**WORKING DOCUMENT**

**EXPLANATORY NOTES**

**Review of Regulation EU 548/2014**

**TABLE ON CONTENTS**

# 1. CONTEXT OF THE PROPOSAL

## 1.1. Grounds for and objectives of the proposal

The Ecodesign Directive 2009/125/EC[1] establishes a framework for the setting of ecodesign requirements for energy-related products. It is a key instrument of the Union policy for improving the energy and other environmental aspects of products placed on the market or put into service in the European Economic Area (EEA). It is an important instrument for achieving the energy saving objectives for 2020 and 2030, and its implementation is one of the priorities in the Commission's Communication on Energy 2020 and Energy Efficiency Plan 2011. Furthermore, implementation of the Directive 2009/125/EC will contribute to the EU's target of reducing greenhouse gases by at least 20 % by 2020 and by 40% by 2030.

Power transformers were included as one of the priority product groups in the Ecodesign Working Plan 2009-2011. In 2014, with the aim of improving their energy efficiency, Regulation (EU) No. 548/2014 was adopted. This Regulation sets minimum energy efficiency requirements for medium and large power transformer with a minimum power rating of 1 kVA used in 50 Hz electricity transmission and distribution networks or for industrial applications.

The minimum requirements established by this Regulation applied from 1 July 2015 in a first step and will apply from 1 July 2021 in a second step. The requirements were based on the calculation of least life cycle costs for representative models of medium power transformers and on percentiles efficiency curves based on real empirical data for large power transformers.

The review clause of Regulation (EU) No. 548/2014 (Art. 7) states:

*No later than three years after the entry into force (i.e., 10 June 2014), the Commission shall review this Regulation in the light of technological progress and present the results of this review to the Consultation Forum. Specifically, the review will assess, at least, the following issues:*

- *the possibility to set out minimum values of the Peak Efficiency Index for all medium power transformers, including those with a rated power below 3 150 kVA*
- *the possibility to separate the losses associated to the core transformer from those associated with other components performing voltage regulation functions, where this is the case*
- *the appropriateness of establishing minimum performance requirements for single-phase power transformers, as well as for small power transformers*
- *whether concessions made for pole-mounted transformers and for special combinations of winding voltages for medium power transformers are still appropriate*
- *the possibility of covering environmental impacts other than energy in the use phase*

To address the issues included in the review article a preparatory review study was launched in September 2016, resulting in a final report published in June 2017. The study included a manufacturer enquiry, two stakeholder meetings (that took place on 16 September 2016 and 29 March 2017) and two interim reports by the study team. It resulted in more than 30 stakeholder position papers from individual stakeholders and associations.

[1] OJ L 285, 31.10.2009, p. 10.

## 1.2. Market significance

The population of power transformers in Europe is estimated to be around 3,6 million units, increasing to almost 4,7 million in 2025. This estimated growth in stock may be partially explained because of the proliferation of distributed generation facilities, which need to be connected to the main distribution grid. On average, in recent years, about 140.000 distribution transformers (Medium Voltage/Low Voltage) have been sold annually in Europe and over 50.000 units for industrial use. Most MV/LV distribution transformers are liquid-immersed. For industry applications, oil-immersed transformers represent around 80% of the market.

The main European industry players for transformers are big international groups like ABB, Siemens, Areva, Schneider Electric, and some large/medium size companies like Cotradis, Efacec, Pauwels, SGB/Smit, Transfix and Ormazabal. Transformer manufacturers from outside the EU include General Electric, Hitachi (Japan) and Vijai (India).

## 1.3. Environmental significance

The preparatory study estimated that for the year 2025 an installed base of almost 4,7 million transformers in the EU will lead to an annual electricity consumption of 120 TWh, corresponding to 28 Mt of CO2 emissions by that year.

Transmission (large power) and distribution (medium power) transformers run 24 hours/day, 365 days a year and have very long lifetimes, of typically between 25 and 40 years, so energy consumption clearly is the dominant factor in their environmental impact. The installation of inefficient products therefore has an adverse environmental impact for a long time, and low stock rotation means that any measure stimulating energy efficiency is likely to take a long time to reach its full potential and make a difference.

