About Nordic Ecolabelled

Machines for parks and gardens

Revision proposal for version 5

Background to ecolabelling

1 October 2012

Nordic Ecolabelling

Nordic Ecolabelled Machines for parks and gardens - Background to ecolabelling

040/Draft of version 5 for consultation, 1 October 2012

1 Summary 1
2 General facts about the criteria 4
2.1 Products that can be labelled 4
2.2 Version and validity of criteria 4
2.3 Nordic Ecolabel licences 5
2.4 The market 5
2.5 Other labels 6
2.6 Environmental impact of machines for parks and gardens 7
2.6.1 Product design, materials and packaging 7
2.6.2 Air emissions and energy efficiency (operation) 8
2.6.3 Noise 11
2.6.4 Vibrations 11
2.6.5 Customer information 11
2.6.6 Summary 12
3 About the revision 13
3.1 Purpose of the revision 13
3.2 About this revision 13
4 Requirement motivation 13
4.1 What products can be Nordic Ecolabelled? 13
4.2 Product design 15
4.2.1 Vehicle fuel 15
4.2.2 Spillage 17
4.2.3 Evaporative emissions 17
4.3 Materials 18
4.3.1 Marking 18
4.3.2 The RoHS Directive 19
4.3.3 Phthalates 20
4.3.4 Flame retardants 22
4.3.5 Surface treatment and metal plating 26
4.3.6 Accumulators/batteries 27
4.3.7 Packaging and other accessories 29
4.4 Operation of the Nordic Ecolabelled machine 30
4.4.1 Test laboratories and test methods 30
4.4.2 Emissions/air emissions 31
4.4.3 Carcinogenic effect 36
4.4.4 Lawnmower fuel efficiency 37
4.4.5 Noise 38
4.4.6 Vibrations 41
4.5 Customer information 42
4.6 Environment and quality requirements and regulatory requirements 44
5 Energy efficiency investigation 46
6 Changes compared with the previous version 49
7 New criteria 49

Appendices

1 Overview of changes to criteria compared with previous versions
2 Description of weighting models LCA
3 Description of EU directives

1 Summary

This product group comprises the following types of machines used for park and garden maintenance, both privately and professionally:

- Lawnmowers
- Lawn trimmers and lawn edge trimmers
- Brush cutters
- Chainsaws
- Leaf collectors and leaf blowers (for professional use only)
- Hedge trimmers
- Garden shredders
- Cultivators
- Riding lawn tractors/Movers
- Snow blowers

Only machines with combustion engines with a nominal engine output of ≤ 19 kW can be Nordic Ecolabelled. Combustion engine operated machines include air-cooled or liquid-cooled two-stroke or four-stroke engines. Petrol, diesel, ethanol or other alternative/renewable fuels may be used. The engine shall be new and adapted to the fuel type(s) for which it is intended.

Electrically powered machines may be corded or battery or solar cell operated. They may also be so called robots.

Nordic Ecolabelling imposes requirements within each of the three machine categories and is thus expected to achieve environmental gains in all three areas. Environmental gains can also be achieved for hand operated/manual machines through the material requirements contained in the criteria.

It is clear from this revision that agricultural and forestry tractors should not be included. Neither should All Terrain Vehicles (ATVs) as these are primarily used for transport purposes.

The life cycle analyses that have been performed for products (lawnmowers) in this category show that materials production and use/operation accounts for by far the highest environmental impact. Materials production contributes significantly primarily due to the energy consumed in the extraction and production of the metals and metallic materials used to manufacture the end products.

The environmental impact of the operation phase is as significant, or even more significant, than that of materials production. The studies that Nordic Ecolabelling has examined show that this impact is far greater for machines with combustion engines than for electrical/battery operated machines. However, results may vary depending on other conditions. For example, the impact resulting from the operation phase depends on how the electricity used was produced. Another health and environmental aspect linked to operation is evaporative emissions of hydrocarbons from the fuel

system. Noise is also an important issue from the point of view of the user and of the general public.

The criteria have existed in their current form since March 2007. Previously there were two sets of requirements for lawnmowers and garden machinery respectively. Appendix 1 to this document contains a table outlining changes to the requirements in this revision compared with version 4.5 of the criteria, dated March 2007. We have summarised the most important changes to the requirements below, including a brief background.

The emissions requirement has been clarified and tightened. While previous requirements stated that fuel systems needed to be designed in such a way as to minimise evaporation, there are presently established limit values for the fuel hose and fuel tank that must not be exceeded. The limit values correspond to those of the progressive requirements for air protection established by the California Air Resources Board (CARB). However, unlike CARB, Nordic Ecolabelling does not require machines to be certified.

Material requirements have been further tightened in the following areas:

- Heavy metals, PBB and PDBE are prohibited throughout machines for parks and gardens and not only in plastic components as was the case previously. This is in line with the RoHS Directive.
- The list of prohibited phthalates has been expanded to include DGP, DCHP, DEP and DIHP, all of which have been identified as substances of very high concern.
- There is also a complete ban on flame retardants HBCDD, TBBP-A and TCEP, as well as on highly chlorinated short-chain and medium-chain chloroparaffins.
- The previous requirement regarding a general ban on all halogenated organic flame retardants and the possibility of certain exceptions to this ban, if this is required for electrical or fire safety reasons, remains.
- Three new battery requirements have been introduced, entailing fundamental requirements with regard to battery quality, performance and safety. In addition, there are now requirements that regulate maximum heavy metal content in batteries, thus disqualifying lead accumulators and nickel cadmium batteries from Nordic Ecolabelling.

One major change is the removal of the requirement for a specific engine test in order to verify compliance with the Nordic Ecolabel’s emission requirements. Instead, the obligatory emission testing performed in connection with engine type approval for the European market has been suggested as verification of the air emission limit values. This would result in significant savings with regard to time, administration and costs, which we hope in turn, would result in an increased number of licence applicants. Limit values for air emissions from combustion engines have been tightened, primarily with regard to carbon monoxide. Hydrocarbon and nitrogen oxides limit values were already very low. The division between engine size and cylinder volume has been adapted and streamlined with the EU’s directive.

The criteria's previous requirements relating to carcinogenic substances in exhaust fumes have been removed. These were based on the assumption that petrol engine would be converted to be able to operate fuelled by ethanol. This does not happen today. It has not been possible to find research that shows what substances are formed in a new ethanol engine manufactured specifically for that fuel. It may be interesting to include this issue in future revisions.

The limit value for lawnmower noise has been divided into limit values for consumer products and limit values for professional products. The limit values for consumer products are deemed strict enough and have therefore been left unchanged. The project group deemed that a minor relaxation of noise limits for professional products was necessary. Professional products are manufactured differently and using other materials, for instance in order to meet requirements with regard to robustness. This results in a higher sound profile and is the reason behind the increased limit values.

One focus area of this revision has been to investigate differences in energy efficiency between machines running on fossil fuels and electricity/battery operated machines. The objective has been to find a functional unit that would enable comparisons between different products. For various reasons, the project group has not been entirely successful in this regard. The conclusion that we nevertheless draw from this is that several factors govern the choice of machines for parks and gardens such as lawnmowers. Energy consumption is one factor alongside several others such as lawn size, incline and other soil conditions, price, brand, overall experience, time required for mowing, etc.

2 General facts about the criteria

2.1 Products that can be labelled

Nordic Ecolabelling's criteria make it possible to Nordic Ecolabel machines for parks and gardens for private and professional use. The following types of manually, electricity or combustion engine operated machines can be labelled:

- Lawnmowers
- Lawn trimmers and lawn edge trimmers
- Brush cutters
- Chainsaws
- Leaf collectors and leaf blowers (for professional use only)
- Hedge trimmers
- Garden shredders
- Cultivators
- Riding lawn tractors/Movers
- Snow blowers

Only machines with combustion engines with a nominal engine output of ≤ 19 kW can receive the Nordic Ecolabel. Engine operated machines must also be covered by the EU's Machinery Directive (2006/42/EC).

Combustion engine operated machines with air-cooled or liquid-cooled two-stroke or four-stroke engines. Petrol, diesel, ethanol or other alternative /renewable fuels may be used. The engine shall be new and adapted to the fuel type(s) for which it is intended.

Electrically powered machines may be corded or battery or solar cell operated. They may also be so called robots.

The product group Machines for parks and gardens does not include agricultural or forestry tractors, nor terrain vehicles, i.e. ATVs (All Terrain Vehicles). Please see section 4.1 "What products can be Nordic Ecolabelled?"

2.2 Version and validity of criteria

There were originally two types of criteria; criteria for Lawnmowers, created in 1994 and criteria for Professional machines, established in March 2002. The evaluation presented in March 2007 established that these two product groups were to be merged. This resulted in the criteria for Machines for parks and gardens (version 4.0).

The criteria document (version 4.0) that has now been revised was created in March 2007. In June of the same year, SLM decided on certain minor adjustments (version 4.1). In November that year the validity period of the criteria was extended until 31 December 2009 (version 4.2). At SLM in October 2008 it was decided that the validity period would be extended by a further two years (version 4.3), making them

valid until 31 December 2011. In November 2010 it was decided that the criteria would be made valid for a further 18 months, resulting in version 4.4. Some typing errors/mistranslations in the criteria documents were corrected at the start of 2011. The latest version is version 4.5, valid until 30 June 2013. In March 2012 the Nordic Ecolabelling Board decided that the criteria would be revised, creating version 5.0.

2.3 Nordic Ecolabel licences

Only two licences have been granted for the product group; one to Husqvarna Manufacturing Sweden AB and the brand Klippo and one to Global Garden Products (GGP) Sweden AB and the brand Stiga. These two licence holders have a total of 19 Nordic Ecolabelled products, all of which are lawnmowers:

- one electricity/battery operated
- three ride-on mowers with petrol engines
- fifteen walk-behind lawnmowers with petrol engines

There has been minimal interest in Nordic Ecolabelling other products in the product group. There are several reasons for this. The main reasons are believed to be a limited interest among consumers in choosing Nordic Ecolabelled machines, the low volumes and small margins for these products and expensive engine tests.

2.4 The market

On a European level, the European Garden Machinery Federation (EMF) is an important stakeholder. The EMF has 16 ordinary members, including licence holders Husqvarna and GGP. Engine manufacturers Honda and Briggs & Stratton are also members. According to EMF, their customers sell more than six million lawnmowers, four and a half million chainsaws, three million brush cutters and as many hedge trimmers annually on the European market. They describe the garden equipment sector as highly dynamic and global. The largest market is the US, accounting for half of global sales. Second is Europe with 35 per cent of the world market, with the UK, Germany, France and Italy representing the largest national markets.

In Finland, the market for machines for parks and gardens is worth approximately EUR 50 million[1]. There are no comparative figures for other Nordic countries in the evaluation.

According to the licence holders themselves, Husqvarna, with several different brands including Klippo, accounts for around 70 per cent of Sweden’s lawnmower sales. Husqvarna estimates its annual sale of lawnmowers on the Nordic market to around 90,000 units. Other important brands on the market include Stiga, Viking, Honda and AL-KO.

[1] Evaluation of Nordic Ecolabelled Machines for parks and gardens, Nordic Ecolabelling, 22 December 2011.

The sale of machines for parks and gardens is highly seasonal with spring and summer the most important periods. Today's Nordic Ecolabelled lawnmowers are sold through various retail chains, primarily in the construction and gardening sectors. Some manufacturers also have their own retail organisations. The manufacturers have dedicated sales organisations for B2B customers and public administrations. It is worth noting that in the consumer market, men tend to be the ones making purchasing decisions for this product group.

2.5 Other labels

The CE label
The CE label certifies that a professional machine meets the requirements stipulated in the EU's Machinery Directive (2006/42/EC), implemented in the national legislation of all EU and EEC countries. These requirements relate to health aspects and the professional machine's safety, particularly when in use. Manufacturers are fully responsible for certifying compliance with the directive's regulations. Stricter certification procedures apply to certain types of machines with a higher risk factor.

The United States Environmental Protection Agency (EPA) has developed a regulatory framework (≤ 19 kW) for machines for parks and gardens which came into force in 2011 or 2012 depending on engine size. The aim is to significantly reduce hydrocarbon emissions. In addition, requirements for lowered evaporation losses from the fuel system aim to reduce carbon monoxide emissions and the creation of tropospheric ozone. The EPA's new regulations for small off-road engines (SORE) align requirements with those recently established by the CARB[2].

The German **Blue Angel** label established criteria for garden shredders in March 2012 and for garden machines in April 2010. It is very clear that the main objective of the Blue Angel is to lessen noise generated by these types of products. The criteria are then completed by requirements for air pollution/emissions. It is worth noting that leaf blowers and collectors are not covered by the criteria. The Blue Angel has presently awarded licences to seven companies, including Bosch, Stihl, Lidl and Grizzly Gartengeräte. Garden shredders account for the largest number of licences (five).

The **Austrian Ecolabelling** has been directly aligned with the Blue Angel but has yet to licence any products.

At present, **EU Ecolabel** has no plans to develop criteria for these product categories.

[2] US Environmental Protection Agency, Office of Transportation and Air Quality, Regulatory Announcement, September 2008.

2.6 Environmental impact of machines for parks and gardens

A buyer/user of a Nordic Ecolabelled machines for parks and gardens should feel safe knowing that the machine is energy efficient and generates only minimal emissions of substances that could be harmful to human health and the environment. It should also contribute less to the greenhouse effect and the spread of hazardous substances than a non-Nordic Ecolabelled machine.

Based on previous pre-studies, assessments and revisions, the Nordic Ecolabel imposes requirements within eight different areas.

