are relevant.		
				There is no evidence for these claims.		

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
4	Step 2	5	Assessment of product scope boundaries	Assessment of the product scope boundaries is missing.	Execute an assessment of the product scope boundaries for the addressed product group.	Such an holistic assessment was not a focus of the project, but might be an interesting area for further research. Response also as above re. 2012 report.
				It is not defined how to consider devices which are shared non-equally with other production systems, e.g. cooling devices		
4	Step 2	5	‘Assessment of product scope boundaries	ISO 14955-1 is cited, hence the impression arises, that ISO 14955-1 solves the question of where product boundaries have to be set.	Delete the sentence *"ISO 14955 Machine tools [….] also covers these aspects in the overall scope"*.	True, the ISO only gives assistance with reagrds to how it can be solved.
				Please note that this is not the case.		
4	Step 3	5	Other impacts (than the use of electrical energy) are usually regarded as being of comparatively minor importance.	This is as a general statement incorrect. There are technologies within the very inhomogeneous field of machine tools where cutting fluids and lubricants prevail the electrical energy, e. g. types of grinding machine tools	Delete this assertion.	True, this case study focused on the feasibility of the method. In general other impacts can easily be integrated in the same manner.
4	Step 3	6	“[…] the majority of the case study focuses on the impact of energy in use…”	Energy impact is only one criterion. Costs, production time and quality of production are crucial for the machine tool users and cannot be neglected. Otherwise we can go back to manual operated machines tools.	Combination of costs, quality and productivity should be considered as well.	Costs, quality and productivity are not part of the ecodesign assessment which was the focus of this study, but the methodology proposed is neutral from a quality and productivity perspective and could be adapted to integrate economic considerations
4	Step 4	6	§1	This is an incorrect assertion.	Reworking of Step 4 is necessary.	True, a buyer’s motivation might be unknown and he/she might also buy an oversized machine for the final task. But this part of the methodology is focused on – via ecodesign considerations - choosing the components within the MT in a reasonable proportion to each other under the assumption of an intended

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
						use profile and/or working principles.
			The earliest stages of product development have the highest impact on the final energy use.			
				Machine tools are products designed for a range of applications. Hence, the concept design defines principles without incorporating definite solutions (mass of moved parts as a function of stiffness, drive system etc.)		
				One key issue is the buyer's decision which range of possible application he has in mind. So he might buy a totally oversized machine, but this is out of the hand of the manufacturer.		
				Furthermore, the user behaviour is as important or even more important. It occurs only during the use phase.		
4	Step 4	6	§ 2 and 3	These statements are only valid if a machine tool would be developed and designed "from the scratch", what is rather seldom the case.	"The passage proves that – because of the inhomogeneity of the product group machine tools - a general determination is not possible and the application of the method is not possible.	The approach is intended to be suitable for new products. For variations most options are suitable, too. But might need to be adapted for any specific set of variations.
				Determination of the relevant phases is completely arbitrary. There is no evidence for the given statements.		

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
4	Step 4	6	*"… the potential to concretely assess environmental impacts via measurement […] is rather low."*	This is correct. We need to keep in mind that in all presented relevant lifecycle phases, neither a component (module) nor a complete machine tool are yet existing. Hence measurements cannot be executed, as this requires the product, which is to be measured, to be built first. Especially for large and custom built machines, this is usually possible only after the machine has been installed at the customer site and real-life processes have been run.	Reworking of Step 4 is necessary.	This study aims to demonstrate the principle of feasibility. How these impacts could be quantified should be a point for further investigation.
4	Step 4	7, § 2	*"Furthermore, the way product is subsequently used has a very significant impact on its energy consumption and thus measures that influence user behaviour are important and need to be taken into consideration."*	This is correct, but how is this done? In early development stages the use behaviour cannot be defined / or is known. Further a variation is possible.	This cannot be done.	There might be measures influencing the user's behaviour reagrding an energy efficient use of the MT. Such as providing a worksheet, for example, or in the case of custom-made products, specific instructions where energy efficiency measures are adressed.
4	Step 4	8	Potential sources of good/best practices	*"Additional criteria like the use of virtual machining…can be easily included in the list of criteria"*	Delete paragraph. Leave listing state-of-the-art applicable criteria to experts.	The final selection of criteria should indeed be identified by exerts, e.g. by an expert panel.
				Certainly many criteria can be easily included in the list. The problem is to identify whether they make sense. Especially virtual machining, i.e., the simulation of machining operations, in general is far from delivering precise information about the energy intake and energy efficiency. Single applications in research have shown that this can be used to increase efficiency, but this is far from being rolled out for a universal application. Mostly because simulation tools often lack detailing, which is not suitable to provide for SMEs.		

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
4	Step 4	10	Detailed product design stage (§ 1)	*"… combinations which would lead to those effects need to be detected an avoided."* ☐ Please show how this is applicable in the field, not only state the theory.	Provide an entire example of a real machine tool as case study.	Once again, the focus of this study was to show the principle feasibility of a point system.
						A real case study would be an interesting point for further investigation.
4	Step 4	10	Potential sources (§ 2)	*"As a first step, the saving potential of a machine tool design may be derived from the findings of the ENTR Lot 5 Preparatory Study"*	Delete the sentence.	True, therefore it is stated "as a first step". If this approach were to be implemented some future work would need to be done with regard this point.
				These are arbitrary examples, and the so-labelled "tendency" of savings potentials certainly lacks conclusive evidence.		
				Please remember that the international ISO experts working group for ISO 14955 discussed supplementing such an information in the standard and in the further process refrained from doing so due to lack of evidence and lack of conclusiveness.		
4	Step 5	11	Environmental impacts of the qualitative stages […] are difficult to estimate with any accuracy in a quantifiable (cardinal) manner. Still they are of major importance […].	This is true but estimations are not accurate and can lead to false measures / assessments.	Estimations cannot be applied, only on a generic level (e.g. is a design method considered).	True, those estimations are always based on subjective considerations. Nevertheless, the assumptions made should be valid enough to convince the person or institution assessing the estimations made (e.g. during the course of market surveillance).
4	Step 6	11	Those components / modules can be assessed and optimised individually.	This is true but there is even more. Components can have a dependency. Individual assessment can lead to a positive assessment, a combination to a negative.	This assessment can't be done.	This is the reason why a correlation matrix applied at the component level might be desirable.