Modern distribution transformers have typical efficiencies higher than 98% and even 99% at half load. Large power transformers are even more efficient, typically above 99%. This might seem to suggest a low improvement potential of their performance. However, due to the very large number of transformers in use in distribution systems, the total impact of small improvements provides a significant contribution to reducing energy consumption and greenhouse gas emissions.

The impact assessment supporting the adoption of Regulation EU 548/2014 estimated that the total losses of the installed transformers fleet in 2008 amounted to 93,4 TWh per year.

Other sources[2] estimate that, in Europe, network losses represent 7,3% of the electricity use in transmission and distribution networks. This would be in line with network losses in North America (7,1%) and below losses in Japan (9,1%) and Australia or New Zealand (9,5%).

The cost-effective improvement potential through more efficient designs of transformers was estimated at about 16,2 TWh per year in 2025, which corresponds to 3,7 Mt of CO2 emissions.

## 1.4. Currently covered products

Regulation (EU) No. 548/2014 covers small, medium and large power transformers. As a first approximation, the threshold between small and medium power transformers is set at the

2 See http://www.superefficient.org/en/Research/PublicationLibrary/2013/Distribution-Transformers-Internationally-Comparable-Test-Methods-and-Efficiency-Class-Definitions.aspx

highest voltage for equipment exceeding 1,1kV, and threshold between medium power and large power transformers is set at the highest voltage for equipment exceeding 36kV.

The regulations establishes product information requirements for all three types of transformers, but minimum energy efficiency requirements only for medium and large power ones. The scope of the regulation includes three phase transformers, but leaves outside single phase transformers, as the necessary data was not available by the time the regulation was adopted.

## 1.5. International legislation

Many economies around the world (e.g., US, Japan, Australia, Canada, Brasil, Mexico, Israel, Korea) have introduced in recent years some sort of minimum efficiency requirements for distribution and transmission transformers. Internationally, these requirements are often referred to as Minimum Energy Performance Standards or MEPS[3].

The US Department of Energy introduced in 2016 new minimum energy efficiency requirements for distribution transformers below 34,5 kV. In contrast to European practice, minimum requirements in the US are based on an efficiency index rather than on absolute levels of losses. This is also the case in other English speaking countries around the world, such as Australia or Canada.

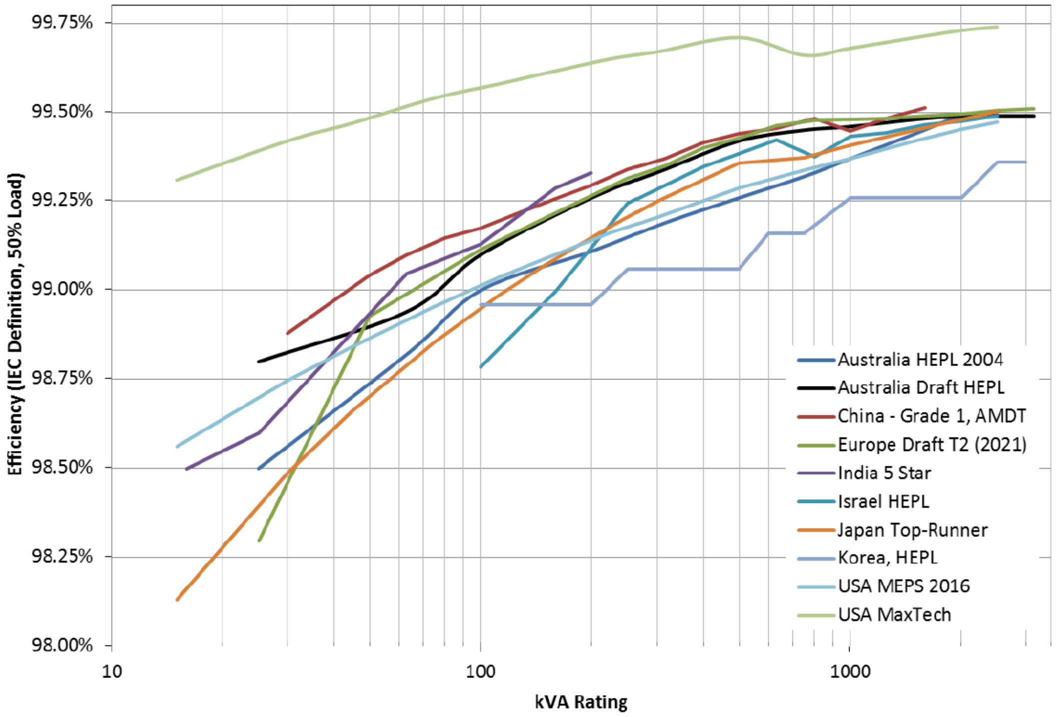
In Japan, the top runner system follows yet a different approach. Minimum efficiency requirements for transformers are based on a fleet average by manufacturer and a maximum distance to a target standard (of efficiency) that needs to be attained by a certain date. This is complemented by reputational measures in case of non-compliance, rather than on market restrictive measures.