1. Environmental and quality requirements with regard to manufacturing and the licence holder
2. Product design
3. Materials and packaging
4. Emissions (air)
5. Energy efficiency
6. Noise
7. Vibrations
8. Customer information

This section describes these areas based on environmental relevance, the potential for improvement and how Nordic Ecolabelling can steer improvement through its requirements. Environmental and quality requirements with regard to manufacturing and the licence holder are not described as these are fundamental requirements that should always be imposed.

2.6.1 Product design, materials and packaging

Relevance
The life cycle analyses that have been performed on products in this category show that the materials production phase and the usage phase are by far the most important in the product life cycle[3]. The materials production phase contributes significantly, primarily due to the energy consumed during the extraction and production of metals and metallic materials. A more in-depth analysis shows that it is the use of copper and iron ore that has the largest individual impact on the environment from a life cycle perspective. The same results are essentially achieved regardless of whether the object of analysis is a standard, petrol fuelled walk-behind lawnmower or a modern robot machine that does not require any manual handling at the time of mowing. Nor are there any significant differences between different manufacturers. The LCA analysis shows that the environmental impact of the manufacturing phase can be lowered by using recycled plastic in the manufacturing process. This is an interesting environmental aspect that could be studied further in a future revision. A future revision could

[3] "Life Cycle Assessment of Lawnmowers", Chalmers University of Technology, Sweden 2010 and "Environmentally Improves Product Design Case Studies of the European Electrical and Electronics industry", Eco-design subgroup, Brite-EuRam, 2002.

also assess the weight (kg/gram) of the materials used in the product as an indirect way of handling the environmental aspect.

An electrical/battery driven end-of-life machines for parks and gardens is covered by the producer/manufacturer responsibility for electrical and electronic products that has been introduced in all Nordic countries. Fuel operated machines are not covered by the producer/manufacturer responsibility. However, the forces driving recycling are strong, primarily due to the value of the metals used. An end-of-life machine is first disassembled as far as this is possible. Metals are separated for material recycling while plastics are often composites, difficult to separate and therefore sent for energy extraction through incineration. The amount of waste sent to landfill is minimised. At present, for example, polluted/soiled glass is sent to landfill[4]. Some components, e.g. batteries and compressor oils must be handled as hazardous waste. Packaging is covered by the producer/manufacturer responsibility for packaging and is included in the system that in the first instance prioritises materials recycling and secondly, incineration of materials.

The assembly that takes place to create the end product has a very limited impact from a life cycle perspective[5]. Overall, this supports the revision's focus on assessing the criteria's material requirements, completing them with battery requirements and not introducing any new requirements for the assembly phase.

Potential

The products available on the market differ greatly, from advanced solar cell operated robot mowers to imported, petrol fuelled, low-cost lawnmowers. The latter often contains more plastic than the former, which tend to have many metal components. There is potential for further environmental improvements through the exclusion of lead accumulators, often founds in low-cost robot mowers. The machines that market themselves based on quality rather than price tend to feature either nickel metal hybrid (NiMH) accumulators or lithium ion accumulators.

Steerability

The evaluation from 2011 conducted by Nordic Ecolabelling, showed that materials may be a difficult area to steer. Manufacturers are often small customers to global plastic and electronics suppliers, meaning that they may struggle to impose their requirements. Experience from licensing still shows that the material requirements imposed so far have been achievable.

2.6.2 Air emissions and energy efficiency (operation)

Relevance

The usage phase and the materials production phase have the largest environmental impact. The combustion of the fuel results in emissions of carbon dioxide (greenhouse

[4] El Kretsen, marketing manager Mårten Sundin, personal communication, 18 April 2012.
[5] "Life Cycle Assessment of Lawnmowers", Chalmers University of Technology, Sweden 2010.

effect) and nitrogen oxides (tropospheric ozone and health effects). However, if the machine is powered by electricity the contribution from the usage phase is far less significant and varies greatly depending on how the electricity was produced.

The LCA study by Chalmers[6] performed on one petrol operated walk-behind lawn-mower and one electricity powered robot lawnmower, illustrates this clearly. Two different methods have been used to weigh the result, EPS 2000 and Eco-indicator 99. For a description, please see appendix 2 to this report. The images below have been taken from the LCA report.

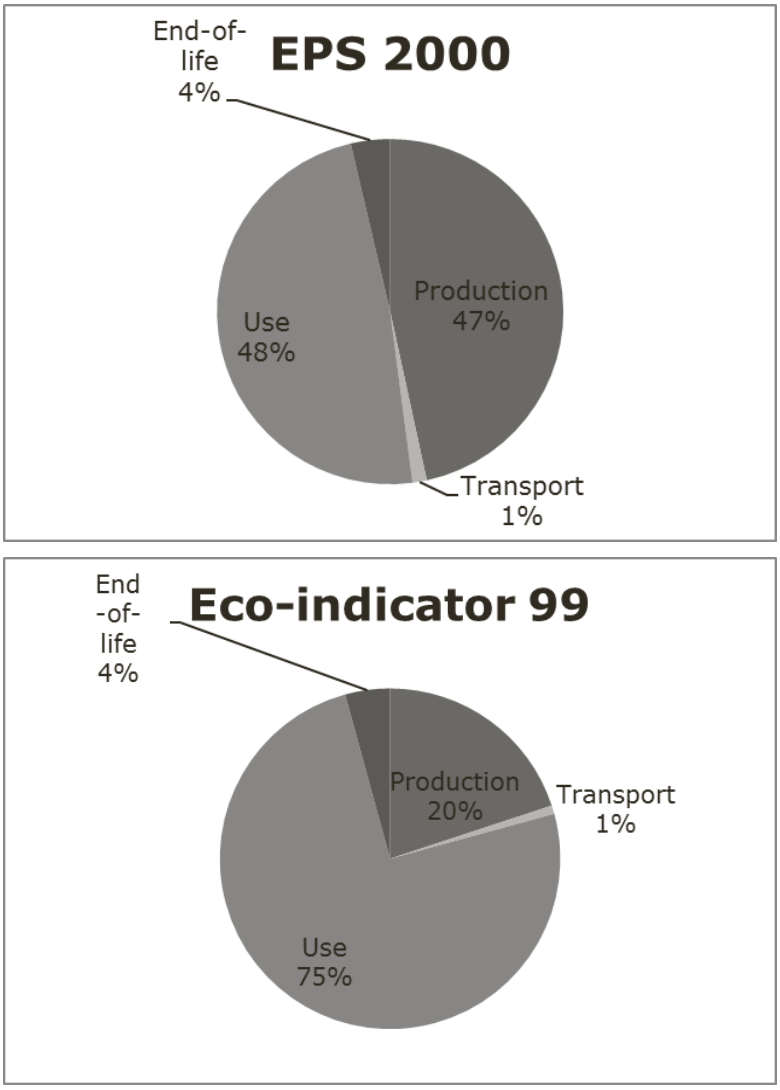


***Image 1**. Weighting results for petrol fuelled, walk-behind lawnmowers. Two different LCA methods are shown.*

[6] Life Cycle Assessment of Lawnmowers", Chalmers University of Technology, Sweden 2010,

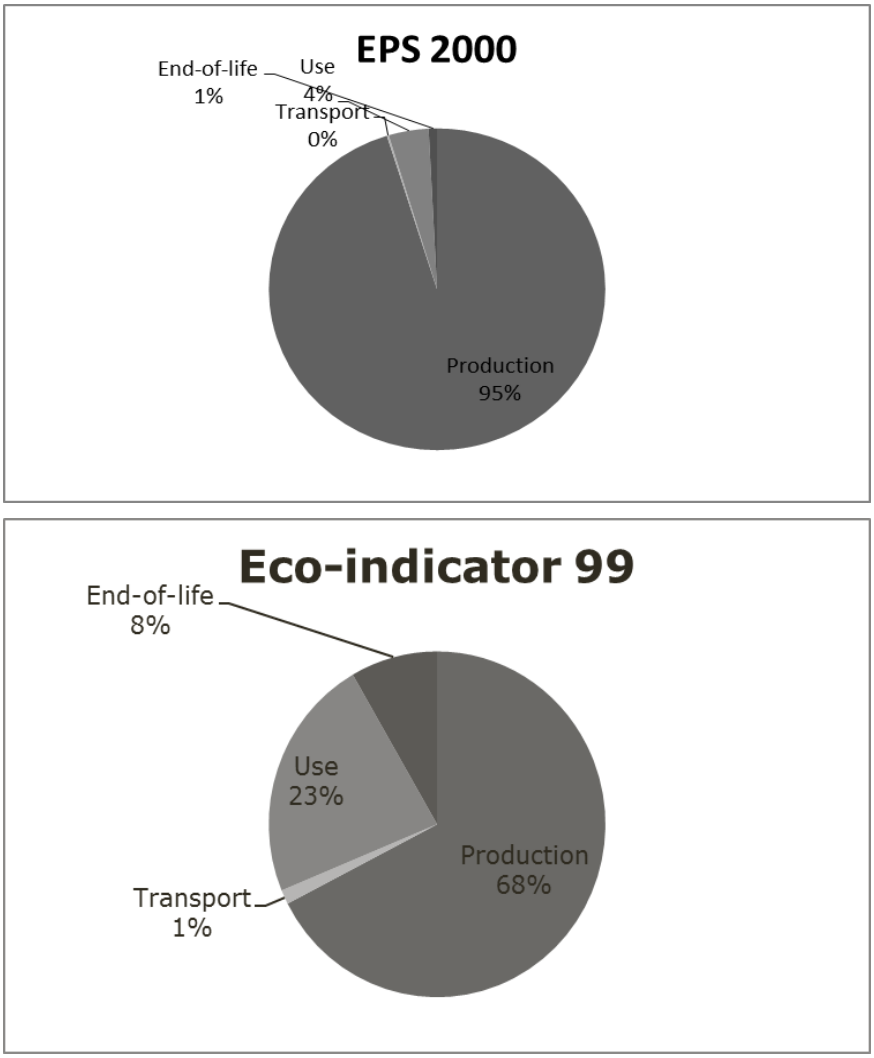


***Image 2**. Corresponding results for an electrical robot mower with a nickel metal hybrid battery.*

The robot mower results vary greatly depending on how the electricity used was produced. The LCA report compares Swedish produced electricity with electricity produced in the UK using coal, natural gas and nuclear power.

When ethanol combusts in a car engine, formaldehyde and acetaldehyde can form under certain conditions, especially when the engine is cold. The catalyst handles these unwanted substances once the engine has heated up. Lawnmowers are not normally equipped with catalysts. There are thus reasons to consider health affecting substances at a potential shift from petrol to ethanol.

Machines for parks and gardens also generate air emissions that are created when fuel evaporates when the engine is turned off, so called evaporative emissions[7]. Organic gas molecules penetrate the walls of the material used in the fuel system and components and evaporate from surfaces such as the fuel tank, fuel hoses, gaskets and seals.

[7] Greener Lawnmowing - a report on lawnmowing in Sweden by Briggs & Stratton, April 2012.

Potential
There are differences in efficiency between the various engines available on the market and there is potential for increasing market shares for both electric and battery-operated products, e.g. robot mowers/automatic mowers, but also for fuel efficient products. We thus judge the potential in all three engine categories (petrol, diesel and electricity) to be good. In future criteria, Nordic Ecolabelling could investigate the possibility of developing the criteria so as to promote battery/electrical machines.

Steerability
Legislation is this area is being tightened, albeit mainly for products over 19 kW sold to professional users[8]. Nordic Ecolabelling may still make a difference for products ≤ 19 kW.

2.6.3 Noise

Market analyses show that noise is by far the most important environmental issue for the general public[9]. Nordic Ecolabelling's noise requirements are now several years old and a comparison with those of, for example, the Blue Angel, indicate discrepancies of 6 dB for products with a cutting width of more than 120 cm. A low level of noise is above all important in consumer/hobby machines. The relevance is thus high but the potential is relatively low as the best machines overall are currently close to the Noise Directive's limit values. This is above all true for professional products. For professional machines, a tightening of the Nordic Ecolabel noise levels may counteract other positive effects such as a high cowl which, although it enables a good spread of grass cuttings, increases resonance. In addition, these machines are used by professionals who are obligated by working environment legislation to wear hearing protectors. See section 4.5.3 for further information.

2.6.4 Vibrations

In order to protect the user from harmful vibrations, the criteria have previously included requirements for hand-held and ride-on machines. For lawnmowers, this has only applied to machines intended for professional use. There is a major difference in exposure between a professional user and a consumer who mows his/her lawn once or twice a week during the season. Please see section 4.5.4 for further information.

2.6.5 Customer information

Issues that are difficult to influence in the field of ecolabelling include the choice of fuel (in cases where different qualities *can* be used), how the users operate and how grass cuttings are handled. As regards the former, alkylate petrol should be used rather than traditional petrol, for health and environmental reasons. This type of petrol emits 60 per cent less dangerous hydrocarbons and 30 per cent less nitrogen oxides[10].

[8] Assessment of Nordic Ecolabelled Machines for parks and gardens, 22 December 2011.
[9] "Environmentally Improves Product Design Case Studies of the European Electrical and Electronics industry", Eco-design subgroup, Brite-EuRam, 2002.
[10] Fact sheet nr 45, Environmental Agency of the City of Gothenburg.

As regards grass cuttings, the most environmentally friendly course of action is to spread the cuttings thinly over the lawn. This is known as mulching. This allows the organic matter to break down, returning the nutrients to the lawn. This way of mowing also lessens lawnmower operation times as there is no need to empty/run on empty nor add lawn fertilizer. The second best approach is to compost the grass cuttings. Perhaps this could be encouraged by combining lawnmower sales with sales of compost containers? This might be a good idea, although it would require a competent and committed retail team. A far simpler measure could be to provide customer information on this issue, for example in the User instructions.