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
				Individual assessment and optimization is not enough for a "fair" assessment.		
				How this can be done if the user behavior can't be known during the design stage? The uncertainty is not high, but extremely high.		
4	Step 6	11	New term: "analytical module"	Meanwhile there are many terms introduced, such as:	Additional information required.	Some additional explanation about the terms can be given.
				☐ Complex product	Show how to apply the method, avoid introducing new theoretical terms without definition and relation to existing products.	
				☐ Product system		
				☐ Product module	If using terms, stick to definitions from standards or other sources, otherwise provide clear definitions, and be aware that some definitions might be already used in other contexts than energy efficiency, which might cause confusion.	
				☐ …		

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
				However, Step 6, introduces suddenly a new term called “analytical module”. What is an analytical module?		
				For a method that shall be applicable in the field we need hard information, not new theoretical constructions.		
4	Step 6	11	Interaction of modules	What is to be done if some modules or parts incorporated in a machine tool are already under ErP regulation, e.g. IE3 motors or pumps?	Please include this aspect.	Clarified.
4	Step 7	12	*"While the energy demand during productive modes is rather independent of the actual application of the machine …, the energy consumed in the times of productive operation can vary substantially …"*	This is not acceptable. Define energy demand and energy consumed. Don’t confuse energy demand with power input rating.	Please rework your line of thought.	Can be clarified
4	Step 7	12, 3rd par.	*“Thus any given machine tool designer can either be expected to know enough about the intended use …”*	This is not correct. Statistics (e.g., from Czech Rep.) for large and medium-size machines sold showed the following:	This main idea is unfortunately wrong and should be modified	Thus it can be considered for the cases when the purpose is known. For those cases when it is unknown, an acceptable way has to be found regarding how to deal with it and how the uncertainty should be considered.

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
				- 10-20% machines are sold with knowledge of the machine will do -> duty profile during production life is known		The MT designer could at least state the main purpose for which the MT is designed. Even while accepting that he/she can't know if his/her customers are really using it for this purpose.
				- Approx. 30% are sold with knowledge of requested technologies (not workpieces) -> duty profile during production life is not known		
				- 50% are sold without ANY knowledge of the user behavior		
				This statistic is valid only for the first 2-5 years of the machine lifetime. After that, it's hard to predict what the machine will do. Machine tools are used up to 30-40 years.		
4	Step 7	12	Sensitivity of points outcome vs. duty profile (last § of Step 7)	This is a very academic point of view. In the context of practicability and effort, this argument is misplaced here.	Delete.	The effort required shouldn't be that high.
4	Step 8.1	13	Product development stage	Self-declaration vs. third party certification	Delete third party certification.	Third party certification is an option, among others. It offers a neutral judgement, which might be more objective than for the case of self-declaration.

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
			Fig. 10	The applied feature for improvement stays the same, whether it is self-declared or third party certified.		This is for illustrative purposes to reflect the notion that 3rd party certification is likely to offer some extra value. Any decision on this issue would need to be made by mandated policymakers.
		15				
				Rating an identical realized feature 3 times higher when it is certified by a 3rd party than when it is declared by the machine tool manufacturer, would cause a major discrimination.		
				Doing less but getting more credit for paying 3rd party is rather establishing a new business model for 3rd party entities than contributing to the aim of ecodesign regulation. It fundamentally counteracts the principle of subsidiarity.		
				In addition to that who would represent a 3rd party? In most cases they are non-public bodies.		
4	Step 8.1	13	Table 1	Weighting the realization of aspects to five levels and assigning the points 0 – 4 is completely arbitrary.	Avoid stating implementation ideas without giving evidence why this is chosen and the (only) correct/valid approach.	True, other systems are also applicable/imaginable. We chose this common five-point scale because it is quite intuitive.

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
						Were the point system to be implemented, the weighting to be ascribed would presumeably need to be elaborated via a panel approach. Sensitivity analyses might also help inform deliberations.
				Where is evidence for doing so?		
				Several other systems are applicable/thinkable.		
				Note that development stage is really kept secret.		
4	Step 8.1	13	Table 1	Who will judge to what extent an aspect is realized?	Give guidance on how to apply this approach in an indisputable way without leaving room for interpretation.	To define the degree of fulfilment, some addtional questions might help. The definition of these supporting questions might be a subject for further work.
				This is completely arbitrary and will work only in theory. In the field it is not appraisable, if a certain extend is reached.	See also next comment, concerning the example.	
4	Step 8.1	14	Method description	This is complex but still not sufficient. How to deal with different machine tool options, e.g. hydraulic accumulators 2l – 20l?	Too complex / but not sufficient enough	Yes, it is complex, because we are dealing with complex products. Different options might be chosen in reponse to the purpose the MT designer has in mind. He/She knows what specific configuration makes sense.

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
4	Step 8.1	15	Figure 10 Example checklist	*"… it was implemented to its full extent, and hence this results in a score of three out of a possible 4."* If an aspect is "implemented to its full extent", it shall be scored 4. This is exactly what was stated in an earlier comment. The arbitrary judgement is taken here as a base.	Give guidance on how to apply this approach in an indisputable way without leaving room for interpretation.	True, will be corrected.
4	Step 8.1	15	Figure 10 Example checklist	Which are the items to be included on this list? Are they the same for any kind of machine tool?	Needs to be clarified if it would be a single list for everyone or different lists for different machine groups.	The detailed extent of such a list would need to be identified by an expert panel. Whether it would be beneficial to apply a generic list or different lists e.g. for wood-working machines,..finally depends on the items which are listed.
4	Step 8.1	15	Figure 10 Example checklist	Points achieved - which are the minimum required points to declare the compliance?	This needs to be clarified. It should be possible to get the minimum punctuation without 3rd party certification.	This is a decision for the Commission and mandated policymakers to decide.
4	Step 8.1	15, 1st par.	*"Because the explanation seems reasonable, […]"*	Who will decide what seems reasonable or what does not? This is very much fuzzy and can't be used for precise points calculation.	More exact decision procedure is required.	Additional supporting questions might provide more clarity.