A 2014 report on distribution transformers from the Super-Efficient and Appliance Development (SEAD) Programme[4] was able to compare the minimum requirements for three-phase liquid-immersed distribution transformers across existing regulatory schemes (see Table 1). The report stated that the EU MEPS for Tier 1 in 2015 are approximately at the same level as the US requirements introduced in 2010 and that the most ambitious MEPS requirements are shared between the United States MEPS 2016 levels at lower kVA ratings and the European Union's Tier 2 levels for 2021 and the Japanese Top-Runner levels at the higher kVA ratings.

Table 1 Comparison of MEPS requirements for three-phase liquid immersed transformers.

[3] In the EU, the term standard normally refers to voluntary measurement methods, but internationally it is often used interchangeably with the concept of minimum requirement.

[4] See http://www.superefficient.org/en/Research/PublicationLibrary/2013/Distribution-Transformers-Internationally-Comparable-Test-Methods-and-Efficiency-Class-Definitions.aspx




### 1.6. Availability of standards

In parallel with the development of Regulation EU 548/2014, a standardisation request invited Cenelec to adapt existing measurement standards and develop new ones in support of the regulation. As a result, Cenelec adopted in 2015 two standards, EN 50588-1:2015 for medium power transformers, and EN 50629:2015 for large power transformers. These standards were cited as harmonised in the OJEU in September 2015. Minor amendments to these standards were already adopted by Cenelec in 2016 and cited again in the OJEU in November 2016[5].

A new standard, (for the time being referred to as TS 50675:2017) is in advance stages of development and is meant to complement both EN 50588 and EN 50629. The standard is very likely to be voted by the time an eventual amendment of Regulation EU 548/2014 is adopted in 2018.

## 2. PROPOSED OPTIONS

### 2.1. Improvements to existing definitions and exemptions

Since Regulation EU 548/2014 was adopted in 2014, standardisation work to come up with standards EN 50588 and EN 50629 has resulted in a fine tuning of some of the definitions included in Article 2 of the regulation and in better explanations for some of the exemptions included in Article 1.2.

[5] See https://ec.europa.eu/growth/single-market/european-standards/harmonised-standards/ecodesign/transformers_en

The consultation document is therefore proposing to incorporate these improvements in definitions and regulatory exemptions if/when a draft amending regulation is voted at the Regulatory Committee.

## 2.2. Tier 2 requirements for three-phase medium power transformers

The main question for investigation in the review study was whether Tier 2 requirements for medium power transformers are technologically feasible and cost-effective.

In response to the first question, the study team launched an enquiry amongst transformers' manufacturers based in the EU. The outcome of this enquiry is that most manufacturers feel comfortable with being able to produce Tier 2 compliant transformers by 2021 based either on the expected improvement of high grade conventional silicon steel and other design techniques, or based on amorphous steel technology. Stakeholder feedback indicated that some progressive utilities (e.g., Synergrid in Belgium) are already using Tier 2 requirements as a reference in their procurement processes.