2.6.6 Summary

Energy efficiency and emission requirements are essential. Noise limit values must be stringent enough to meet the general public's expectations. This applies above all to consumer and hobby machines. Aside from this, relevant material requirements that promote the use of an increased share of recycled materials (particularly metals) are key.

There should be good potential for Nordic Ecolabelling professional machines, particularly lawnmowers, for public park and garden maintenance customers.

3 About the revision

3.1 Purpose of the revision

This revision aims to revise the criteria for Machines for parks and gardens based on the 2011 revision. The revision has focused on emission, noise and vibration requirements with the aim of ensuring that only the best products on the market are given the Nordic Ecolabel.

Other focus areas have included the development of battery requirements for robot mowers/automatic mowers, the revision of material requirements and providing suggestions for cost effective engine test requirements. The revision has also included an overview of how lawnmowers are categorised for improved legal compliance, clarification of the product group definition for landscaping tractors and the formulation of relevant requirements for energy efficiency.

3.2 About this revision

The project was launched in April 2012. Anders Moberg was the Area Coordinator (AO) who commissioned the revision. Lena Axelsson has been AO since August 2012.

The project group consisted of:

- Sara Bergman (SE), Project manager
- Jesper Gruvmark (DK), Product manager
- Ola Rise (NO), Product manager
- Björn Simons (SE), Product manager
- Finland did not participate

4 Requirement motivation

4.1 What products can be Nordic Ecolabelled?

The product group is limited to certain professional machines used for park and garden maintenance, both privately and professionally. Section 2, General facts about the criteria, outlines what machines are included in the product group.

This revision has adjusted the product group definition which now requires engine operated professional machines to be covered by the Machinery Directive (2006/42/EC). The reason for this is a desire to clarify the product group definition and ensure that Nordic Ecolabelled professional machines are reasonably safe when in use. Manual tools such as hedge trimmers are not covered by the Machinery Directive but are still included in the product group and make for perfect candidates for ecolabelling.

The revision has also lead to the maximum nominal engine output being lowered from 37 kW (50 hp) to 19 kW. This ensures alignment with European and US legislation for small, off-road engines. This adjustment has no practical consequences.

The 2011 criteria evaluation showed that clarity was lacking in two areas of the product group definition.

1. The possibility of labelling automatic or robot lawnmowers. Nordic Ecolabelling believes that this type could definitely be labelled. The battery requirements for these have therefore been developed further in this 2012 revision.



***Image 3**. Robot lawnmower example.*

2. The distinction between landscaping tractors and ATVs (All Terrain Vehicle) as professional tools is not clear. This revision has clarified this. The conclusion is that ATVs shall not be ecolabelled.



***Image 4.** The image on the left shows a landscaping tractor and the image on the right depicts an ATV fitted with a plough.*

The background to this is that ATVs are to a large extent manufactured and used for transport purposes. A landscaping tractor, however, is used with associated equipment for park and garden maintenance. ATVs thus fall outside of the product group definition.

From a safety point of view, ATVs are covered by the Machine Directive. The directive references standard (DS/EN 15997) which defines various ATV categories as follows:
A motorised vehicle, propelled by an internal combustion engine with liquid fuel, intended primarily to travel on unpaved surfaces on four wheels with low-pressure tyres, having a seat designed to be straddled by the rider and handlebars for steering, and subdivided into single rider no passenger and single rider one passenger for recreational and/or utility use (DS/EN 15997).

The European standard has been issued in various national editions and serves as EU legislation. It replaced all then existing national standards as of May 2012. Nordic Ecolabelling has opted to use this definition to clarify the product group definition. The criteria for Machines for parks and gardens combines these definitions to cover both ATVs used as tools and for recreation. We have also made it clearer that agricultural and forestry tractors are not covered by the product group definition. This has previously been implied but benefits from being made clear. Tractor emissions are regulated by a separate directive (2000/25/EC).

4.2 Product design

The continuation of chapter 4 outlines the background to the different requirement fields respectively while the heading Requirement suggestions outlines the revised requirements by area. The appendices referenced under 'Requirement suggestions' are appendices to criteria document 5.0.

4.2.1 Fuel

In order to lessen the environmental impact, above all in densely populated areas, an environmental classification system has been introduced for vehicle fuels. A lower class means a more environmentally friendly fuel, regardless of whether the fuel is petrol or diesel. The environmental classification system has been developed primarily for car fuel although better fuels also result in lower emissions from the engines of other vehicles such as professional tools and boats. The environmental classification does not govern the exact composition of the fuel. Instead, the levels of a number of substances are capped (for example, there must be no lead in petrol and aromatic compounds can account for 35 per cent at most). The environmental classification also regulates a number of characteristics (such as boiling point and octane number) that are of importance to the environment and fuel functionality.

EU-wide petrol requirements are imposed as of 2000. The Swedish equivalent to the EU requirement is Environmental class 2 while Swedish Environmental class 1 is better in some regards, e.g. sulphur content. In other Nordic countries petrol is classed as Environmental class 2. The gradual introduction of so called sulphur-free petrol (10 ppm) is underway in the EU and was concluded in Swedish Environmental class 2 at the end of 2004. Since 1994 lead has been banned in petrol as it is no longer needed in car engines.

Environmental class 1 has been the dominant diesel fuel in the Swedish market since 1995. Fuels classed as Environmental class 1 may not contain any polyaromatic hydrocarbons that are considered to be problematic from a health perspective while the EU's requirements do allow these substances[11]. Diesel is of environmental class 3

[11] http://www.transportstyrelsen.se/sv/Vag/Fordon/fordonsregler/Miljokrav/Avgaser/Miljoklassade-branslen.

in other Nordic countries and the rest of the EU[12]. The sulphur level that Sweden has applied for a long time (10 ppm) is obligatory throughout the EU since 2008.

European legislation permits the blending of petrol and diesel with renewable fuels. An ethanol concentration of 5 per cent was already permissible and this limit has now been raised to a maximum of 10 per cent (E10). This does not affect lawnmower engines which can be run on vehicle fuel E10 without the need for any modifications. Diesel may contain a maximum of 7 per cent biodiesel (FAME).

There are more than one million petrol operated lawnmowers in Sweden. There is special fuel known as alkylate petrol for engines lacking exhaust fuel cleansing equipment, e.g. outboards, snowmobiles, lawnmowers and chainsaws. The use of alkylate petrol is particularly important in two-stroke engines as with this engine type close to a third of the fuel is released uncombusted. The two-stroke engine is practically invisible in the lawnmower market and has been replaced by the four-stroke engine. Alkylate petrol is practically free from benzene and other aromatic hydrocarbons. It is also free from lead and sulphur. This fuel has a lower vapour pressure so does not evaporate as easily as other types. Many machines are easier to start when run on alkylate petrol as it creates less deposit build-up in the engine. In addition, the exhaust fumes are less strongly smelling.

A transition to renewable fuels is essential in order to limit the greenhouse effect. A standard lawnmower petrol engine cannot be run on ethanol (E85 or similar) without the engine cutting out. Unfortunately it has proved too costly to convert engines for the use of ethanol[13].

Requirement suggestions

R 1. Fuel qualities

The combustion engine shall be constructed for use of one or several of the following fuel qualities, listed here in no particular order:

- lead-free petrol of the highest environmental class according to applicable European or national legislation;
- alkylate petrol;
- biofuel based fuel;
- diesel of the highest environmental class according to applicable European or national legislation.

✉ The User instructions should contain information about what fuel types can be used.

[12] Personal communication with Ebba Tamm at the Swedish Petroleum & Biofuels Institute, Sara Bergman 24 August 2012.
[13] Telephone meeting with Husqvarna's Marketing Manager for walk-behind lawnmowers, May 2012. Sara Bergman and Björn Simons.

4.2.2 Spillage

Oil or fuel spillages may have a relatively significant impact locally, including ground and/or water pollution. Spillages may occur in connection with refuelling, oiling or if a pipe or duct comes lose or breaks, resulting in a fuel spillage. It is important that machines are constructed in a way that minimises and ideally prevents spillage.

Requirement R11 in criteria document 4.5 relating to the use of biodegradable motor oil has been moved to the section entitled 'Customer information'.

Requirement suggestions

R 2. Spillage

The machine shall be constructed in such a way that refuelling and cleaning is possible without any risk of fuel spillages. There should be no oil spillage in connection with normal cleaning of the machine and the engine should be constructed in such a way that the oil can be changed without spillage.

✉ The User instructions should contain information about refuelling, cleaning and oil changes.

4.2.3 Evaporative emissions

The diffusion of liquids and gases depends on the movements of the molecules that make up these substances via partitions. In this case it is hydrocarbon molecules in the evaporated petrol vapours that strive to permeate the tank wall. The driving force behind this phenomenon is the substance' attempts to counteract pressure differences[14].

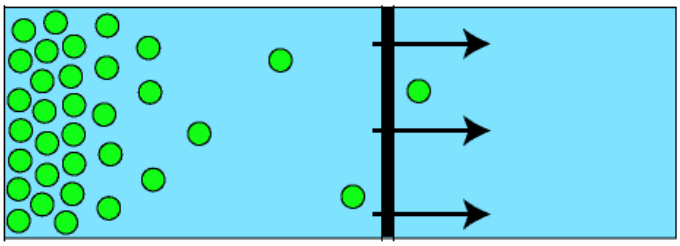


Figure 5: *Diffusion through a partition.*

Nordic Ecolabelling requires licensees to implement measures in order to minimise evaporative emissions and to inform customers of this. Suitable such measures include:

- Choosing materials for the fuel hose and fuel tank that guarantee a low level of fuel diffusion.
- Choosing a cap that ensures that uncleaned fuel vapours do not escape from vents. It should not be possible to remove this lock from the machine and/or the mechanism should notify the user if the cap fails to close correctly.

[14] Fuel Evaporation Control System, Dissertation, Halmstad University, 29 May 2007.

- A carbon filter (i.e. carbon canister) that cleans evaporated petrol vapours of hydrocarbons. The carbon filter must have a suitable capacity expressed in grams active carbon/litre nominal tank volume.

The state of California has introduced requirements in this area which have gradually been tightened. These requirements specify that machines must be certified and thus able to demonstrate that they meet the established requirements for low evaporative emissions. In brief, the certification may be described as being either design based, i.e. pre-certified components are used, or performance based, meaning that the machine is tested for evaporative emissions.

The German Blue Angel ecolabel requires garden machinery to meet the CARB criteria with regard to emission levels. The revision has demonstrated the relevance of clarifying the evaporation losses requirement and introducing a requirement regulating levels of these emissions. However, Nordic Ecolabelling does not impose any certification requirements.

Requirement suggestions

R 3. Evaporation losses

The fuel system should be constructed to ensure that evaporation losses (evaporative emissions) in terms of Reactive Organic Gases do not exceed the following limit values:

For fuel pipe/duct: 15 g ROG/m^2 per day.

For fuel tank: 1.5 g ROG/m^2 per day.

✉ Complete test report pursuant to test TP 901 showing that the limit value has been respected. Alternatively, a certificate showing that only pre-certified components have been used.

4.3 Materials

4.3.1 Marking

Uniform marking of plastic components is a requirement in order to be able to separate parts at disassembly for further treatment and materials recycling. At present, a very large share of plastic material in end-of-life machines for parks and gardens is incinerated[15]. Increased materials recycling would therefore be a positive development. In order to ensure alignment with other product groups within Nordic Ecolabelling, the weight limit for the marking of plastic parts has been lowered to 25 grams/part.

Some questions have arisen in connection with the licensing process with regard to what is to be defined as plastic material. As there are special standards for the marking of rubber, as well as for cables and electronics, the requirement has been made clearer.

[15] "Life Cycle Assessment of Lawnmowers", Chalmers University of Technology, Sweden 2010.

Requirement suggestions

R 4. Marking of plastic parts

Plastic parts that weigh 25 grams or more must be marked in accordance with ISO 11469.

This requirement does not apply to rubber parts or cables. If the surface is smaller than 200 mm^2, the plastic part does not need to be marked.

✉ Manufacturer's declaration. Appendix 1 can be used.

4.3.2 The RoHS Directive

The new edition of the RoHS Directive (2011/65/EU)[16] bans the use of mercury, cadmium, hexavalent chromium and flame retardants PBB and PBDE in electrical and electronic equipment. Humans and the environment are exposed to these health and environmentally toxic substances primarily during manufacturing and when the products become waste.

Nordic Ecolabelling's requirements relating to particularly problematic heavy metals and flame retardants are based on the stipulations of the RoHS Directive. However, the EU directive has introduced a maximum concentration of 0.01 per cent cadmium for homogenous parts and 0.1 per cent for other substances, regardless of whether they have been added or occur as pollutants. This exception does not apply to Nordic Ecolabelled professional machines as these substances are considered particularly problematic, including in small added concentrations.

Nordic Ecolabelling has nevertheless introduced a maximum limit for heavy metals that occur as pollutants. The requirement level is 0.01 per cent (corresponding to 100 ppm) in homogenous materials and applies to all heavy metals regulated by the requirement, even though the RoHS Directive only applies this level to cadmium. For example, zinc used in professional machines may contain cadmium pollutants.

The handling of surface treatment agents has been discussed on EU level. Surface treatment agents are considered separate, homogenous materials according to the British guide document to the RoHS Directive (National Measurement Office 2010). This view is also supported by the Swedish Chemicals Agency. Please see the section on surface treatment of metals.