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
4	Step 8.2	16	Assessment	This methodology to assess which is the better combination to design the machine only takes into account eco-design requirements. It does not guarantee that the chosen option complies with other client specifications, such as cost, productivity, final part quality… Due to the high customizing of machines, list of components can't be done in this stage. This information is not known. Machine tools are tailor-made according to customer wishes.	New/Other variables should be taken into account.	This is an ecodesign point system and therefore concentrated on eco-design. While of course other factors also are playing a crucial role, they are not part of the scope of this study. The text has been clarified to reflect this
4	Step 8.2	16	Definition of the correlation matrix	The correlation matrix can possibly have hundreds of variants of design options because the interaction between components/modules and due to the modulating control of some components. This will be a monster table with some unknown or known but indescribable variants.	This is almost impossible to do. Please, propose the procedure, how to make the matrix smaller (like prescreening) Otherwise this matrix can't be done properly and there will be massive administrative burden.	Additional future work is required to enable simplification. A software based solution might provide some helpful support.
4	Step 8.2	19		*"… It is assumed that the combination of the design options can be calculated by a linear combination of the individual savings. …"* This assumption is incorrect.	Accept that this method is not applicable for the product group of machine tools, if the aim is achieving higher energy efficiency for the product group.	Yes, it this assumption is connected with uncertainties. But this combination of saving options offers a possibility for how to compare all the different types and purposes of MT with a MT specific reference case.

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
				As this assumption is a pillar of the whole method, but indefensible, the method cannot be applied in the field when the aim is to achieve a lower energy use/ higher energy efficiency.		
4	Step 8.2	20	Table 3	It may be an example only, but values are completely nonsense and far away from reality. Do you expect to prepare a reference cases or could each machine tool builder establish and then estimate his own reference case(s)?	Use realistic values, e.g. apply an example of an existing machine tool.	The values are not intended to be realistic and it should be underlined that this is not an actual machine tool but an illustration of principle. Under this method each MT builder is required to consider their own reference case, based on the presence or not of energy saving features.
4	Step 8.2	20	Table 3 – energy use	The total energy use is lower than the sum of the individual operation states. This is confusing. The power intake is usually calculated as average value, but energy use is usually calculated as a sum.	Recalculate the energy use as a sum of energy consumption during the year.	Yes, this might be confusing in the sum, but this listing appears more reasonable when concentrating on the different operating states.

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
4	Step 8.2	20	Table 3 - fraction of time	Fraction of time CAN'T be defined during the design stage. The designer doesn't know what the machine will do for next 1-40 years (the productive life of standard machine tools), different user groups behave totally differently (series production vs. job shop), and their share in the sales of the actual machine can hardly be predicted. The same is true for the power intake.	This methodology is not suitable for machine tools. Such calculation can be highly manipulated to have good results.	This might be true, but reasonable assumptions for the MT could be given. Nevertheless, this should also be the subject of future investigation.
4	Step 8.2	20	Table 3	Who is going to decide about the weighting of the annual consumption of the machine in the different operation modes?	Needs explanation. Use realistic values, e.g. apply an example of an existing machine tool.	The focus of this study is to show the feasibility of the principle of a points-system. A real case study would be an interesting point for further investigation.
4	Step 8.2	20	Last sentence (written in bold) on the page	*"Rather it makes sense to use the approach set out in ISO 14955-1:2014 that lists energy savings design options and the typical savings expected from their use. …"*	Delete this statement as it is incorrect.	Has been deleted.

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
					Think about the method. It seems that the method is based on too many assumptions and incorrect interpretation of ISO standards.	
				ISO 14955-1:2014 **does not** give "typical savings expected …".		
4	Step 8.2	21	Last sentence on the page:	Please explain how to deal with variants, where machine tools manufacturers often assume that changing a piece of equipment will suit the customer better, without re-evaluation the full load profile that was considered in the original design.	Show how variants can be easily and without major additional effort managed under the methodology.	In this case, once again, software based support might offer some help.
			"This reference case has to be defined individually for each assessed product and load profile"	There can be unlimited number of load profiles of the machine due to its usage by customer, used technologies, interaction between components etc.		
4	Step 8.2	22	Table 5 - Energy use	The total energy use is lower than the sum of the individual operation states. This is confusing.	Recalculate the energy use as a sum of energy consumption during the year.	Yes, it might be confusing in the sum, but more reasonable when concentrating on the different operating states.
				The power intake is usually calculated as average value, but energy use is usually calculated as a sum.		
4	Step 8.2	22	Identification of the BAT case	*"By knowing all feasible design options"*	Avoid the illusion that the method requires the machine tools manufacturer	Were the points-system to be implemented, the correlation matrix

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
				Who can say he knows them ALL? Certainly engineering follows a methodology, but project-driven business is usually not as comprehensive as the academic approach.	to evaluate ALL thinkable design options.	and the list of design options should be structured to allow the possibility of adding new design options.
4	Step 8.2	22	BAT case / general cases	You define two general cases with reference to building the BAT. Again, you do not consider that design options may not only dominantly increase the overall energy consumption, but may do so in order to significantly reduce energy per part. This concept, as aforementioned, is nowhere to be found.	Please consider the importance of efficiency increase in terms of energy per part.	The focus of the ecodesign assessment is not energy per part but the whole energy consumption of the MT.
4	Step 8.2	22	BAT - individual duty profile	How to define individual duty profile?	More specific definition is required.	The duty profile of the BAT is the same as intended for the MT which is to be designed.