The answer to the second question has been less straightforward. The study provides a reasonable reassurance that Tier 2 compliant transformers are close to the least lifecycle cost for new installations (so called greenfield sites). However, for replacement transformers in existing installations (so called brownfield sites), particularly in specific urban locations, there may be lock-in effects whereby more efficient models[6] may not fit into existing substations.

The prevalence and geographical distribution of this lock-in effect is not fully clear, neither from the review study nor from stakeholder feedback. The analysis in the study suggests that utility brownfield sites may account for 27% of total EU medium power transformers sales when expressed by their rated power capacity (in kVAs).

While it is clear that the size of substations should not hold back the technological development and the pursuit of efficiency in transformer design, a situation where the replacement of an existing transformer requires the replacement of a substation[7] is not satisfactory either. It would not seem wise either to fragment the market, through regulatory intervention, into different transformer designs for greenfield and brownfield installations, as this would probably prove to be unenforceable in practice.

Additionally, transformers have long service lives of up to 40 or even 50 years. The calculation of lifecycle costs requires making assumptions on a number of key variables such as the discount rate, the price of electricity and the evolution of future electricity prices. All this is necessary to calculate the net present value of the future losses which are trying be avoided.

The use of different assumptions produces different outcomes, which may or may not justify the adoption of stricter requirements in Tier 2. As anticipated, it proved difficult to find agreement amongst stakeholders on the appropriate values for these key parameters. To address this, the review study provides in section 1.1.8 a sensitivity analysis with up to eight scenarios for different combinations of key variables.

---

[6] Generally speaking more efficient transformers require more magnetic steel and copper or aluminium and are therefore larger and heavier. The extent to which other design options may compensate for this increases in size and weight is not fully clear.

[7] The price of a new substation can be several times the price of a new transformer. Additionally, there can be other costs associated to the purchase/rent of additional ground. For transformers housed in listed building, it may not even be possible to modify the grounds.

The conclusion of this discussion is that minimum requirements for Tier 2 may need to be complemented with some form of regulatory relief, when the installation of compliant transformers becomes uneconomic under specific circumstances. As it is not possible to know in advance all situations in which this will be the case, such regulatory relief needs to be as future-proof as possible and should not lend itself to situations of potential abuse. A number of options to address this issue are presented in the related consultation document.

## 2.3. Requirements for single-phase transformers

Single-phase transformers are only used in single phase power medium voltage networks in rural parts of Ireland and the United Kingdom. They were excluded from Regulation EU 548/2014 primarily on the grounds of lack of available data, lack of measurement standards and limited potential for energy savings.

According to the review study, some 154 MVA of single phase transformers are installed in the UK annually and 84 MVA in Ireland, thus a total of 238 MVA of single phase transformer capacity is installed annually in the EU as a whole. This is negligible compared to the capacity installed annually in the EU for three phase transformers.

Therefore, additional energy savings to be gained from the introduction of minimum efficiency requirements for single phase transformers would be practically insignificant at EU level. Furthermore, stakeholder feedback suggests that there is very little risk of a substitution effect for three-phase transformers in case single-phase ones would remain unregulated.

However, there is stakeholder consensus to address the current regulatory asymmetry between three phase and single phase transformers and introduce minimum requirements, at least as a market backstopping mechanism, to prevent the placing on the market of models more inefficient than those installed today. This would also bring the EU in line with other jurisdictions, where the energy efficiency of single phase transformers is also regulated.

The consultation document presents the option of introducing minimum energy efficiency requirements based on minimum PEI (Peak Efficiency Index) values included in the updated EN 50588-12015+A1:2016.

## 2.4. Regulatory concessions

### *2.4.1. Large power transformers*

Large power transformers are normally engineered to order and assembled on site, in some cases next to power generation sources. Because of their weight and dimensions, large power transformers are sometimes subject to transport restrictions.

Regulation EU 548/2014 already foresees a regulatory exemption in cases where the installation of one-to-one replacement transformers in existing sites cannot be achieved without entailing disproportionate costs (associated to their transportation and installation).