In previous versions of the criteria the requirements relating to particularly problematic heavy metals and flame retardants applied only to plastic parts. Coloured plastic parts typically contain 0.1-2 per cent pigment. These pigments may consist of heavy metals. The current criteria extend the ban to the entire professional machine and all its parts, regardless of the material. This is line with the RoHS Directive and means, among other things, that only lead-free solder materials may be used. Nor may hexavalent chromium, often applied as corrosion treatment for metal surfaces, be used.

[16] Replaces RoHS-(I) Directive 2002/95/EC as of June 2011.

The RoHS Directive also contains an exception for:
"off-road, mobile machinery for professional use exclusively"

This means that some professional machines included in the product group are unaffected by the RoHS regulations. Nordic Ecolabelling banned these substances in all Nordic Ecolabelled professional machines in previous criteria versions and has decided to maintain this general ban despite the new edition of RoHS introducing exceptions for certain machine types. The ban is in line with Nordic Ecolabelling's chemicals policy and based on the assumption that there are satisfactory alternatives to these chemicals on the market, including for professional machines intended for professional use exclusively.

Requirement suggestions

R 5. Heavy metals and flame retardants of very high concern

A Nordic Ecolabelled machine for parks and gardens may not contain heavy metals cadmium (Cd), lead (Pb), mercury (Hg), hexavalent chromium (Cr^{VI}) or their compounds. Nor may it contain polybrominated biphenyls (PBB) and polybrominated diphenyl ethers (PBDE).

The maximum permissible heavy metal pollutant concentration is 0.01 weight per cent in homogenous materials.

This requirement does not apply to batteries. Please see R11-R13 for special requirements for batteries.

Note that unlike the RoHS Directive (2011/65/EU), Nordic Ecolabelling has only introduced maximum concentrations for pollutants. The maximum concentrations of the RoHS Directive apply even if the substance has been actively added. The requirement means that the addition of any of the above substances to Nordic Ecolabelled professional machines is completely forbidden.

Surface treatments such as chrome plating are considered homogenous materials.

Note that, unlike the RoHS Directive, the Nordic Ecolabel enforces these requirements also for machines for parks and gardens for professional use exclusively.

✉ Manufacturer's certificate. Appendix 2 may be used.

4.3.3 Phthalates

Phthalates are primarily used to soften plastics and can account for up to 40 per cent of the finished product. The use of DEHP (di(ethylhexyl) phthalate) as a softener in PVC in particular has garnered attention. Softeners are not fixed to the PVC polymer, meaning that plastic products emit phthalates throughout their service life. This diffuse spread means that phthalates are almost omnipresent[17].

DEHP, dibutyl phthalate (DBP) and butyl benzyl phthalate (BBP) are classed as toxic and as reproductive toxicants, i.e. they may cause reduced reproduction ability and foetal damage. DBP is also classed as toxic to the environment and as highly toxic to

[17] The Swedish Chemicals Agency, http://www.kemi.se/templates/Page____3283.aspx.

aquatic organisms. The EU has introduced restrictions for the three most harmful phthalates (DEHP, DBP and BBP). These are completely banned in toys and childcare products [18]. For the three less harmful substances (DINP, DIDP and DNOP), this ban applies only to toys and childcare products that a child may put in its mouth.

According to the LCA report for Husqvarna's two lawnmowers[19], plastic is the second most common material after metal. However, not all plastic is softened. The criteria shall continue to include bans on the phthalates that have proven to be toxic or are likely to prove to be toxic, i.e. those that consist of straight mid-length, straight long or branched carbon chains. Phthalates DCO and DIBP are already banned.

This revision extends the list of banned phthalates to include the four phthalates/ groups of phthalates below. The first three substances are found in the EU's priority list of endocrine disruptors. The fourth substance is included on the EU's list of dangerous substances. All four meet the criteria for classification as Substances of Very High Concern (SVHC).

- Dihexyl phthalate (DHP)
- Dicyclohexyl phthalate (DCHP)
- Diethyl phthalate (DEP)
- Diisohexyl phthalate (DIHP)

All phthalate requirements apply to plastic and rubber parts that weigh 25 grams or more. Circuit boards are excepted. The exception also applies to cables and pipes/ ducts. The reason for the latter is that machines must be constructed to withstand being parked outside in cold weather, perhaps all winter. They must also be able to withstand UV radiation without any impact on their service life.

[18] If the level of the substance in toys and child care products exceeds 0.1 per cent
[19] "Life Cycle Assessment of Lawnmowers", Chalmers University of Technology, Sweden 2010,

Requirement suggestions

R 6. Phthalates

The following phthalates must not be added to plastic or rubber materials:

- Di-2-ethylhexyl phthalate (DEHP)
- Di-n-butyl phthalate (DBP)
- Benzyl butyl phthalate (BBP)
- Dicyclohexyl phthalate (DCO)
- Diisobutyl phthalate (DIBP)
- Diisooctyl phthalate (DIOP)
- Diisononyl phthalate (DINP)
- Diisodecyl phthalate (DIDP)
- Dihexyl phthalate (DHP)
- Dicyclohexyl phthalate (DCHP)
- Diethyl phthalate (DEP)
- Diisohexyl phthalate (DIHP)

Cables, hoses/pipes/ducts, circuit boards and electronic components weighing less than 25 grams are completely exempt from the requirements.

✉ Duly completed declaration from the manufacturer/supplier of the plastic and rubber parts. Appendix 2 can be used.

4.3.4 Flame retardants

There is a certain fire risk associated with all electrical and electronic products. Various flame retardants are used to minimise this risk. The choice of flame retardant is governed by various factors, including the material that is to be protected, fire safety requirements and cost. The flame retardant must not impair the technical function of the product. Flame retardants are intended to protect the product throughout its service life. They are therefore designed in such a way as to avoid breaking down easily, meaning that once the substances to come into contact with the environment, they are not readily degradable. *Brominated flame retardants* have been a particular area of concern, partly because these have been found in breast milk and blood. The most common compounds in non-brominated flame retardants are organic phosphorus and nitrogen compounds and inorganic salts.

There are around 70 brominated flame retardants on the market and knowledge of their health and environment consequences varies. The five most commonly used, and thus the most extensively studied, brominated flame retardants are[20]:

- pentabromodiphenyl ether
- octabromodiphenyl ether
- decabromodiphenyl ether
- hexabromocyclododecane (HBCDD)
- tetrabromobisphenol A (TBBP-A)

[20] Large parts of the section from the Swedish Chemicals Agency, www.kemi.se/en

The first three above are part of a group of substances known as polybrominated diphenyl ethers (PBDE). The EU directive Restriction of Hazardous Substances (RoHS) bans the use of polybrominated diphenyl ethers (PBB) in new electrical and electronic devices.

No new substances were banned in connection with the revision of the RoHS Directive (which came into force in June 2011). The flame retardants that the commission was tasked with including in the RoHS Directive were the brominated flame retardants HBCDD and TBBP-A.

Sweden participated as a reporter in the risk assessment of HBCDD within the EU's Existing Substances programme. The report concluded that the substance is persistent, bioaccumulative and highly toxic to aquatic organisms and may cause long-term damage to the aquatic environment. Animal tests have shown that HBCDD affects the liver and thyroid. It has also proven to be a reproductive toxicant. The risk assessment for HBCDD has now been completed within the EU and HBCDD has been identified as a Substance of Very High Concern (SVHC).

TBBP-A has also been risk assessed as part of the EU's Existing Substances programme and is classed as highly toxic to aquatic organisms and may have a harmful long-term impact on the aquatic environment. TBBP-A is not readily degradable and may bioaccumulate. Flame retardant alternatives to TBBP-A have been developed and are increasingly replacing this substance. TBBP-A is the most commonly used brominated flame retardant on a global scale. It is primarily used in circuit boards. Due to the fact that TBBP-A is chemically bound to the material in the circuit board and thus less easily spread to the surroundings, the EU has deemed it harmless to human health when used in circuit boards.

Chloroparaffins, which are also used as flame retardants, are stable and not readily degradable compounds that can bioaccumulate in the environment. Highly chlorinated short-chain and medium-chain chloroparaffins are highly toxic to aquatic organisms and may have a harmful long-term impact on the aquatic environment. Short-chain chloroparaffins have been classed as substances of a very high concern, or SVHC.

Table 1. Summary of flame retardants, their risks and usage limitations.

Flame retardants	Regulatory framework	Risk assessment	The Nordic Ecolabel's assessment for Machines for parks and gardens
Polybrominated biphenyls (PBB)	Banned in new electrical and electronic products pursuant to the RoHS Directive since July 2006.	PBB was the first brominated flame retardant to prove dangerous. The substance has been studied extensively and is to the best of our knowledge no longer manufactured.	May not be used
Polybrominated diphenyl ethers (PBDE)	Banned in new electrical and electronic products pursuant to the RoHS Directive since July 2006 (decaBDE since July 2008).	pentaBDE: persistent, harmful to the environment, harmful to health. POP substance (UNEP). octaBDE: reproduction toxic, persistent and bioaccumulative. POP substance. decaBDE: suspected dangerous but risk assessment not yet complete.	May not be used
Hexabromocyclododecane (HBCDD)	May be used	Classed as SVHC. Included in the candidate list. Entered in the permit list, REACH.	Criteria version 4: No requirements Suggestion for criteria version 5: May not be used
Tetrabromo-bisphenol A	May be used	Highly toxic to aquatic organisms. May have a harmful long-term effect on aquatic environments.	Criteria version 4: No requirements Suggestion for criteria version 5: May not be used
High chlorinated short-chain chloroparaffins	May be used	Classed as SVHC. Included in the candidate list.	May not be used
High chlorinated medium-chain chloroparaffins	May be used	Highly toxic to aquatic organisms. May have a harmful long-term effect on aquatic environments.	Criteria version 4: No requirements Suggestion for criteria version 5: May not be used

An electrical/battery operated machine for parks and gardens contains a small amount of electronics that may require flame retardant treatment.

Machines for parks and gardens contain various plastics, including polypropylene, polyethene, ABS [21], PVC and polyacrylates[22]. PVC has flame retardant properties and does not normally require additional flame retardant treatment.

[21] Acrylonitrile-butadiene-styrene
[22] "Life Cycle Assessment of Lawnmowers", Chalmers University of Technology, Sweden 2010

Table 2: List of brominated flame retardants used in various common polymers[23].

Polymer	Content (%)	Substance/substances
Polystyrene foam	0.8-4	HBCDD
High-impact polystyrene	11-15	decaBDE, brominated polystyrene
Epoxy resin	0-0.1	TBBP-A
Polyamides	13-16	decaBDE, brominated polystyrene
Polyolefins	5-8	decaBDE, propylene dibromo styrene
Polyurethanes	n/a	No brominated flame retardants available
Polyethylene terephthalate (PET)	8-11	Brominated polystyrene
Unsaturated polyesters	13-28	TBBP-A
Polycarbonate	4-6	Brominated polystyrene
Styrene copolymers	12-15	Brominated polystyrene

Against this background and, above all, the thorough risk assessment performed, the criteria are revised as follows:

1. The ban on polybrominated biphenyls (PBB) and polybrominated diphenyl-ethers (PBDE) remains in place for compliance with the RoHS requirements.
2. The ban on highly chlorinated short-chain chloroparaffins remains in place. A ban on highly chlorinated medium-chain chloroparaffins is added.
3. New requirement bans the use of hexabromocyclodecane (HBCDD), tetrabromobisphenol-A (TBBP-A) and tri(2-chloroethyl) phosphate (TCEP)[24].
4. Other halogenated organic flame retardants may not be added but exceptions may be made in cases where these are required for electrical or fire safety reasons under the Low Voltage Directive **73**/23/EEC (NB: typographical error in criteria version 4.5) or standard EN 603 35-1.

Requirement suggestions

R 7. Flame retardants in plastic and rubber parts

Hexabromocyclodecane (HBCDD), tetrabromobisphenol-A (TBBP-A) and tri (2-chloroethyl) phosphate (TCEP) may not be actively added to the product. The same applies to highly-chlorinated short-chain and medium-chain chloroparaffins.

Circuit boards and plastic and rubber parts in electronic components weighing less than 25 grams are completely exempt from the requirements.

✉ Duly completed declaration from the manufacturer/supplier of the plastic and rubber parts. Appendix 2 can be used.

[23] Pedro Arias, Brominated flame retardants – an overview. 2nd International Workshop on BFR, Stockholm, 2001.
[24] The substance has been included in the ECHA's Candidate List.

R 8. Other halogenated organic flame retardants

Other halogenated organic flame retardants may not be added. Exceptions may be made in cases where these are required for electrical or fire safety reasons under the Low Voltage Directive 73/23/EEC or standard EN 603 35-1.

The exemption does not apply to the flame retardants regulated by R5 or R7 above.

Circuit boards and plastic and rubber parts in electronic components weighing less than 25 grams are completely exempt from the requirements.

✉ Duly completed declaration from the manufacturer/supplier of the plastic and rubber parts. Appendix 2 can be used.

4.3.5 Surface treatment and metal plating

Aluminium, iron, steel and copper are common metals used in lawnmowers. Previous criteria included requirements regulating the surface treatment of metals. The current requirements are based on these but have been revised and aligned with surface treatment requirements for other Nordic Ecolabel product groups. A clarification of the definition of the term "small parts" has been suggested.

Requirement suggestions

R 9. Metal surface treatment

Metal may not be coated using lead, mercury, cadmium, chromium, nickel or their compounds.

Parts may be coated with chromium, nickel or compounds of these where this is necessary on the grounds of chemical or mechanical wear or another specific technical need. The chrome plating process shall be based on trivalent chromium. It must be possible to recycle or reuse parts surface treated with nickel and/or chromium.

Any chrome plating and nickel plating processes must be carried out with the help of process water/waste water treatment technology such as ion replacement, membrane technology or similar in order to ensure the greatest possible recovery of the metals. The process water shall be captured for recycling or destruction. The system must be closed.