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
4	Step 8.2	22 - 31	Identification of the BAT case (and subsequent sections)	All the calculations give the impression that the method is giving precise results. This is however not the case as at the beginning way too many assumptions have to be made.	Consider method not mature to be applied in the field or find a solution to substitute all the assumptions, assertions without evidence and incorrect interpretation of ISO Standards with correct facts and data that can be proved.	Yes, there are assumptions and uncertainties.
4	Step 8.2	23, §3	Wrong reference in the sentence: *"The following Table 6 shows all combinations of three design levels."*	This should be linked to the Figure 15, not Table 6.	Correct the reference.	Has been corrected
4	Step 8.2	24	Table 6 - Case 2 and Case 3 are swapped	2nd column is for Case 3, the 3rd column is for Case 2.	Correct the Table 6.	Has been corrected
4	Step 8.2	24	*"The reference case always has 100% energy use."*	The calculation comes from Table 2 but it is valid only for stand-by.	Add to the text, that this example is only for stand-by.	The text has been edited. The example is only for standby, but illustrative for all modes.
4	Step 8.2	25	Table 8	What if the chosen case does not comply with other requirements such as cost or productivity requirements?	Provide a solution to incorporate all expectations a machine tool needs to meet.	This was not within the scope of the study but might represent an interesting point for future investigation.

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
4	Step 8.2	25, §1	This means, that the maximum saving can only be determined depending on the shares of operating states (duty profile stages) and the energy budget of the various operating stages.	How to define shares of operating stages (duty profile)?	Duty profiles are seldom known. Assumptions have to be made but shall be avoided.	Yes, assumptions have to be made. Furthermore, they might be addressed by sensitivity analyses.
4	Step 8.2	26	Table 11 - Fraction of time	Who defines the share of the machine tool stages?	Needs clarification, if this is an assumption it might be not suitable or can be manipulated.	The MT designer if the purpose of the MT is known. If not assumptions have to be made.
4	Step 8.3	30	§3 of 8.3 *"This situation is a classic example why a points system can be helpful because it can recognise degrees of progress towards an eco-design objective …"*	Unfortunately, this case study does not cover an example of an existing machine tool. Hence there is no evidence for the statement given.	Execute the case study/apply the methodology to a real existing machine tool or even better on several types/technologies of machine tools, e.g. metal working machining centre, metal working grinding machine tool, etc.	One or more real case studies would be an interesting point for further investigation.

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
4	Step 8.3	30 - 31	An example checklist for a mechanical servo-press or mechanical presses	Features assessed in the Figure 16 are not (all) correlating to this type of machine tool.	The case study is – as the method of described in Task 3 – a theoretical model. It cannot be applied in the field.	The features are only intended to provide an example. Whether the list should contain all features or only those relevant for a special type of machine tool, may be decided by an expert panel (as is also the case for the items and features addressed in the previous stages).
			(§4 of 8.3 and Figure 16)	It seems that all the given "micro-examples" aim to proof that the whole variety of machine tools can be covered within the method/case study. This is clearly not the case.		This would be a good point for further investigation
				Points achieved - which are the minimum required points to declare compliance?		Any specific setting of thresholds should be done by the Commission and mandated policymakers with the assistance of an expert panel. This issue is thus beyond the scope of the current study.
					It should be possible to reach the minimum score without using 3rd party certification.	This is an issue to be addressed by the Commission and mandated policymakers with the assistance of an expert panel.

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
4	Step 8.3	32, §3, 2nd sentence	Adjustment to Task 3 methodology	*"However, the method put forward here based on ISO 14955-1:2014 …"* Objection: The method of ISO 14955-1:2014 and the method of Task 3 and Task 4 are obviously not identical or similar.	Please avoid giving the impression that the method is in line/covered by an ISO Standard.	Yes it is not and this is not what the sentence intends to say.
4	Step 8.4	33	Assembling the energy budget	*"…a panel approach, or, for example, consulting experts via a pairwise Analytical Hierarchy Process…"* To have an impact factor for any of the three stages be decided by any panel cannot be part of a transparent, universal methodology for complex industrial goods for the following reasons: a) The proportion of the stages cannot be identical for different types of machine tools, because their application is different	Accept that the method is a theoretical model and not applicable in the field/for the product group of machine tools. Assumptions that discriminate individual or groups of machines and their application cannot be the foundation of a regulatory approach.	When really thinking about implementing this method, these points should be addressed and discussed. But this cannot be done within this exploratorily-oriented study.

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
				b) The impact of the user impact varies (e.g. from automated serial production to invidiual workpiece manufacturing), hence this needs to be considered		
				c) Who constitutes such a panel and how should it work, if the global experts' panel (ISO TC39 WG12 for ecodesign of machine tools) cannot cope with such a task?		
4	Step 8.4	33		*"… the energy budget that is directly measurable."* This is not the case, as already explained. For measurement a component (or to be exactly a component and all its adapted variants (with/without features)) must exist. This is clearly not the case in the detailed design phase!	Accept that the method is a theoretical model and not applicable in the field/for the product group of machine tools.	For most components past data or data for calculations might be available.

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
4	Step 9	34 – 36	Normalisation and awarding of points	All the calculations give the impression that the method is giving precise results. This is however not the case as at the beginning way too many assumptions have to be made.	Consider method not mature to be applied in the field or find a solution to substitute all the assumptions, assertions without evidence and incorrect interpretation of ISO standards with correct facts and data that can be proved.	True, there are many assumptions to be made and thus the result is subject to uncertainties. These might be addressed by sensitivity analyses or by considering the extent of uncertainty in the that any minimum required score were to be defined.
4	General		Checklist approach	A Checklist with possible features, whether this list is taken form a standard or developed from another group of experts will always be an incomplete list. However, in the very heterogeneous product group of machine tools there are way more possible features for improvement, depending on the certain technology/individual machine tool.	Extend the method to leave room for technical innovation and entrepreneurial freedom.	As is also the case for the list of energy saving features, the checklist should also provide the possibility to add new features providing they are reasonable and provable.

