REVIEW

POTENTIAL ECODESIGN REGULATION FOR ECONOMIC CABLE CONDUCTOR SIZING IN BUILDINGS

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BASIC PRINCIPLE AND WHY IT IS A SYSTEM

Increasing the conductor cross sectional area (CSA) of a cable reduces its energy losses. The most economic CSA is that for which the cable investment cost is equal to the total lifetime cost of energy losses.

Cable sizing is subject to regulation through national building codes, but these only take safety and aspects of functionality into account, not energy efficiency. These mandatory cable sizing prescriptions have given rise to the general misconception that following them precisely is best practice. The notion that the regulations *are only the bare minimum requirement* is often disregarded. As a result, economic cable sizing is not usually even taken into consideration during installation design or energy management initiatives.

Economic cable sizing cannot be derived just from the physical design parameters, but depends on the load profile of the electrical circuit in which the cable is used. Consequently, it is not the cable and its current-carrying capacity that should be regulated, but the choice of the cable cross section in the context of the electrical circuit and its load profile – in other words *the installed cable system*.

FIRST ESTIMATE OF THE SAVINGS POTENTIAL

Approximately 8% of the electrical energy generated in the EU gets lost in the network between generation and end-use. Of this 8%, around 6% represents losses in the transmission and distribution network and 2% is behind-the-meter. Of the latter, 1.5% can be attributed to non-residential buildings – around 50 TWh per year – and the remaining 0.5% to residential buildings. See the Annex for the origin of these figures.

- In the transmission and distribution sector, cable losses are substantial due to long distances and high loading, but cables are core business, so the energy losses are already taken into consideration by regulatory authorities (e.g. in Energy Efficiency Directive art 15.2).
- In the residential sector, the total losses attributed to cables is limited, as is the potential economic gain from optimising cables.
- In non-residential buildings, the energy losses are substantial and they go largely unnoticed.

REGULATORY HISTORY

The opportunity was identified in the Ecodesign Working Plan 2012-2014 and further analysed in the corresponding Preparatory Study (Lot 8 - Power Cables, 2013-2015, report published May 2015 [1]).

The Preparatory Study concluded with negative, albeit ambivalent advice: as installed cables are *a system* not *a product*, Ecodesign was not seen as the best policy instrument (more detail on this in the next section). The study stated that they would be better addressed by alternative policy instruments such as the Energy Performance of Buildings Directive (EPBD) [1, p. 316, section 7.1.2.2].

This negative advice appears to have been followed – the Ecodesign regulatory process for cables has not been pursued to date.

DETAILED FINDINGS OF THE PREPARATORY STUDY

OBSERVED MARKET FAILURES

The study observed the following market failures [1, p.124], which explain why sub-optimal cables are still widely installed despite the associated economic losses:

- Electrical installers are unaware of circuit losses;
- Cable loss calculations are not conducted when designing installations;
- Life cycle cost (LCC) evaluations are not carried out because budgets for capital costs are separate from operating expenses;
- Life cycle costing calculations are not requested in tenders.

EXCLUDED REGULATORY AVENUES

The option to impose an increased CSA without considering the load profile was excluded for two reasons:

- For some circuits the default CSA has the lowest life cycle cost (e.g. for lighting circuits);
- Doing so would have a positive impact on the Global Warming Potential, but could have a negative impact on some other environmental impacts (use of Polycyclic Aromatic Hydrocarbons (PAHs), generation of Particulate Matter (PM) and Eutrophication).

It was also decided not to consider policy options that would phase out one material versus another, for three reasons: the use phase of the cable has the most significant impact; the materials that are used can be, and are being, recycled, and it is hard to compare the impact of different material manufacturing processes with sufficient accuracy. [1, p. 315, section 7.1.2.1.2]

Residential buildings were excluded from the study because the savings potential was thought to be limited. That does not mean, however, that there are no potential energy savings in making existing installations compliant with the current codes for new installations.

SCENARIOS FOR ECONOMIC CABLE SIZING IN NON-RESIDENTIAL BUILDINGS

The Preparatory Study did not investigate the option in which the most economic CSA is calculated for each individual case. Instead, it classified the circuits into four types (distribution circuit, lighting circuit, socket circuit, dedicated circuit) and two sectors (tertiary sector, industry), resulting in eight different cases. A ninth case was added consisting of a dedicated circuit in industry with an aluminum conductor. All other conductors were assumed to be copper. The study developed four different scenarios that stipulate a particular CSA for each of the nine cases. All scenarios assumed that policies were adopted in 2020.

The study does not make clear whether these scenarios were only developed to facilitate the impact calculation, or whether they are also seen as potential regulatory avenues.

Scenario II is said to have “the lowest life cycle cost”, which is misleading, because it has not the lowest life cycle cost of all possible scenarios (see Comments). It has, however, the lowest life cycle cost of all the scenarios calculated in the study, which is why we selected this scenario’s energy and economic savings potential.