Fastening components and similar small parts are excepted.

✉ Manufacturer declaration. Appendix 3 can be used. Specification of any need for metal plating and cleaning technology.

R 10. Surface treatment agent content

Surface treatment agents may not contain more than 5 per cent (w/w) organic solvents.

✉ Manufacturer declaration. Appendix 3 or 4 can be used.

4.3.6 Accumulators/batteries

The market share for robot mowers is constantly increasing. The number of robot mowers is increasing at the expense of both ride-on and walk-behind models. Husqvarna was one of the first companies to start manufacturing robot mowers around 1993. At present, Husqvarna manufactures robot lawnmowers with both nickel-metal hydride (NiMH) and lithium ion accumulators. The share of products with NiMH accumulators is currently greater but will in all likelihood diminish in the future. None of Husqvarna's products contain lead-acid batteries.

The batteries in Husqvarna's robot lawnmowers are based on discrete/individual battery cells that are combined to achieve the desired energy storage and performance characteristics. In order to achieve optimum battery service life, the battery must never become completely depleted during operation. It is therefore relevant to impose requirements stating that the machine must switch off/stop before the battery becomes completely depleted. A NiMH battery, however, can be recharged up to 3,000 times[25]. Similarly, a lithium ion battery can be recharged between 3,000 and 6,000 times depending on what type of cell is used and how the battery is charged.

GGP Stiga's product range also includes robot mowers. These use lithium ion batteries. Israeli company Robotmow has been on the market for almost as long as Husqvarna. Their consumer products use lead batteries with a service life of three to four years. Robotmow's general agent nevertheless envisages a shift towards lithium ion batteries in future products.

The environmental impact of lead and lead accumulators has long been a focus area in the Nordic countries. The harmful effects of lead have long been known and are extensively documented. The lead ion is classed as a category 1 reproductive toxicant. Lead compounds such as lead acetate are classed as suspected carcinogens. The introduction of the European RoHS Directive which states that new electric and electronic goods must be lead-free hastens the process to stop the use of lead in society in general. On the basis of this, Nordic Ecolabel has excluded lead-acid batteries from the criteria applicable to rechargeable batteries.

A comparison[26] of the energy density of various battery types (see table below) performed through the study of the relationship between energy content and weight shows that NiMH and lithium ion batteries record significantly higher values than lead-acid batteries; something which is preferable as this means less energy is required in order to move the battery (and the lawnmower).

Table 3. Energy density of various battery types.

	NiCd	NiMH	Lead Acid	Li-ion	Li-ion polymer	Reusable Alkaline
Gravimetric Energy Density (Wh/kg)	45-80	60-120	30-50	110-160	100-130	80 (initial)

[25] Conversation with Fredrik Klavesjö at Husqvarna, Björn Simons June 2012.
[26] http://batteryuniversity.com/learn/article/whats_the_best_battery

There is no standard regulating how a lawnmower battery should be constructed. They may consist of several battery cells connected in series that are in turn connected in series to parallel connected cells, etc. Robot mower battery solutions vary and are often unique to each individual manufacturer. It is nevertheless possible to impose quality requirements on the individual cell with regard to performance.

As regards battery safety, standard IEC 62133 is applicable to NiMH and lithium ion batteries. The standard imposes general safety requirements on portable battery solutions. Batteries must be constructed in a way that ensures safety during normal use and under foreseeable circumstances where the battery may be used incorrectly. The safety requirements are motivated specifically for lithium ion batteries considering the fact that the cell temperature should never exceed 130°C[27] in order to avoid thermal instability and the risk of explosion. Pollution during manufacturing may lead to thermal instability which entails a risk of internal short circuiting within the battery. Consumer batteries are normally equipped with safety mechanisms to prevent short circuiting and overheating. It is unclear whether these mechanisms are adequate and whether they are applied in lawnmower batteries where several batteries are connected to form a battery pack or operation battery. Nor is it clear whether these safety mechanisms are always present in industrial batteries. The individual protection circuits in the batteries are sometimes disassembled to make it possible to monitor the battery pack using a central monitoring unit, known in the industry as a Battery Management System or BMS. Its purpose is to ensure that the individual batteries in the battery pack function in accordance with the battery manufacturer's specifications.

Battery manufacturers test their batteries pursuant to standards EN 61951-2 (NiMH) and EN 61960 (lithium ion) to ensure performance and quality. This also applies to industrial batteries. One factor tested is the number of rechargings. It is reasonable to expect individual battery cells in a lawnmower battery to meet these quality requirements. If technology other than NiMH or lithium ion technology is to be used in the batteries, a reconciliation should be made against Nordic Ecolabel before commencing the application process. Lead acid and nickel cadmium batteries cannot be used as these do not meet the metal requirement.

Furthermore, the individual battery cell in the robot lawnmowers battery solution must meet the metal content and quality requirements pursuant to the Nordic Ecolabel's criteria for the rechargeable battery product group.

This is the first revision to include robot lawnmowers. We decided not to include accessories such as battery charges this time. This means that the material requirements outlined in previous sections should not be applied to accessories. The inclusion of these in future revisions may nevertheless be justified.

[27] http://batteryuniversity.com/learn/article/lithium_ion_safety_concerns

Requirement suggestions

R 11. Battery quality and performance

The individual cell in the operation battery must have undergone testing to EN 61951-2 for NiMH or to EN 61960 for lithium ion batteries. It must also have passed all tests applicable to the cell. The machine must be designed to switch off when the battery reaches a 'minimum power level' pre-established by the manufacturer.

✉ Test protocol pursuant to EN 61951-2 or EN 61960 and declaration from the machine manufacturer stating that the machine will switch off to prevent complete battery depletion. Appendix 5 can be used.

R 12. Safety

The operation battery must meet the safety requirements stipulated by standard IEC 62133.

✉ Declaration from the battery manufacturer stating that the requirement is fulfilled. Specification outlining how the safety requirements are fulfilled. Appendix 5 can be used.

R 13. Battery metal content

The metal content in the individual battery cell must not exceed the following levels:

Mercury	≤ 0.1 ppm
Cadmium	≤ 5.0 ppm
Lead	≤ 5.0 ppm
Arsenic	≤ 10.0 ppm

✉ Declaration stating that the requirement is fulfilled. Appendix 5 can be used.

4.3.7 Packaging and other accessories

Standard packaging materials for this product group include corrugated fibreboard, styrofoam, stretch and shrink wrap and wood pallet. The current requirement has been updated focusing on recycling and customer information.

The requirement stating that petrol canisters with anti spillage mechanisms should be offered to those purchasing a Nordic Ecolabelled machine has been removed (R22). The reason for this is that all modern petrol canisters are equipped with anti spillage mechanisms as standard, making the requirement redundant.

Requirement suggestions

R 14. Packaging

Materials used in packaging must be recyclable or reusable. The licensee shall submit a description of the packaging stating how waste is handled in the Nordic countries where the Nordic Ecolabelled machine for parks and gardens will be sold.

Chlorine based plastics and biocide treated/impregnated timber must not be used in the packaging.

✉ A description of packaging and how it should be handled shall be included in the User instructions, see R22.

4.4 Operation of the Nordic Ecolabelled machine

4.4.1 Test laboratories and test methods

Until now, the criteria have required products to undergo special test processes for emissions and energy consumption in order to be given the Nordic Ecolabel. This has the subject of debate due to the large added costs associated with testing. Engine test costs can be as high as SEK 200,000. The most recent evaluation, performed in 2011, found that the internal costs of engine testing are so high that it is difficult to justify ecolabelling of products, above all those with small volumes and small margins. The revision has focused heavily on identifying a satisfactory, cost effective solution for emission testing, including a test of emission profile stability (so called durability testing).

According to the European directive relating to the emission of gaseous and particulate pollutants from internal combustion engines to be installed in non-road mobile machinery (97/68/EC), engines must be type approved before they are released on the market. Type approval is issued for various classes. Emission testing must be performed by a Notified Technical Service that meets the requirements pursuant to ISO 17025 and that has an agreement with a Notified Body. In Sweden, the notified technical service authorised to perform such emission testing is Swedish Machinery Testing Institute (SMP) in Umeå. Once testing is complete, SMP submits a complete test report to the notified body which issues type approval. In Sweden, this body is the Swedish Transport Agency.

Type approval may also be issued for a basic engine representing a group of engines (engine family) that has been built using similar components based on similar construction principles.

Normally, it is the engine manufacturer who verifies the type approval of their engines. If the engine manufacturer has not had the engine type approved for the European market, the lawnmower manufacturer can type approve the engine, although this is not standard procedure.

In summary, the criteria now include requirements that are entirely in accordance with the applicable regulations for type approval pursuant to the Emission Directive 97/68/EC. Emission tests for type approval involve quality requirements that are as stringent as Nordic Ecolabel's own requirements.

One factor that makes it possible to use type approval is that the requirements have gradually been tightened since the directive came into force and that emission testing now includes durability testing in connection with type approval (comparable to Nordic Ecolabel's previous durability test requirement). This is essential as it is

important that an engine's emission profile does not deteriorate over the course of its service life.

The fact that Nordic Ecolabelling has chosen to use the emission tests performed in connection with type approval has several advantages:

- Usage of the same classification of engines and engine sizes which facilitates communication. It has in the past been difficult for manufacturers and retailers supplying Nordic Ecolabelled machines to explain the classification A, B, C1 and C2. These classifications have in the past been unique to the Nordic Ecolabel and are also contradictory as class A should normally correspond to the most environmentally friendly class.
- Facilitates comparisons and makes it much easier for engine manufacturers and machine producers to determine, in advance, whether an engine will be able to meet Nordic Ecolabel's requirements. This is relevant to the decision whether or not to label machines for parks and gardens.
- Corresponds to EU legislation which makes sense in the Nordic market as it is part of the European market. Engines intended for the European market are normally manufactured in Europe or in the US.

No changes have been made with regard to *noise* testing requirements.

4.4.2 Emissions to air

Nordic Ecolabelling's 2011 evaluation of the product group found that there was a clear need to tighten requirements, above all with regard to air emissions, noise and vibrations. One manufacturer is even said to have stated that its credibility would be damaged if its products were to be Nordic Ecolabelled based on the requirement levels applicable at the time. This opinion has *not* been substantiated in this revision. Instead, both engine manufacturers and licensees feel that Nordic Ecolabel's requirements are stringent and reflect, overall, levels that excellent and professional engine manufacturers should be able to achieve.

Objectively speaking, it is clear that the emission regulations of the state of California[28] are the most far reaching and those that are leading developments in this field. The US, through the federal organisation EPA, and the EU are monitoring developments and adapting their requirement levels accordingly. North America and the US in particular are the most important markets for the product group and it is therefore very important for manufacturers to meet the requirements applicable in these regions. Developments in this field are being led by major engine manufacturers such as Honda, Briggs & Stratton, etc.

The EU has introduced a directive regulating the emission of gaseous and particulate pollutants from internal combustion engines to be installed in non-road mobile machinery (97/68/EC). See appendix 3 for further explanation of the directive.

[28] These are established by the California Air Resources Board (CARB) which is part of the California Environmental Protection Agency.

The German ecolabel the Blue Angel includes noise requirements and emission requirements in its criteria for products within this product group. It also imposes requirements on lawnmowers and other gardening tools, as well as garden shredders.

The below section compiles the various legal requirements for petrol and diesel engine machinery.

Summary of legislation and requirements imposed by other ecolabels.

Table 4. The EU's limit values for emissions generated by engines with a net output < 19 kW pursuant to directive 97/68/EC. The limit values apply to step II, taking into account deterioration factors.

Class/ category	Cylinder volume (cm^3)	Carbon monoxide (CO) (g/kWh)	Sum of hydrocarbons and nitrogen oxides
			HC + NOx (g/kWh)
Hand-held engines (e.g. chain saws, brush cutters and leaf blowers)			
SH1	<20	805	50
SH2	≥20 <50	805	50
SH3	≥50	603	72
Non hand-held engines (e.g. lawnmowers, both walk-behind and ride-on, landscaping tractors, etc.)			
SN1	<66	610	50
SN2	≥66 <100	610	40
SN3	≥100 <225	610	16.1
SN4	≥225	610	12.1

NOx emissions may not exceed 10 g/kWh for any engine class. Two-stroke snow blower engines are only required to meet the norms for SH1, SH2 and SH3.

Table 5. The US limit values for petrol engines in machines for parks and gardens established by the EPA.

Engine class	Cylinder volume (cm^3)	Carbon monoxide (CO) (g/kWh)	Sum of hydrocarbons and nitrogen oxides
			HC + NOx (g/kWh)
Hand-held engines			
Class III	<20	805	50
Class IV	≥20 <50	805	50
Class V	≥50	603	72
Non hand-held engines			
Class I	≥80 <225	610	10.0
Class II	≥225	610	8.0

Source: Environmental Protection Agency, Phase 3 Exhaust Emission Standard.

Table 6. California's limit values for emissions from petrol engines in Small Off-Road Spark Ignition Engines.. Limit values corresponding to the voluntary value for the Blue Skyes Series shown within brackets.

Model year	Cylinder volume (cm^3)	Carbon monoxide (CO) (g/kWh)	Sum of hydrocarbons and nitrogen oxides	Particles
			HC + NOx (g/kWh)	
2005 or later	<50	536	50 (25)	2.0
	≥50 <80	536	72 (36)	2.0
2006 or later	≥80 <225	549	10 (5.0)	–
2007 or later	≥225	549	8.0 (4.0)	–

Source: California Air Resources Board

Table 7. The EU's diesel engine emission limit values pursuant to directive 97/68/EC. Only the output category that is relevant to the product group definition is shown. The limit values apply to step IIIA. There are no established limit values for machines with smaller engines.