Organization: CETOP	Name: Jörn Dürer	Date: 30.03.2017

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
4	General			It is not clear what the advantage of the proposed point system is when the points are given to an individual machine tools. How can machine tools be compared and requirements be set taking in account that the bureaucratic burden and the costs are acceptable (see also comment on 8.2, pages 20/21)?	The method as proposed cannot be used for an eco-design regulation and has to be overworked.	The benefit of this method is, that it enables a comparison of complex products not with other complex products (as reference case) which are due to their nature inherently different, but with the complex product itself. Thus generic reference cases are unnecessary.
4	8.1	13	Third party audit	Third party audit	Delete the statements regarding third party audit in this and the following paragraphs.	Third party certification is one option, among others. It offers a neutral judgement, which might be less subjective than for the case of self-declaration.
				It is not comprehensible that two similar machine tools achieve different scores only because of an audit of a third party during the product development process.		The extent to which this is really an option, has to be decided by others.
				It should be the target to get more points for more efficient technology and not for involving a third party.		

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
				A higher rating of the third party auditing in comparison to self - auditing does not represent the efforts of the design improvements, so a better machine tool ends up with lower points than a highly optimised machine tool, only because of third party audit without any technical reason. Third party audit would be a very high and misleading effort especially for lot size 1 machine tools and increases significantly costs of product.		
4	8.2	17	Figure 11	Figure shows too many options which makes it hard to read and misleads concerning relevance. On the other hand it shows how complicated the correlation matrix can become. In real live there can be even more options than demonstrated in the example.	Reduce options for each field to three (e.g. option 1, option 2, option n) and propose a procedure which leads to a smaller matrix for a real machine.	To assess all its benefits, the correlation matrix is indeed quite complicated. Further work has to be done to enable simplifications to be made. A software based solution might provide some helpful support.
4	8.2	18	Figure 12:	See previous comment	See previous comment	The figure is just intended to show how the correlation matrix is linked to the steps which follow it.

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
4	8.2	20/21		The bureaucratic burden for the calculation of different design options for each module is not acceptable especially for tailor made subsystems (only one of all calculated options will be realised). Subsystem suppliers as e.g. suppliers of the hydraulic and pneumatic modules of complex machines will have a high effort to support the manufacturers of complex machines. As it is mostly lot 1 quantities for specific machines, the efforts to support the machine manufacturer with detailed calculation will be between 3-5 working days. The additional costs endanger the competitiveness of complex machine - manufacturers competing in worldwide markets. In many cases the calculations can only give a rough estimation because the use is often not known and can vary during the use phase.	The method depends on many estimations that can strongly influence the result of the whole point.	The calculations might indeed become quite complex and if the points system were ever to be implemented, a way must be found to simplify the calculation within the described steps. This would be an interesting point for further investigation.

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
				Precise measurements are only possible when the machine is already built for a certain use behaviour which can be changed during the use phase as already stated above.		

Organization: TRUMPF	Name: Sebastian Frank	Date: 31.03.2017

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
4	Title	1	Title: „Case Study“	According to its title, the study is supposed to be a „case study“. Unfortunately, the study presents no complete example of a real machine tool, which is assessed according to the proposed method.	Perform a complete assessment of an existing machine tool according to the proposed method.	The focus of this study was to show the feasibility of the principle of a points system. Nevertheless, a real case study would be an interesting point for further investigation.
4	General, Step 8.2	16-29	Method in general; handling of variants; page 21 last sentence: „This reference case has to be defined individually for each	The effort for conformity assessments according to the proposed method is too high.	Make suggestions, how to reduce the effort for implementing the proposed method.	The effort for the assessment is indeed quite high and complex. But since machine tools are complex products this can hardly be prevented.

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
			assessed product and load profile."	It is not clear, how to handle different variants of a machine tool. If there had to be a complete conformity assessment for every variant of a machine tool, the effort would be gigantic and the method would be totally impractical. If, on the other hand, the machine tool designer had only to assess one variant of each machine type he offers and he could choose this variant, it would become easy to manipulate the result. The machine designer could assess an „eco"- variant of his machine tool that is sold only in small numbers, because it is much more expensive than the other variants.	Make a suggestion, how to handle the conformity assessment of machine types with many variants, so that it remains feasible.	Perhaps a software based solution may offer some support.
4	Step 8.1	15, 37	page 15 fig. 10;	In the study (see fig. 10) all criteria are weighted the same, although the potential for reduction of energy consumption or the magnitude of the environmental impact is very	Will the criteria have weighting factors later? Can you tell about those weighting factors?	While further weighting with regard to the energy efficiency potential may surely make sense, it would also increase the complexity of assessment. And since these rather

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
			page 37 second paragraph	different.	Is the higher point value for a criterion because of a third party certificate, although realized to the same extent, really justified?	qualitative aspects are quite hard to assess, the benefit coming from a higher degree of detail in the assessment, may be outweighed by the greater effort required for the assessment.
					Please note the following: As soon as a market supervision authority checks the conformity assessment, this automatically at least equals an external audit. This means, after an inspection, the factor must always be 3.	
4	Step 8.1	15	page 15 fig. 10	The criterion „Sustainability criteria are taken into account during the whole product-life-cycle" is not very precise. In which cases a machine designer may award himself 1, 2, 3 or 4 points here? Which "Sustainability criteria" shall be considered?	Remove this criterion.	The list of criteria is only intended as an example and should, if the points system is ever intended to be implemented, be edited and completed by an expert panel.
				Besides that, the consideration of sustainability criteria during the product lifecycle has only an advantage, if it has an impact on the product design or leads to concrete measures that can influence the behavior of the user (which are considered in stage 3).		

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
4	Step 8	31, 20, 22	Productivity and idle time	The point scores calculated by the proposed method don´t reflect progress in productivity and the reduction of idle time sufficiently, because these two factors are essential potentials for improvement of efficiency of machine tools. According to the proposed method, they are only considered in stage 3 (which in total contributes to only 14,3% of the overall score) as two of four criteria of stage 3. This weighting is too small. Besides that, they are only assessed qualitatively in stage 3, but productivity and idle times can and should be assessed quantitatively. To do that, it isn´t necessary, to compare the output of different machine tools on the basis of absolute numbers. Rather one can follow the concept of stage 2: Base the conformity assessment on the saving of processing time and idle time of the machine tool as realized compared to the reference machine and the BAT-machine compared to the reference machine, each expressed as a percentage of the processing time or idle time needed by the reference machine.	Proposal:	Since the focus of the study is on an ecodesign assessment, the productivity doesn’t play a crucial role.
					The criteria of productivity and idle time are taken into account in stage 2. To do this, the durations of the respective operating states used in the calculation are	But the suggestions made are promising and could be a good point for further investigation.
					• adjusted starting from the values for the realized machine according to the relative time savings of the realized machine compared to the reference machine for the calculation of the reference machine;	
					• adjusted starting from the values for the realized machine according to the relative time savings of the BAT-machine compared to the realized machine for the calculation of the BAT-machine.	