Based on stakeholder feedback, the review study suggests extending this exemption also to new sites (so called greenfield applications) where similar conditions are met. In order to prevent abuse of this (new) provision, an additional requirement related to the properties of the transformer core[8] is suggested.

[8] The introduction of maximum specific core losses (not higher than 1 W/kg at 1,7 Teslas) ensures at least that the best available magnetic steel is used to build the core.

The review study has identified an anomaly in the current regulation in the transition in energy efficiency requirements from the largest medium power transformers to the smaller large power ones.

The separation between medium and large power transformers is derived from the relevant EN standards and primarily depends on the highest voltage for equipment being higher or not than 36 KV. Based on this threshold, requirements for large power transformers are expressed as minimum values of the Peak Efficiency Index, while requirements for medium power transformers (below 3150 kVA) are expressed as maximum values of losses. Because network losses are more related to the active power than to voltage itself, the current categorisation results in distortions for specific types of transformers[9].

The consultation document is proposing the introduction of separate requirements for an additional sub-category of large power transformers between 36 and 72,5 kV to address this situation.

### *2.4.2. Transformers with unusual combinations of winding voltages*

Regulation EU 548/2014 foresees a concession in the form of an extra allowance for load and no-load losses for transformers with unusual winding voltage combinations (e.g., dual voltage). This was justified to compensate for the extra insulation required in building such transformers.

It has been reported that some market players are using these concessions to take advantage of the extra allowance (10% to 15%) and sell dual ratio transformers at a cheaper price than single ratio ones, even if only a single ratio is required.

The consultation document discusses an option to close this apparent loophole.

### *2.4.3. Pole-mounted transformers*

Regulation EU 548/2014 provides for separate efficiency requirements for medium power pole-mounted transformers with power ratings between 25 kVA and 315 kVA. This was justified on the grounds that a large stock of medium power transformers in some Member States are mounted on the support structures of overhead power lines, which impose weight limitations and prevent them from achieving the levels of energy efficiency that apply to ground mounted transformers. This lock-in effect has been reported only in a limited number of Member States. In parallel, some manufacturers have reported being capable of manufacturing Tier 2 compliant medium power transformers suitable for pole-mounted installation.

In order to accelerate the phase out of this practice, which perpetuates low efficiency transformers, a number of options are proposed in the consultation document, from abandoning the existing regulatory concession altogether, to limiting it in time, to qualifying it with complementary requirements.

[9] For instance, PEI values for large power transformers (i.e., with Um higher than 36kV) with rated power below 3,15 MVA are more restrictive than the losses for medium power transformers (i.e., with Um lower than 36kV) with similar levels of rated power.

## 2.5. Other miscellaneous topics

### *2.5.1. Small power transformers*

There are currently no minimum efficiency requirements in Regulation 548/2014 for low power transformers. A new draft standard prEN 50645 will be specifying measurement methods for small power transformers. With the evolution of electric vehicles and their need for charging, a growth in low voltage (LV/LV) transformers is expected. It will be therefore advisable to investigate the opportunity to set minimum energy efficiency requirements for this type of transformers as part of a future review of Regulation 548/2014.

The consultation document therefore proposes to consider the introduction of minimum energy efficiency requirements for small power transformers in time for the next review of this regulation, provisionally, in 2023.

### *2.5.2. Technology neutrality of requirements for liquid immersed and dry type transformers*

The review study has identified the difference in energy performance requirements for dry type medium power transformers and liquid transformers of the same power rating as a potential issue related to technology neutrality. There is no consensus on whether the lower requirements for dry type transformers could cause substitution effects in the market, neither on the extent to which these two types of transformers constitute separate product markets.

The consultation document therefore proposes to investigate this question further as part of possible Tier 3 future requirements, in time for the next review of this regulation, provisionally, in 2023.

### *2.5.3. Retrofitted transformers*

Regulation EU 548/2014 is silent with regards to repaired or retrofitted transformers and implicitly relies on the generic provisions made in the Blue Guide on the implementation of EU product rules[10].