Net output, P (kW)	Class	Carbon monoxide (CO) (g/kWh)	Sum of hydrocarbons and nitrogen oxides	Particles, PT (g/kWh)
			HC + NOx (g/kWh)	
19≤P<37	K	5.5	7.5	0.6

Table 8. California limit values for emissions from diesel engines in Small Off-Road Compression Ignition Engines, models 2005 or later.

Maximum Net output, P (kW)	Carbon monoxide (CO) (g/kWh)	Sum of hydrocarbons and nitrogen oxides	Particles, PT (g/kWh)
		HC + NOx (g/kWh)	
P<8	8.0	7.5	0.8
8≤P<19	6.6	7.5	0.8

Source: California Air Resources Board.

Summary

This revision has focused on finding a suitable *categorisation* system for lawnmowers that would correspond to the existing legislation. European and US legislation have some similarities but also differ somewhat with regard to existing categorisations/ divisions. The present revision has concluded that we will base our requirements on European legislation. As regards limit values, it is very difficult to make comparisons against previous requirements as the test process is different. The revised criteria are based on the testing that takes place in connection with type approval of the engine whereas version 4.5 of the criteria required separate testing with a different operation cycle for Nordic Ecolabelling. In conclusion, the revision has led to a tightening of limit values, above all with regard to carbon monoxide. Limit values for NOx, HC and particles were already low. Nordic Ecolabelling believes that in general, only the best machines available on the market will be able to meet the requirement levels.

Other definitions pursuant to the EU directive have also been used, e.g. HC instead of THC. See suggested emission requirements below.

As regards diesel engines, we suggest an alignment with the division established by the state of California. This enables us to impose limit value requirements on more engine sizes. The requirement levels are those established for California, with the exception of carbon monoxide where the EU's imposes a lower limit. We have no experience of licensing diesel engines. The majority of the products within the product group have petrol engines.

Requirement suggestions

R 15. Emission testing

Emission testing must be performed by a notified technical service that meets the requirements pursuant to EN-ISO/IEC 17 025 and the Emission Directive 1997/68/EC and that has an agreement with the national notifying body for type approval.

The engine shall be tested according to the requirements and specification stipulated in the EU directive relating to the emission of gaseous and particulate pollutants from internal combustion engines to be installed in off-road mobile machinery (97/68/EC). Appendix III and IV to the directive specify the testing process for engines with compression ignition and spark ignition respectively.

If the engine manufacturer performs tests, Nordic Ecolabelling may use the information on requirement fulfilment in applications from other companies wishing to Nordic Ecolabel their professional machines, unless otherwise agreed.

If a catalyst and/or particle trap is used, the manufacturer must prove, by way of a durability test that it may conduct itself in accordance with good engineering practice and good laboratory practice and using a test protocol, that these mechanisms for exhaust treatment can be expected to function correctly for the duration of the engine's service life.

✉ Test report from a notified technical service that meets the requirements pursuant to Appendix 6.

R 16. Recorded limit values for petrol engine emissions

Emissions in connection with engine testing may not exceed the limit values stated below. This requirement apply both to the testing of new machines and to durability testing, see R 18.

Class/ category	Cylinder volume (cm^3)	Carbon monoxide (CO) (g/kWh)	Sum of hydrocarbons and nitrogen oxides
			HC + NOx (g/kWh)
Hand-held engines (e.g. chain saws, brush cutters, hedge trimmers and leaf blowers)			
SH1	<20	480	50
SH2	≥20 <50	480	40
SH3	≥50	480	15

Class/ category	Cylinder volume (cm^3)	Carbon monoxide (CO) (g/kWh)	Sum of hydrocarbons and nitrogen oxides
			HC + NOx (g/kWh)
Non hand-held engines (e.g. lawnmowers, both walk-behind and ride-on, landscaping tractors, etc.)			
SN1	<66	450	12/15*
SN2	≥66 <100	450	12
SN3	≥100 <225	450	10
SN4	≥225	450	4.3/6*

**numbers showing limit values for testing of new machines and after durability testing respectively.*

NOx emissions may not exceed 10 g/kWh for any engine class.

Engines used in products that are used solely in winter, e.g. snow blowers, do not need to meet the sum of hydrocarbons and nitrogen oxides requirement[29].

Two-stroke snow blower engines are only required to meet the norms for SH1, SH2 and SH3.

✉ Test report featuring results from complete emissions test.

R 17. Limit values for diesel engine emissions

Emissions must not exceed the limit values below at testing of new machines. The requirement applies regardless of whether the diesel engine uses fossil fuel or biofuel.

Maximum engine output, P (kW)	Carbon monoxide (CO) (g/kWh)	Sum of hydrocarbons and nitrogen oxides HC + NOx (g/kWh)	Particles (g/kWh)
P<8	8.0	7.5	0.8
8 ≤ P ≤ 19	6.6	7.5	0.8

✉ Test report featuring results from complete emissions test.

R 18. Durability requirements

Emissions shall be measured following durability testing. The limit values stated in R16 and R17 must be met.

The same engine that was short-term tested shall be durability tested according to the specification stipulated by the EU's directive relating to the emission of gaseous and particulate pollutants from internal combustion engines to be installed in off-road mobile machinery (97/68/EC). The durability period category selected should be the one that best reflects the expected service life of the machine(s) for which the engine is intended.

✉ Test report featuring results from complete emissions test. The licensee shall verify that the stated service life is correct in the same way as to the notifying body.

[29] This is in accordance with CARB.

4.4.3 Carcinogenic effect

Looking at the developments that have taken place in the road vehicle segment, it is not unlikely that engines for machines for parks and gardens will develop in a way that will enable the use of alternative fuels such as ethanol or biodiesel. Aside from the already regulated parameters (see section on emissions) there would if so be a need to regulate the negative health effects here. At time of the 2003 revision[30] cancer risk was deemed to represent a suitable starting point. Any change from petrol to ethanol operation would result in a change to the emission composition and an increase in the levels of formaldehyde and acetaldehyde. The level of fossil carbon dioxide (greenhouse gas) emissions would decrease. However, in order to avoid a so called burden shift, emissions of carcinogenic substances from professional machines must not increase. There is also direct exposure to substances that are harmful to health.

The various compounds have different carcinogenic potential which is why previous criteria have contained a risk unit factor. This factor describes mortality risk after lifetime exposure to 1 $\mu g/m^3$ to the substance in question. This means that the concentration measured should be multiplied by the relevant risk unit factor and the result added up. This gives a sum of hazards that must not be greater for ethanol than for petrol. The 2003 background report further states that the risk unit factor method is applicable in cases where engines have been converted from petrol to ethanol operation. In cases where new ethanol engines are manufactured, a direct comparison cannot be made. Conversations with Husqvarna have made it clear that a lawnmower equipped with a four-stroke petrol engine definitely must not be run on ethanol (E85 or similar) as this risks the engine seizing up[31].

The 2003 background report also found that there is less information on two-stroke engines (for brush cutters, chainsaws, etc.) Knowledge in this field must be improved, not least considering the fact that there is direct exposure as a result of these machines being hand-held and used in conditions that further concentrate exhaust fumes such as severe cold and soil or snow indentations.

A large number of environment and health agencies have been contacted as part of the 2012 revision, as well as several research institutes. None of these have stated that they monitor or have monitored this field and were thus unable to provide further information on this matter. Several individuals stated that no more research has been conducted into this field[32].

[30] Background document, revision of lawnmower criteria version 2.4, 2003, Nordic Ecolabelling.
[31] Telephone meeting with Husqvarna's Marketing Manager for walk-behind lawnmowers, May 2012. Sara Bergman and Björn Simons.
[32] Personal communication with Roger Westerholm, Margareta Thörnqvist and Ola Rannug, all at the University of Stockholm. Researchers at the departments of environmental medicine at Karolinska Institutet and Umeå University were also contacted. Sara Bergman.

Requirement suggestions

Against this background, the requirement calling for a calculation of the risk associated with carcinogenic emissions has been removed. There is no reason to retain a requirement that is not adapted for new engines built for renewable fuels but only applies to converted engines. Instead, the product group definition is clarified, stating that the engine shall be new and thus adapted for the relevant fuel.

4.4.4 Fuel efficiency

There is already a requirement stating that petrol consumption should be measured as part of the first short-term test at 50 per cent load. In order for a product to be Nordic Ecolabelled the result must not exceed 500 g/kWh. This revision has focused on investigating the differences in energy efficiency between machines that run on fossil fuels and those who are electric/battery operated. The purpose of this was to formulate an energy efficiency requirement regardless of the energy source. Unfortunately, this has not been possible, see chapter 5 for further information. On this basis, the project group has decided to let the requirement regarding the highest allowable petrol consumption for four-stroke lawnmower engines remain in place, and instead lower the limit value.

There is raw data information available relating to engine fuel consumption as the test laboratory testing engines pursuant to the directive relating to the emission of gaseous and particulate pollutants (97/68/EC). However, this information is not included in the technical report submitted by the laboratory to the notified body. This information is important to customers, which is why we have decided to keep this requirement and the limit value.

Requirement suggestions

R 19. Lawnmower fuel consumption

The petrol consumption of a four-stroke lawnmower engine must not exceed 480 g/kWh. The engine that was short-term tested shall be durability tested according to the specification stipulated by the EU's directive relating to the emission of gaseous and particulate pollutants from combustion engines to be installed in non-road mobile machinery (97/68/EC).

✉ Data on petrol consumption from an authorised test laboratory. This information should also be available in the User instructions.

4.4.5 Noise

Some information on the term 'noise' found on the Swedish Environmental Protection Agency's website[33].
"Noise is unwanted sound. Physically, there is no difference between sound and noise. What we consider to be unwanted sound varies greatly depending on who perceives it and also on the time of day. For example, during the day we might not even notice the sound of a truck passing by our house due to all the other activity taking place concurrently. At night, the passing of the same truck might wake us up. How much noise disturbs us is governed by for example the type and nature of the sound (e.g. sound level and frequencies), the time of day, what we are doing at the time, whether the noise is accompanied by vibrations and our attitude to the source of the noise. Our sensitivity to noise also differs in different environments. We tend to be more sensitive to noise disturbances in recreation areas where we expect a more peaceful environment than we are in closely populated areas."

The lawnmower sound emission requirement in criteria version 4.5 is stricter than that of the EU's noise directive (2000/14/EC consolidated version). For Nordic Ecolabelled products, the sound intensity must be 1-4 dB(A) below the legal requirement, for all cutting widths and for both personal and professional products. The European directive regulating environmental noise from equipment intended for outdoor use was tightened when step II of the directive came into force in March 2006. The EU directive also includes limit values for noise emitted by cultivators. Other machines in the park and garden product group are, pursuant to the noise directive, only required to report the measured noise intensity.

The lawnmower classification system differs for the smaller class where the applicable criteria impose a maximum cutting width of 40 cm while the directive's limit is 50 cm. In practice, the Nordic Ecolabel's classification results in a relaxation of requirements for machines with a cutting width between 40 and 50 cm. This revision aligns the Nordic Ecolabel's classification with the directive in order to facilitate communication of this requirement to the consumer and producer.

No further tightening of the noise requirements has been announced by the authority concerned (the Swedish Work Environment Authority) or the EU as far as we are aware. The present requirements remain highly relevant to household products.

Performance requirements for professional products have in some cases resulted in these having higher sound emissions than previously. For example, grass cuttings are to be spread out in order to avoid visible grass lines. In order to achieve as fine a spread possible, manufacturers have had to raise the cowl, resulting in increased resonance. Contact with SMP[34] has made it clear that the strictness of the European Noise Directive's requirements actually has a negative impact on the emission profile. In order to meet noise requirements, there is a significant risk of engines having to

[33] http://www.naturvardsverket.se/Start/Verksamheter-med-miljopaverkan/Buller/Buller-ar-oonskat-ljud/
[34] Svensk Maskinprovning AB, part of Sveriges Tekniska Forskningsinstitut SP.

operate at a less than ideal Q-point and the number of rotations being lowered. This result in higher emission levels than those obtained from tests.

In summary, the noise limit values for lawnmowers will be divided into limit values for consumer products and limit values for professional products. The limit values for consumer products remain unchanged. In order to be able to continue to licence lawnmowers for the professional market, requirements for these are relaxed somewhat and the limit values applied are aligned with those outlined in the EU's Noise Directive. This criteria revision has resulted in the removal of categories A, B, and C. We now apply the distinction between professional and consumer products over the given service life that the manufacturer has verified to the notified body[35] for engine type approval.

This relaxation can be motivated by the fact that these machines will normally be used by professionals in situations where the employer has an obligation to ensure that the work is performed in accordance with the applicable legislation. For examples, the Swedish Work Environment Authority's statutes on noise (AFS 2005:16) stipulate that the wearing of hearing protectors is always required when the noise level exceeds 85 dB. The machines involved here will normally be used in public spaces where the noise level tends to be relatively high during working hours/daytime already.

In 2005, SMP performed an overview of the Nordic Ecolabel's noise requirements on behalf of Nordic Ecolabelling[36]. The results showed that the limit values for other products covered by the product group Machines for parks and gardens (brush cutters, chainsaws, leaf blowers, etc.) are so low that the market is in fact unable to meet them. Since no products other than lawnmowers have been Nordic Ecolabelled, there is a lack of licensing experience. The noise limit values in this revision have not changed other than for lawnmowers, with the exception of garden shredders, where previous criteria did not contain an established limit value, requiring only noise levels to be reported. Based on the corresponding limit value established by The Blue Angel, the upper limit for measured garden shredder sound intensity is set at 92 dB(A).