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
					To determine the relative time savings, design options, which boost productivity or reduce idle times, are considered. Organizational (as opposed to technical) measures to reduce idle times are not considered in stage 2. They are still considered qualitatively in stage 3 together with all measures targeting the user behavior, because their effect is hard to quantify and depends on the behavior of the user.	
4	Step 9	37-38	Regulation based on	The study doesn´t make a statement	Question:	Any specific setting of thresholds

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
			the points system	regarding what shall happen with the calculated points value.	Shall all machine tools, which score below a given threshold be excluded from the market? How great shall this threshold be? Shall machine tools be classified in efficiency classes on the basis of their points values and labeled accordingly? How great shall the thresholds for the different efficiency classes be?	should be done by the Commission and/or evaluated by an expert panel. This issue is thus beyond the scope of the current study.

Organization:	Name:	Date:
ISO/TC 39/WG-12	**Ralf Reines**	**2017-03-24**

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
4	**General**		**Offer**	ISO/TC 39/WG 12 is dealing with the environmental evaluation of machine tools. Experts from around the world gather to discuss these topics.	Consider mandating ISO/TC 39/WG 12 to develop a solution to determine the progress and results that will be achieved when applying ISO 14955-1 or whatever is helpful to support the ongoing process of regulating the product group of machine tools concerning directive 125/2009/EC.	Thank you very much for his kind offer. This is a decisison for the Commission to make.

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
				As already offered during the 2nd Stakeholder meeting ISO/TC 39/WG 12 would like to manifest its availability to serve as an expert panel. We are certain that the developed method at ISO 14955-1 is working, leads to improved energy efficiency and is applicable in the field.		
				ISO/TC 39/WG 12 is also certain that a solution can be developed to determine the progress and results that will be achieved when applying ISO 14955-1 by a single machine tool manufacturer and/or as a sector.		
4	General		Title: case study	Title of the Task 4 says that is supposed to be a case study. Unfortunately, there is no case study on a real existing machine tool presented. Only an example for a hypothetical component, called a “module” is given. This is not sufficient for a case study.	Execute the case study/apply the methodology to a real existing machine tool or even better on several types/technologies of machine tools, e.g. metal working machining centre, metal working grinding machine tool, etc.	The focus of this study was, to explore the feasibility of the principle of a points system.

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
						Nevertheless, a real case study would be an interesting point for further investigation.
4	General			Neither scoring, nor machine comparisons, can be made unless a specific component is used. The component's dimensions, material, accuracy and surface finish must be clearly specified, as otherwise comparisons are worthless. Even with the same part, a machine designed to take large components may score poorly if the component is towards the lower end of its size range.	To be considered when reworking the method.	Yes, should be considered in a further assessment.

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
4	General			Several parts, e.g. those used in compressors or engines, may have tight accuracy specifications in order to perform efficiently and with low energy supplied in their final machines over their lifetime of many years, The machine tool may therefore require high thermal control, which may in turn require high energy expenditure in its coolant systems and operating environment. This may result in a low score, even though the overall environmental benefit is many times greater than if the machine accuracy, and therefore its need for higher energy input, was lower.	To be considered when reworking the method.	This point should also be considered in a further investigation. E.g. by offering the possibility to neglect the energetic disadvantage resulting from this option. This of course also means, that a reasonable explanation has to be provided, ensuring, that those special treatments are not used in general.

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
4	General			The developed method is based on the assumption that modules of machine tools are independent and that independent optimization of single modules leads to a optimization of the overall system. This assumption is indefensible.	Consider if method is mature and leads to the result of higher energy efficiency of the overall system.	To consider negative effects between modules, a correlation matrix aplied at the modules level would offer some transparency.
4	Step 2	5	‘Assessment of product scope boundaries	ISO 14955-1 is cited, hence the impression arises, that ISO 14955-1 solves the question of where product boundaries have to be set. Please note that this is not the case.	Delete the sentence *"ISO 14955 Machine tools [….] also covers these aspects in the overall scope"*.	True, the ISO standard only gives assistance with regard to how it can be solved.
4	Step 4	10	Potential sources (§ 2)	*“As a first step, the saving potential of a machine tool design may be derived from the findings of the ENTR Lot 5 Preparatory Study”* These are arbitrary examples, and the so-labelled “tendency” of savings potentials certainly lacks conclusive evidence.	Delete the sentence and the related Figure 8.	True, therefore it is stated “as a first step”. If this approach should be implemented some future work has to be done regarding this point.

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
				Please remember that the international ISO experts working group for ISO 14955 discussed supplementing such an information in the standard and in the further process refrained from doing so due to lack of evidence and lack of conclusiveness.		
4	Step 8.1	13, 14	Third party audit	Third party audits do not provide more benefits to the energy efficiency of a machine tool.	Set factor to 3, if harmonized standards regarding energy efficiency is followed.	Third party certification is just one option, among others.
				Looking to the machinery directive and annex IV machines, no third party inspection is required if harmonized standards for these machines are followed.		We just made the assumption, however, the degree to which this is really an option, has to be decided by others.
4	Step 8.1	15, Figure 10	Machine tool specific aspects	The second part for the checklist will create a disadvantage for machine tools with only few functions. If only few functions are installed, only few points are earned, even if this machine tool is more efficient during the use phase than a machine tool with many functions, which are not needed for this type of production. Simpler machine tools can have a better efficiency than complex machine tools with functions not needed.	Split the checklist in two parts. In the first part are common features, the second part is machine tool related. Insert a new column in the second part: The percentage of energy used for each machine tool function as a weight factor. The sum of the factor in this column is 100%. This also will help to determine the quality of saving related to the machine tool in total.	This is just an example list and also offers the possibility to ignore some aspects if they are not relevant for this kind of machine tool.