However, the existence of a market for the upgrade, repair, refurbishment and retrofitting of transformers makes it necessary to provide guidance on the circumstances under which a transformer that has undergone some or all of those operations can be considered a new products and must therefore comply with the minimum energy performance requirements set out in Annex 1 of the Regulation.

The consultation document is proposing to consider the feedback given by stakeholders, including CENELEC Technical Committee 14 and Gimelec[11], to the review study in order to provide further clarity on this question.

[10] See http://ec.europa.eu/DocsRoom/documents/18027/

[11] Gimelec is a French national association of providers of electrical equipment and services, which is part of T&D Europe

### 2.5.4. *National deviations in standard voltages*

The adoption of Regulation EU 548/2014 failed to take into account the existence of national deviations in standard voltages in electricity distribution grids exist in some Member States[12]. These standard voltages coincide with the thresholds used in this Regulation to determine which minimum energy performance requirements are applicable to three-phase medium power transformers with rated power below 3150 kVA.

This has resulted in a situation of legal uncertainty, at least in the Czech Republic and possibly in Slovakia, where economic operators are unclear about how to comply in practice with minimum requirements laid out in Tables 1.1, 1.2 and 1.3 in Annex 1 of the Regulation.

The consultation document is therefore proposing to remedy this situation by recognising the existence of such national deviations when interpreting the mentioned tables in the regulation and proposing a notification mechanism for concerned Member States.

## 3. MEASUREMENTS AND CALCULATIONS

Member States authorities shall use the measurement methods and calculation methods set out in Annex II. The formula for the calculation of the Peak Efficiency Index is likely to be replaced with the new proposal being made as part of the standardisation work being done under prTS 50675.

Other than these specific methods, the testing of energy efficiency performance shall be done according to generally recognised state of the art methods, including methods set out in documents the reference numbers of which have been published for that purpose in the OJEU (so called harmonised standards).

## 4. CONFORMITY ASSESSMENT

The verification tolerances set out in Annex III of the Regulation relate only to the verification of the measured parameters by Member States authorities and shall not be used by the manufacturer or importer as an allowed tolerance to establish the values in the technical documentation.

## 5. MARKET SURVEILLANCE

It was not in the remit of the review study to collect data on compliance levels, or on other issues related to market surveillance. The only information that has been made available to the review process has been provided by the Swedish Energy Agency.

Feedback from the Swedish experience suggests that market surveillance can be done normally for medium power transformers up to 3150 kVA and that self-declarations remain appropriate. For larger transformers above 3150 kVA, only witness testing may be possible, as measurements must be done at the manufacturer's premises. These transformers are most often engineered to order and witness testing needs to fit into tight production and delivery schedules.

It has been suggested that for these larger transformers, third party verification might be more appropriate than self-declarations, as customers often hire technical experts to evaluate

[12] CENELEC EN 60038 includes in Annex 2B a national deviation in the Czech Republic according to which the standard voltage for the highest voltage for equipment in AC three-phase systems are 38,5kV instead of 36kV and 25kV instead of 24kV

calculations and monitor measurements. However, it has also been pointed out that there are only a few independent laboratories in the EU equipped to test large power transformers.

Finally, in order to maintain a level playing field, it has been suggested that cooperation with customs authorities must be increased to closely monitor imports into the EU.

## 6. BENCHMARKS

The list of indicative benchmarks listed in Annex IV of Regulation EU 548/2014 contains a material mistake, which should be rectified in the amending regulation. The benchmark for medium power transformers with amorphous steel core should be Ao-50%, Ak and not Ao-50%, Ak-50%.

The review study did not perform an in-depth investigation to refresh the list of indicative benchmarks. It did suggest, however, that the best available technology is capable of delivering transformers more efficient than those required by Tier 2, which could pave the way for eventual Tier 3 requirements in the future.

It seems, however, that transformers with efficiency levels substantially higher than those of Tier 2 can currently only be achieved with amorphous core steel. It is recommended to revisit the discussion on benchmarks and Tier 3 in time for the proposed review of this regulation in 2023, once conventional high-grade magnetic steel is more widely available and such more ambitious requirements can be met by both competing technologies.