Below is a definition of measured and guaranteed sound intensity levels from the Swedish Environmental Protection Agency's regulation (SFS 2001:1084) relating to noise generated by certain outdoor equipment.

- **measured sound intensity level**: a sound intensity level established in accordance with the measurements outlined in appendix III to the Noise Directive. The measured values may be established either for one single machine that is representative of the type of equipment or as the average of a number of machines.
- **guaranteed sound intensity level**: a sound intensity level established in accordance with the requirements outlined in appendix III to the Noise Directive, including the uncertainty factors deriving from variations in production and measuring methods.

[35] The Swedish Transport Agency is the notified body
[36] Report G2/2005 Overview of noise and vibration requirements imposed by Nordic Ecolabel. SMP

Requirement suggestions

R 20. Noise testing

The manufacturer of the professional machine can test noise itself if it is audited by a notified body appointed for the test method and product type in question pursuant to the Noise Directive 2000/14/EC and subsequent amendments. Other laboratories may be authorised if they are appointed a notified body for the test method and product type in question pursuant to the Noise Directive 2000/14/EC and subsequent amendments.

The EU's information system NANDO (New Approach Notified and Designated Organisations) contains a list of notified bodies:
http://ec.europa.eu/enterprise/newapproach/nando/

The weighted sound intensity level (LWA) shall be established. The sound intensity shall be established in accordance with general standard ISO 3744 as stipulated by the EU's Noise Directive 2000/14/EC.

Product specific standards stipulate the circumstances under which noise testing shall be performed. These standards are stated in the directive. If there are not such standards, the Noise Directive will stipulate the measurement conditions.

At least one randomly selected example of the relevant machine should be tested. At least two measurements are to be taken for the machine. The arithmetic average of the measurements shall represent the established emission level for the machine. A further two machines should be tested if the machine fails to meet the requirements.

The following limit values may not be exceeded.

Machine	Machine data	Sound intensity level dB(A)/picoW Private use/ professional use
Lawnmowers*	X ≤ 50 cm	90.0/94.0
	50 cm < X ≤ 70 cm	94.0/98.0
	70 cm < X ≤ 120 cm	98.0/98.0
	X > 120 cm	102.0/103.0
Lawn trimmers and lawn edge trimmers	combustion engine operated	104
	electrical engine operated	94
Brush cutters	<1.5 kW	107
	>1.5 kW	110
Chainsaws	<2.5 kW	105
	> 2.5	110
Leaf collectors and leaf blowers	for professional use	105
Hedge trimmers	combustion engine operated	103
	electrical engine operated	96
Garden shredders		92
Cultivators*		93
Riding lawn tractors/movers*		reported

Machine	Machine data	Sound intensity level dB(A)/picoW Private use/ professional use
Snow blowers		reported

Personal machines are defined as those where the engine's service life is given as ≤ 250 hours. Professional machines are defined as those where the engine's service life is given as >250 hours. The service life stated has been reported to the notified body for type approval pursuant to EU directive 97/68/EC.

**Covered by the limit values of the Noise Directive (2000/14/EC). Riding lawn tractors are covered to the extent that they fall under the directive's lawnmower definition. The limit value stated is the guaranteed limit value.*

✉ Complete test report.

R 21. Sound pressure level at the operator's ear

The weighted sound pressure level at the operator's ear shall be established under the same conditions as sound intensity. The result should be disclosed as customer information.

The method pursuant to standard EN 836 "Safety Standard for Powered Lawn-mowers Noise and vibration" shall be used for lawnmowers and riding lawn tractors.

✉ Complete test report. This information should also be available in the User instructions.

4.4.6 Vibrations

Directive 2002/44/EC on the minimum health and safety requirements regarding the exposure of workers to the risks resulting from physical agents (vibration) establishes certain minimum requirements for vibrations, see table 9. Member states can thus adopt lower limit values for improved protection.

Table 9. Limit values and exposure action values for vibration according to the Vibration Directive, 2002/44/EC. These values apply to machines for professional use.

Type of exposure	**Limit value (m/s^2)**	**Exposure action value (m/s^2)**
Hand and arm vibrations	5	2.5
Full body vibrations	1.15	0.5

The limit values must not be exceeded. If an exposure action value is exceeded, the employer is obligated to take measures to mitigate risks and offer medical check-ups. The purpose of the EU directive and associated national legislation is to protect workers from risk and harmful exposure whilst at work. The limit and exposure action values relate to the exposure that a person is subjected to by all machines during an 8 hour working day. In other words, the shorter the exposure time, the higher the vibrations accepted. Limit and exposure action values are not linked to a specific product but rather to total exposure.

Nordic Ecolabelling introduced vibration requirements in criteria version 3.0, primarily as a result of pressure from manufacturers. The vibration requirement in the merged criteria document version 4.5 stipulate the same limit values for vibrations as those in table 10. It is important to note that for lawnmowers, these requirements were only to be applicable to *professional machines.*

The new European Directive on machinery 2006/42/EC contain requirements relating to vibrations (section 1.5.9):
"A machine should be constructed and manufactured to that the risks resulting from vibrations caused by the machine are minimised, taking into account technical developments and access to mechanisms that can be used to reduce vibrations, above all at the source. The vibration level can be assessed using comparable data for similar machines."

Furthermore, the revised Machinery Directive requires the User instructions to contain information about vibrations:

- Values must be stated when the exposure action values, i.e. 2.5 m/s^2 for hand/arm vibrations and 0.5 m/s^2 for full body vibrations are exceeded. The vibration value shall be the value measured on the machine or a technically comparable machine.
- If the exposure action values are lower than those above, this too should be reported.

Requirement suggestions

The project group's contacts with the industry have not resulted in any consistent idea of the current requirement level and how it could be raised. During the 2003 revision the referral body suggested that vibration requirements should be established based on the Machinery Directive, i.e. with a product focus instead of being based on overall exposure as stipulated by the Vibration Directive. It is important to bear in mind that vibrations are entirely a working environment issue that has no impact on the external environment.

Legislation in the Nordic region, primarily in the form of the Machinery Directive, is considered sufficiently robust to be capable of handling the risk associated with vibrations.

Against this background, the requirements relating to vibrations have been removed from the criteria for machines for parks and gardens.

4.5 Customer information

Experience from licensing against version 4 of the criteria shows that the majority of customer information requirements are relevant and should remain unchanged. The requirement has been revised as follows:

- Section 5 recommends the use of environment adapted motor oil. In criteria document 4.5 this was contained under requirement R11.
- Section 11 has been revised so that it corresponds to the manufacturer responsibility for electrical and electronic products.
- Section 12 has been changed in order to encourage not the return but rather the handing over of components that are harmful (to the environment) to waste/ recycling stations.
- Section 14 has been clarified to prevent misunderstandings.
- Section 16 has been simplified and encourages the use of ear protectors at all times.
- Point 18 references the EU's new Machinery Directive.
- Section 19 is new and stipulates that the length and dimensions of power supply cables for corded machines must be clearly stated.

Requirement suggestions

R 22. User instructions

Hardcopy User instructions containing the following information shall be included with the machine:

a) assembly, operation and maintenance instructions;

b) information about the maintenance required in order to ensure that the machine's emission values remain acceptable;

c) if maintenance is required pursuant to b) a service manual shall accompany the machines. This manual shall contain space for notes relating to maintenance performed;

d) what type of fuel the engine is intended for;

e) information recommending the use of biodegradable motor oil and environmentally adapted fuels such as alkylate petrol for petrol engines and diesel of the highest environmental class for diesel engines;

f) how to refill fuel in order to avoid fuel spillages;

g) how to clean the cutting unit without risking fuel leakages or oil spillages;

h) how to change the oil in order to avoid oil spillages;

i) the machine's fuel consumption, stated as a specific consumption in g/kWh and information as to whether this is considered average, low or high;

j) information stating that the fuel system has been designed so as to minimise evaporative emissions;

k) that the customer should hand the end-of-life product in to a waste handling station in order to facilitate recycling or other correct waste handling in accordance with national and local regulations;

l) that components that may be harmful to the environment, such as spilled oil (including Nordic Ecolabelled products), batteries etc., shall be handed over for treatment as hazardous waste;

m) what type of batteries are included in the machine;

n) petrol canister characteristics or how petrol should be refilled in order to avoid spillages;

o) the sound pressure level measured at the operator's ear;

p) a recommendation relating to the use of ear protectors whenever the machine is in operation;

q) the machine's highest guaranteed sound intensity level;

r) vibrations stated in accordance with the Machinery and Machine Safety Directive (2006/42/EC);

s) information on the length and dimension of the power supply cable for corded machines;

t) information on how to separate packaging for recycling.

✉ User instructions in the Nordic languages applicable to the markets in which the product is sold.

4.6 Quality and regulatory requirements

Requirements R1 to R9 in version 4.5 of the criteria are general requirements that are included in all Nordic Ecolabelling product criteria. The requirements have been updated to ensure consistency with corresponding Nordic Ecolabelling requirements. These requirements now come last in the criteria document, together with the requirement for correct marketing.

Requirement suggestions

To ensure that the Nordic Ecolabel's requirements are fulfilled, the following procedures must be implemented. If the manufacturer has an quality management system that is certified to ISO 9001 and the following procedures are applied, it is sufficient if the accredited auditor certifies compliance with the requirements.

R 23. Legislation and regulations

The licensee shall ensure compliance with all applicable local laws and provisions at all production facilities for the Nordic Ecolabelled product, e.g. with regard to safety, working environment, environmental legislation and site specific requirements/concessions.

Documentation is not required. However, Nordic Ecolabelling may revoke the licence if the requirement is not fulfilled.

✉ Declaration from the licensee that the requirement is fulfilled, plus a report to the regulatory authority, see Appendix 8.

R 24. Licence administrators

The company shall appoint an individual responsible for ensuring the fulfilment of Nordic Ecolabel requirements, and a contact person for communications with Nordic Ecolabelling.

✉ Organisational chart showing who is responsible for the above.

R 25. Documentation

The licensee must be able to present a copy of the application and factual and calculation data supporting the documents submitted with the application (including test reports, documents from suppliers and suchlike).

☺ On-site inspection.

R 26. Machine quality

The licensee must guarantee that the quality of the Nordic Ecolabelled machine for parks and gardens is maintained throughout the validity period of the licence.

✉ Procedures for collating and, where necessary, dealing with claims and complaints regarding the quality of the Nordic Ecolabelled machines.

R 27. Planned changes

Written notice of planned product and marketing changes that affect the Nordic Ecolabel requirements must be given to Nordic Ecolabelling.

✉ Procedures detailing how planned product and marketing changes are handled.

R 28. Unforeseen non-conformities

Unforeseen non-conformities that affect Nordic Ecolabel requirements must be reported to Nordic Ecolabelling in writing and logged.

✉ Procedures detailing how unforeseen non-conformities are handled.

R 29. Traceability

The licensee must have a traceability system for the production of the Nordic Ecolabelled machines.

✉ Description of/procedures for fulfilment of the requirement.

R 30. Recycling/Take-back system

Relevant national regulations, legislation and/or agreements within the sector regarding recycling systems for products and packaging shall be met in the Nordic countries where the Nordic Ecolabelled machines are marketed.

✉ Declaration from the applicant regarding affiliation to existing recycling/processing agreements.

R 31. Marketing

Marketing of the Nordic Ecolabelled machines for parks and gardens must comply with “Regulations for the Nordic Ecolabelling of Products” 22 June 2011 or later versions.

✉ Duly completed Appendix 9.

5 Energy efficiency investigation

One focus area in this revision has been to investigate differences in energy efficiency between machines running on fossil fuels and electricity/battery operated machines. The idea behind an energy efficiency requirement applicable to all energy sources is that this would enable comparisons between different types of machines for parks and gardens. Although this is a good idea, it has proved difficult to achieve in practice. One reason for this is the lack of standardised lawns[37] on which to compare the result. Nor has it been possible to identify functional units for all products within this broad product group. The below reasoning is entirely based on the most common product; the lawnmower.

We would like to start by making it clear that a manual, mechanical lawnmower is the best option in terms of environmental impact. It produces no emissions and is less complicated to manufacture than other lawnmowers. A manual lawnmower nevertheless works best on small and medium-sized lawns. In cases where an engine operated lawnmower is required, the following should be taken into consideration:

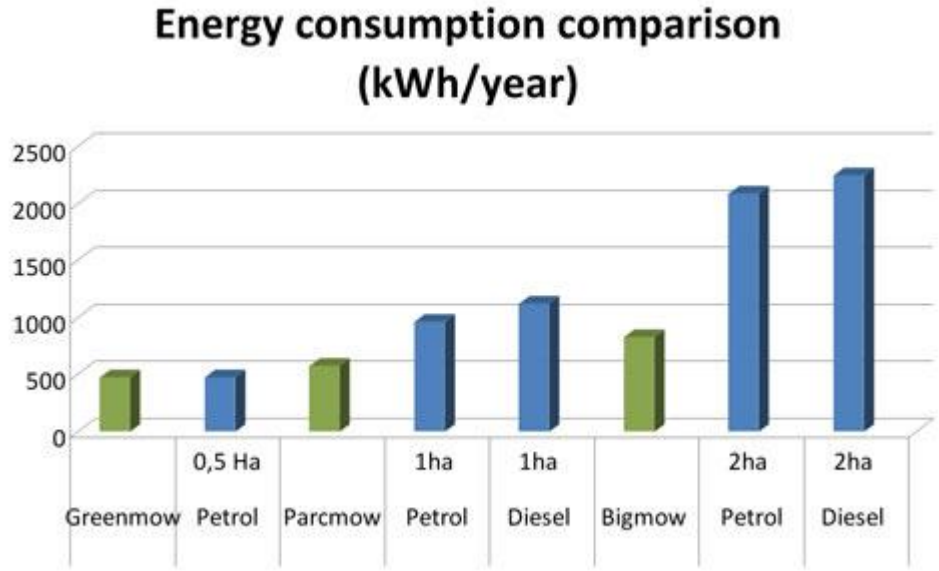
Depending on how the electricity is produced, a corded electric lawnmower or a battery powered lawnmower (where energy is stored) may be a more environmentally friendly option than a combustion engine lawnmower. An electric lawnmower does not generate any direct emissions on operation and is less noisy. From a life cycle perspective, the generation of electricity does, however, result in an environmental impact. The level of environmental impact depends on how the electricity was generated (hydropower, nuclear power, biofuel, fossil fuel etc.). A corded lawnmower if preferable if the use of such is possible as it avoids the environmental impact that would otherwise result from battery production. A rechargeable battery has a limited service life and will need to be replaced over the course of the lawnmower's service life.