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
4	Step 8.2	20	Last sentence (written in bold) on the page	*"Rather it makes sense to use the approach set out in ISO 14955-1:2014 that lists energy savings design options and the typical savings expected from their use. …"*	Delete this statement as it is incorrect.	It has been deleted.
					Think about the method. It seems that the method is based on too many assumptions and incorrect interpretation of ISO standards.	
				ISO 14955-1:2014 **does not** give "typical savings expected …".		
4	Step 8.2	20 ff.	Table 3 and similar tables	The line "Energy use" in the table is the energy used per year. The value given in the column "Total" shall be the sum of all other columns	Change value in line "Energy use" and column "Total" to the addition of other values of this table.	Yes, it might be confusing in the sum, but it becomes more reasonable when focussing on the different operating states. We will think about changing it.

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
4	Step 8.2 Step 9	22 – 31 34 - 36	Identification of the BAT case (and subsequent sections)	All the calculations give the impression that the method is giving precise results. This is however not the case as at the beginning way too many assumptions have to be made.	Consider method not mature to be applied in the field or find a solution to substitute all the assumptions, assertions without evidence and incorrect interpretation of ISO Standards with correct facts and data that can be proved.	Yes, there are assumptions and uncertainties, which will have to be addressed in future investigations before the method could be considered to be mature.
4	Step 8.3	32, §3, 2nd sentence	Adjustment to Task 3 methodology	*"However, the method put forward here based on ISO 14955-1:2014 …"* Objection: The method of ISO 14955-1:2014 and the method of Task 3 and Task 4 are obviously not identical or similar.	Please avoid giving the impression that the method is in line/covered by an ISO Standard.	Yes it is not and this is not what the sentence intends to say.

Organization: **VDMA**	Name: **Hanna Blankemeyer**	Date: **27 March 2017**

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
4		13 - 14	Product development stage / assessment	The text states that conducting a voluntary third-party audit increases the degree of credibility when applying a checklist methodology. Furthermore, producing such "credible evidence" should be given a higher weighting than weaker documentation or self-declaration. This would allow a point score of 4 for a specific measure to be multiplied by 3, in case a third-party audit was conducted. To the contrary, a measure with the point score of 4 would remain 4 if the evidence supporting its claims are based on self-declaration. If this logic was followed through, it seems that the overall points scored by two similar machines could vary considerably due to the assessment method alone.	Third-party auditing and self-declaration should be weighed evenly	Third party certification is an option, among others. Of course this doesn't prevent cheating, but makes it more challenging. The allocations proposed in this case study were intended of illustration of the notion that third party certification gives an extra level of surety and hence is worthy of some reward within the points allocation; however, this is an issue that would have to be decided by mandated policymakers.

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
				Firstly, third-party auditing is expensive. It seems that in this particular case, a financially potent economic operator would be able to afford a third-party auditing, and thereby multiplying his point score by three. Whereas a less wealthy company might not be able to afford a third-party auditor. If his product incorporates more environmental aspects than the more affluent competitor, his product would have to be three times as good to be able to compete. This would give incentive to invest into a third-party auditor rather than a more thorough environmental product development phase.		

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
				Secondly, VDMA disagrees with the value judgment underlying this section that suggests third-party auditing is generally more credible than self-declaration. Dishonest manufacturers will present false information about self-declaration as well as third-party auditing. Third-party auditors certify before a product is launched on the market. The product finally placed on the market may vary from the initially presented documents. Therefore, it cannot replace market surveillance authorities. Moreover, third-party auditors are not generally more reliable as a recent case about breast implants demonstrates where the certifier TÜV Rheinland was found liable for having certified substandard products.		

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
		16 - 29	Detailed product design stage	The calculations underlying the detailed product design stage are extremely complicated and complex. Company experts from the machine tool industry estimate the necessary calculations to take one person up to 2 to 3 weeks for one machine. Considering that in the machine tool industry we are dealing with the lot size 1, this process would have to be undergone for nearly every machine produced. Therefore, before going ahead with such a methodology, it stands to question whether this economic and administrative effort is proportionate to the environmental gain and does not hamper industry's competitiveness nor the affordability to the consumer. Recalling Directive 2009/125/EG, and, in particularly, article 15 (2)(c) and (5)(c)(d)(f), it is required that "the product shall present significant potential for improvement in terms of its environmental impact without entailing excessive costs" and implementing measures shall have, amongst others, "no significant negative impact on consumers in particular as regards the affordability and the life cycle cost of the product; no significant negative impact on industry's competitiveness, no excessive administrative burden shall be imposed on manufacturers".	Thorough impact assessment as to the economic and administrative feasibility of the proposed methodology	The effort required for the assessment is indeed quite high and complex, but since machine tools are complex products this can hardly be prevented. Perhaps a software based solution may offer some support under consideration of the listed premises of the Directive.

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
4	General		Title: case study	Title of the Task 4 says that is supposed to be a case study. Unfortunately, there is no case study on a real existing machine tool presented. Only an example for a hypothetical component, called a "module" is given. This is not sufficient for a case study.	Execute the case study/apply the methodology to a real existing machine tool or even better on several types/technologie s of machine tools, e.g. metal working machining centre, metal working grinding machine tool, etc.	This study focused on the assessment of the feasibility of a points system in principle. Nevertheless, a real case study would be an interesting point for further investigation.
				The developed method is based on the assumption that modules of machine tools are independent and that independent optimization of single modules leads to a optimization of the overall system. This assumption is indefensible.	Consider if method is mature and leads to the result of higher energy efficiency of the overall system.	The use of a correlation matrix applied at the module level would offer some more transparency regarding potential negative effects between modules.