Using alkylate petrol in petrol mowers reduces the emission of substances that are harmful to health and the environment. A four-stroke engine emits cleaner exhaust fumes and is quieter than a two-stroke engine. These days, almost all two-stroke lawnmowers have been replaced by four-stroke machines.

As robot lawnmowers gain ground, it may be interesting to compare traditional combustion engine lawnmowers with battery operated electrical robot mowers.

[37] Conversation with Carl Lönnberg, course consultant for the Swedish Golf Federation, Sara Bergman, June 2012.

Table 10. Energy consumption (kWh/year) comparison of petrol and diesel engine lawnmowers and three robot lawnmowers (Greenmov, Parcmov and Bigmov) on various lawn sizes. Source: Belrobotics.se/miljö. It has not been possible to obtain further background information to the calculations despite attempts during conversations with Belrobotics. It is not clear whether a primary energy factor has been used in the calculations.



The table shows a comparison of machines with comparable cutting widths, representing a measure of the machine's 'usefulness'. The calculation is made as follows:

- The mowing season is in theory limited to 33.8 weeks.
- Ride-on mowers have been assumed to be used twice a week.
- Depending on the ride-on mower's capacity, it takes:
  - Just under an hour to mow 5,000 m^2
  - Just under two hours to mow 10,000 m^2
  - Just under four hours to mow 20,000 m^2.

Table 10 shows that the larger the surface to be mowed, the greater the energy savings using a robot lawnmower. Energy consumption for the smallest area measuring 5,000 m^2 is essentially the same for a robot lawnmower as for a petrol engine lawnmower. However, the robot mower consumes 828 kWh/year mowing the largest surface, 20,000 m^2, while the petrol engine lawnmower consumes 2,000 kWh/year on the same area, i.e.[38] 2.4 times more energy.

Modern electrical engines are highly efficient with a thermal efficiency rate of around 90-95 per cent. An electric engine lawnmower is light and has an output of around 20 W-60 W. However, it is used more frequently, i.e. it needs to mow for several hours in order to achieve the same result; a well mowed lawn. At 30 per cent the thermal efficiency of a petrol engine is relatively low. Lawnmower petrol engines normally

[38] Although the table uses diesel engine lawnmowers for comparison, our reasoning below is based on petrol engine lawnmowers as these are by far the most common type in the Nordic market.

range from 7-10 kW. The fact that there is no linear relationship between the energy consumption of the petrol lawnmower and that of the robot lawnmower is due to the movement pattern of the robot mower. A robot mower is very prone to 'double mowing'; i.e. it covers the same surface several times. This means that it has to mow several times in order to achieve an adequate result, but also because its movement pattern is designed in a certain way. The robot lawnmower moves back and forth inside the marked area in a zigzag pattern. As the mower approaches an obstacle, it changes direction and starts moving the other way. Once the robot notices that it has arrived at a corner, it turns 90 degrees and begins to zigzag in the other direction[39].

The smaller the surface the smaller the difference in energy consumption between the different products. What is gained with an energy efficient robot lawnmower is lost as the robot mows areas several times. However, a robot mower can help make significant energy savings on larger areas.

Petrol engines are tested under certain specific conditions. Emissions and fuel consumption are measured and reported. The lawnmower's *actual* petrol consumption, and thus also the emissions to the air, are impacted by other factors not considered in tests:

- The Q-point that the engine operates at. Optimum thermal efficiency is usually achieved at a high load. It is nevertheless common that the number of revolutions is reduced and the engine operates at a much lower Q-point in the actual lawnmower, or else the noise and vibration levels would be too high.
- The width of the cutting unit affects the time required to mow a certain area and is a measure of the usefulness of the lawnmower. The matching of engine size to cutting width is thus an important factor. One hypothesis is that there is an optimum relationship between engine output and cutting width and that Nordic Ecolabel could introduce requirements in this regard. According to machine manufacturers there is no definite answer to this issue. They also indicate that the choice of lawnmower engine is governed by various factors. Firstly, the number of engine types available is limited. Secondly, various factors such as price, branding, performance, requirement profile etc. need to be taken into account.
- The driving style is another factor, including empty running and the use of the choke valve (should only be used for cold starts to provide a richer fuel mixture).

In conclusion, it has not been possible, within the framework of this revision, to find a functional unit showing energy consumption regardless of energy source, or for each product category in the product group. The project has resulted in the following conclusions:
Many factors influence consumer choices, including energy consumption. Even though it would be possible to objectively compare energy consumption, many other factors also govern the product selection; lawn size, incline and other soil conditions, price, brand, overall experience, personal preference, etc.

[39] Text taken from "Hur fungerar en helt självgående gräsklippare?" www.robotshop.se

It is nevertheless important to point out that the larger the area that is to be mowed regularly, the greater the difference in energy efficiency between a petrol lawnmower and an electrical one. If we also take into account the fact that an electrical mower generates no direct emissions, the difference in favour of this type of machine from a climate perspective is even greater.

It might also be useful to be able to make energy efficiency comparisons within each individual category and giving customers the information they need to be able to select the most fuel efficient petrol lawnmower, if such a machine is what they want, and doing the same for other product categories.

6 Changes compared with the previous version

Appendix 1 contains a summary of all requirements and the changes suggested from version 4 to version 5.

7 New criteria

Future criteria revisions for the product group should include:

- Required share of recycled materials or raw materials in the machine.
- Requirement for machines to be constructed to enable reuse or material recycling of a certain material share.
- Analysis of the mass/weight of various materials used in the product.
- Limit values for substances that represent a health hazard on combustion of biofuels, e.g. ethanol and biodiesel.
- An overview of noise limit values to assess the possibility of tightening this requirement.
- A tightening of limit values for emissions from diesel engine machines.
- Occurrence and risk associated with nano materials and perflourinated materials, e.g. on blade edges or in the grass cuttings collection sack.
- Possibility of imposing material requirements for electrical machinery accessories, e.g. battery chargers.
- Analysis of requirements for other types of oils such as transmission fluid, gear oil.

Appendix 1. Overview of changes in criteria 5.0 compared with previous version

Previous criteria (4.5)	Revised criteria (5.0)	Comment
R1-R9	R23-R31	The requirements are largely unchanged but have been updated to ensure consistency with the criteria documents. Requirement R6 has been integrated with requirement R20.
R10	R1	It has been made clear that the fuels are listed in no particular order. It has been made clear that engine petrol containing a percentage of biofuel is also acceptable.
R11	See R22	Requirement R11 relating to the use of biodegradable motor oil has been moved to the section entitled "Customer information".
R12	R2	Unchanged
R13	R3	The requirement has been made clearer and stricter. Limit values for evaporative emissions for fuel hose and fuel tank have been introduced.
R14	R4	The weight limit has been lowered from 50 g to 25 g. It has been made clearer that requirement does not apply to rubber parts, cables and electronics.
R15	R5	The ban on using heavy metals cadmium, lead and mercury has been extended to include hexavalent chromium and flame retardants PBB and PBDE accordance with the EU's directive (RoHS).
R16	R6	The list of banned phthalates has been extended to include DHP, DCHP, DEP and DIHP; all of which meet the criteria for classification as SVHC. All phthalate requirements apply to plastic and rubber parts that weigh 25 grams or more. Circuit boards are excepted. The exception also applies to cables and hoses/ pipes/ducts. The reason for the latter is that machines must be constructed to withstand being parked outside in cold weather, perhaps all winter. They must also be able to withstand UV radiation without any impact on their service life.
R17	R7- R8	The flame retardant requirement has been split into two separate requirements and now includes a ban on high chlorine medium-chain chlorinated paraffins, hexabromocyclododecane (HBCDD), tetrabromobisphenol A (TBBP-A) and tris(2-carboxyethyl)phosphine (TCEP).
R18 - R19	R9 - R10	Previous criteria included requirements regulating the surface treatment of metals. The present requirements are based on these but have been revised to correspond to the surface treatment requirements applicable to other Nordic Ecolabel product groups. The exception relating to "small parts" is made clearer by the inclusion of the text "Fastening components and similar small parts are excepted. "

Previous criteria (4.5)	Revised criteria (5.0)	Comment
R20	R14	The packaging requirement has been updated, focusing on recycling and customer information.
R21	R11 - R13	The battery requirement has been extended to comprise three requirements. These requirements regulate quality, safety and metal content.
R22	—	Removed as the requirement is no longer relevant.
R23	R15-R16	Engine efficiency division according to the EU's directive. Limit values significantly more restrictive than legal requirements. Not comparable against previous requirements as the test cycle and test process have changed.
R24	R17	Emission requirement for diesel engine machines. Engine output allocation and limit values pursuant to CARB.
R25	—	Requirement included under R15.
R26	R18	The requirement for emissions measurement, including after a number of hours in operation, remains. Testing according to engine type approval.
R27	—	The requirement regulating the content of substances that are harmful to health in exhaust fumes generated when renewable fuel is used instead of petrol or diesel has been removed. The reason for this is that there is no reason to retain a requirement that is not adapted for new engines built for renewable fuels. Instead, the product group definition is clarified, stating that the engine shall be new and thus adapted for the relevant fuel.
R28	R19	The maximum petrol consumption permissible for four-stroke engine lawnmowers has been lowered to 480 g/kWh from 500 g/kWh.
R29	R20	The sound intensity levels for lawnmowers are divided into two categories; one for hobby machines and one for professional machines. Higher noise levels are generally accepted for professional mowers. Hobby machine sound intensity levels remain unchanged. A limit value of 92 dB(A) has been introduced for garden shredders.
R30	R21	Unchanged
R31	—	The requirement has been removed as it has not been possible to get a consistent idea of the possibilities for tightening up the requirement. The requirement can be removed as vibrations are a working environment issue exclusively.
R32	R22	Licensing experience shows that the majority of customer information requirements are relevant. These thus remain but have been revised as follows: Section 5 recommends the use of environment adapted motor oil. In criteria document 4.5 this was contained under requirement R11. Section 11 has been revised so that is corresponds to the manufacturer responsibility for electrical and electronic products.

Previous criteria (4.5)	Revised criteria (5.0)	Comment
		Section 12 has been changed to encourage not the *return but rather the handing in of components that are harmful to the environment to waste/recycling stations.* *Section 14 has been clarified to prevent misunderstandings.* *Section 16 has been simplified and encourages the use of ear protectors at all times.* *Point 18 references the EU's new Machine Directive.* *Section 19 is new and stipulates that the length and dimensions of power supply cables for corded machines must be clearly stated.*
R33	R31	Moved to section on Environment and quality requirements and regulatory requirements.

Appendix 2. Description of weighting models LCA

The below text is an extract from the report Life Cycle Assessment of Lawnmowers", Chalmers University of Technology, Sweden 2010.

CML, Eco-indicator 99, EDIP and EPS2000 are some of the most popular LCIA methods today. In this case, EPS2000 and Eco-indicator 99 were chosen for the weighting.

EPS2000, developed by CPM (center for environmental assessment of product and material system) was chosen because the EPS system is aimed to be a tool for a company's internal product development process. It may be used externally and for other purposes, like for environmental declarations, for purchasing decisions, for education or for environmental accounting, but in those cases, the knowledge of the EPS system and its features and limitations is crucial (CPM, 2010). EPS is based on willingness-to-pay to avoid environmental damages (Baumann & Tillman, 2004) and impact is expressed in a monetary value called "ELU" (Environmental load units).

Eco-indicator 99 is also a widely used method and the purpose of using two methods is to let the company to see the different result with different analysis ways. Eco-indicator 99 is based on distance-to-target principle.

Appendix 3. Description of EU directives

The "mother" directive, 97/68/EC[40], covers diesel fuelled engines for common (Non-Road Mobile Machinery) NRMM. It became effective from 1 January 1999 for certain types of engines. The first stages presented in 97/68/EC, stage I (1 January 1999) and stage II (1 January 2001), covers diesel fuelled engines between 37 and 560 kW.

The second directive, 2002/88/EC, covers spark ignited engines up to 18 kW for engines installed in handheld and non-handheld equipment. Stage I (and stage II) became effective in August 2004 with some exemptions for certain applications. The work with transposition is going on in the Member States.

The third directive, 2004/26/EC, covers diesel fuelled engines from 19 kW to 560 kW for common NRMM and regulates the emission in 3 further stages. The directive includes also railcars and locomotives and inland waterway vessels and for the 2 latter categories there are no upper limits concerning engine power. The different stages in the 2004/26/EC directive are as follows: …

The fourth directive, 2006/105/EC, introduced some modifications to the Directive 97/68/EC, amending Annex VIII, point 1, section 1. This concerns the approval certificate numbering system, with the code for each MS.

[40] http://ec.europa.eu/enterprise/sectors/mechanical/documents/legislation/emissions-non-road/index_en.htm