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
4	General		Efficiency increase by productivity increase	Successful machine tool builders provide efficiency to their customers, in the sense of efficient production cost per part, which includes energy cost. Customers analyse the solution of the competing machine tool builders with respect to that property, i.e., this is a strong market force. The task 4 report doesn't mention at all that a high productivity increase in combination with a mild increase in energy consumption can increase energy efficiency (i.e., savings per part produced) dramatically, more than many technical measures. Certainly this is feasible only where there is a defined part, e.g., specified in the contract.	Explicitly demonstrate how a reduction of energy consumption per part will be considered when evaluating the energy savings.	This is true, but costs, quality and productivity are not part of the ecodesign assessment, which is the focus of this study.

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
4	General		Effort vs. savings	The method lacks the assessment whether a feature that improves energy efficiency is worth the technical and economic efforts.	Implement a system to judge effort vs. additional increased energy efficiency to the methodology.	Same comment: Costs, quality and productivity are not part of the ecodesign assessment which is the focus of this study.
				Many features may be possible and contribute to increased energy efficiency from a pure technical point of view. However, the level of additional increased energy efficiency is outweighed by the efforts to implement such features.		In principle the methodology put forward here could be adapted to include a life cycle cost analysis which could inform decisions regarding requirements; however, the study's terms of reference were clear in not desiring such an analysis. In the end, the machine tool manufacturer has to decide what makes economic sense.

Organization:	Name:	Date:
ECOS-EEB-Coolproducts	**Chloé Fayole**	**20/03/2017**

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
4-both case studies			Environmental impacts covered	Both the machine tools and data storage case stuides have been restricted to the energy in the use phase. This is unfortunate, because it does not give any idea about how the proposed methodology could be applied for other environmental aspects than energy use, especially resource efficiency (which is meant to be increasingly considered in the Ecodesign policy). It would be relevant and appreciated to have two highly differentiated case studies.	Change the scope of one of the case studies to ensure that the methodology is illustrated on (at least) two different environmental impact categorie	This is a valid point, however, it was decided only to look at energy in the use phase to simplify the method. This was also based on input from the 1st stakeholder meeting
4		33	Weighting of stage 1 and 3	The explanation is underdeveloped on how stage 1 and 3 are to be weighted in the overall energy budget. The decision to use a 20% weighting seems totally subjective. The reference to possible expert panels or AHP process needs to	Beef up the explanation on how nominal data (such as checklist points) are to be weighted in the final score system. Provide clarification and discussion in the task 3 report.	The 20% weigthing is a first suggestion based on observations reported in the literature. If the approach were ever to be considered for implementation, this would be a point for further investigation.

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
				be developed and better detailed. Otherwise, this step seems too arbitrary. Also, this kind of weighting step should be addressed and discussed in the general methodology task 3 report.		
		33	Weighting of stage 1 and 3	In addition to the previous comment, it seems incorrect to fully allocate stage 1 and 3 to the total energy budget, as several of the lines in the stage 1 and 3 checklists do not relate to energy consumption but other environmental impacts. For instance, 'prolonging component lifetime', 'disposal of the product', 'reducing scrap' may improve resource efficiency but are not related to the energy budget per se.	Provide a more rigorous allocation of stage 1 and 3 that respects the differences in environmental categories, and avoids inconsistencies in the energy scoring.	This checklist is not in a final stage but rather meant to provide some examples of an approach. Furthermore the current focus on energy consumption may be widened to other environmental impacts. The detailed content of a final checklist would need to be determined be experts mandated through an Ecodesign process and subject to the existing regulatory approval process.
		33	Table 19	Table 19 is not very clear. What do you mean by 'module 1' and 'module 3'? What do the figures '3.20 MWh' and '3.42 MWh' in the table correspond to? As stage 1 and 3 are nominal checklist scorings, how can they lead to precise MWh numbers at this stage?	Rewrite table 19 to make it clearer, or clarify how to read it	The energy budget reference case of 3.46 MWh is 20% of the stage 2 energy budget (of 22.32 MWh). The 3.2 MWh of the selected design results from multiplying this value by the score which was attained of 43 out of 60 (~71%) possible points as described in the chapter: Application in a worked example
		34	Methodology and innovation	As your method is based on using a published list of energy savings potentials per design option, how does it cope with innovation? What if a manufacturer wants to use a new design option that brings further savings, or finds ways of increasing the savings of an existing design option? How will this be promoted through this method? What kind of updating/revision process should be put in place?	Clarify how the method works with innovation, and how it can reward innovators	It is not a closed list and thus is open to innovations. The manufacturer may e.g. add this design option to his list. Acceptance of this would require provision of adequate documentation to demonstrate what the saving potentials are. In practice, some kind of guidelines would be required on how this is to be done and an approval process would need to be agreed.
		36	Comparison to CECIMO VA	The proposed methodology is not compared against the (already quite developed) voluntary initiative proposed by the machine tool industry. What are the differences, benefits, potential added-value, etc.?	Add a paragraph comparing the proposed method with the CECIMO VA, and what would be the added value.	The methodology was compared to other point systems, while we also considered elements from other approaches, e.g. the "Blue Competence" scheme from VDMA. Comparison with the CECIMO proposal would be time-consuming and beyond the study's resources and mandate. However, the

Task #	Section #	Page #	Topic	Comment	Proposed change	Reply study team
						utility of a scheme and methodology for considering "points systems" within a VA – in general – was part of the remit of the five-part study that we have undertaken, as set out in the Terms of Reference from the European Commission.

HOW TO OBTAIN EU PUBLICATIONS

Free publications:

- one copy:
  via EU Bookshop (http://bookshop.europa.eu);
- more than one copy or posters/maps:
  from the European Union's representations (http://ec.europa.eu/represent_en.htm);
  from the delegations in non-EU countries
  (http://eeas.europa.eu/delegations/index_en.htm);
  by contacting the Europe Direct service (http://europa.eu/europedirect/index_en.htm)
  or calling 00 800 6 7 8 9 10 11 (freephone number from anywhere in the EU) (*).

  (*) The information given is free, as are most calls (though some operators, phone boxes or hotels may charge you).

Priced publications:

- via EU Bookshop (http://bookshop.europa.eu).

Priced subscriptions:

- via one of the sales agents of the Publications Office of the European Union
  (http://publications.europa.eu/others/agents/index_en.htm).

Catalogue number

Publications Office

doi:10.2873/211016