CALCULATED SAVINGS POTENTIAL

Scenario II has the following net savings potential, with savings rising gradually over the years, proportional to the renovation rate and increasing electricity end use:

- Annual energy savings in 2025: 7.60 TWh/a [1, Table 7-14]

- ➢ Annual energy savings in 2050: 28.01 TWh/a [1, Table 7-14]
- ➢ Cumulative net GHG emission savings by 2050: 159 million tonnes CO_{2eq} [1, Table 7-19]

ECONOMIC BENEFITS

Scenario II would lead to the following economic advantages compared to business-as-usual, calculated for the entire EU-28:

- Annual savings in electricity costs of €1,142 million in 2025 [1, Table 7-22]
- Annual savings in electricity costs of €7,076 million in 2050 [1, Table 7-22]
- Reduction in the total cost of ownership of €5,688 million by 2050 [1, Table 7-24]

The study found that the proposed policy option was expected to create jobs for electrical installers, cable manufacturers and distributors. The most significant job creation was expected in manual labour by electrical contractors — jobs that will always be local. [1, Section 7.3.2, p.344]

POTENTIAL REGULATORY AVENUES

The study excluded the option of Ecodesign regulation at product level, but mentioned two obligations that could be placed on cable manufacturers [1, p. 313-314, section 7.1.2.1.1]:

- To provide generic information about energy losses (e.g. the annual energy losses per meter for a limited number of predefined load profiles)
- To provide a cable sizing tool (e.g. a link to an on-line tool) which calculates the optimum (least lifecycle cost) cable CSA for a given load profile

Instead of the cable itself, the “installed electric power circuit” could be regulated. The authors of the study doubted whether Ecodesign was the right regulatory tool for this, for the following reasons [1, p. 315, the second section labelled 7.1.2.1.2]:

- Up to now, Ecodesign has only regulated products subject to CE marking.
- CE marking requires a free movement of goods. Introducing CE marking for installed electric power circuits is not an option, as they cannot be moved or relocated.
- If every installed electric power circuit is considered unique, the minimum annual sales volume of 200,000 items to be eligible for Ecodesign regulation is not reached. This argument is then put into perspective : *“there are more than 200,000 new power circuits brought on the market per year which could provide an argument pro*”.
- Electrical installers would be burdened by conformity assessments and the associated administrative work, for which they lack the capacity.

The study downplayed the conclusive character of this analysis by stating the following: “*Despite the above arguments it should be noted that in principle nothing has been found to preclude as such to consider ‘installed electric power circuits’ as products and installers as their manufacturers, therefore it remains a policy option to be decided by the EC.*” [1, p. 315-316]

Subsequently, the study mentions some alternative policy measures that could be considered in a revision of the EPBD and/or could be implemented in local installation codes [1, p 316-318, section 7.1.2.2], such as:

- Always conduct a LCC analysis before selecting a cable with minimum CSA – to be added to an updated IEC 60287-3-2
- A CSA correction factor based on the load factor in an updated IEC 60364-8-2 (similar to the correction factors for installation method and ambient temperature in IEC 60364-5-52)

- Mandatory information to be provided by the installer prior to and after commissioning (expected load factor, rated current, estimated energy loss)
- Monitoring of cable losses with Building Automation and Control Systems with alarms that notify the building operator when the estimated values are exceeded.

Comments on the Preparatory Study

1. The suitability of regulating systems in Ecodesign directive

The supposition of the Preparatory Study authors that the Ecodesign is restricted to CE marked products is based on the application of the directive to date, not on fundamental grounds.

The revised Methodology for Ecodesign of Energy related Products (MEErP), adopted in 2011, advised that studies should look for opportunities at systems level. The MEErp described it as a critical success factor for achieving its energy and resource efficiency targets. It stated that *"(...) it always makes sense for a regulator to look beyond the strict product approach (...) in order to avoid sub-optimisation."* What is more, in 2018, the European Parliament announced that it "*urges the Commission to include more of such system-level opportunities in the next Ecodesign work programme*."

2. On the scenarios of the Preparatory Study

The Study does not give any justification for the choice of the investigated scenarios. Scenario II is said to have "the lowest life cycle cost", which is misleading. It has the lowest LCC out of the four scenarios that were studied, but a mixture of Scenario II and III would have an even lower LCC. The lowest LCC would be achieved by calculating the most economic CSA for each individual circuit.

3. A standardisation gap

There is no international standard for economic CSA calculation of behind-the-meter cables to date which is entirely fit for purpose. IEC 60287-3-2 provides a methodology for calculating the most economic cable size, but is very detailed, which makes the calculations highly complex. Moreover, it requires a reasonably accurate prediction of the *loss load factor*, but does not offer any advice on how to make this prediction. It claims to be a standard for all cables, but all the examples in the annexes concern utility cables. These have a less erratic load profile than cables in buildings, making it easier to estimate the loss load factor.

A standardised, simplified formula for behind-the-meter cables that makes abstraction of some of the less important factors would be welcome. For the loss load factor, tables with typical values per sector and per type of circuit could be provided. Table 3-13 in the Preparatory Study provides a good starting point for this [1, p.148].

4. Inefficient installations being locked in

Six years after completion of the Preparatory Study there is no progress on the regulatory process for installed cables. This loss of time is costly. Electrical installations in non-residential buildings typically have a lifetime of 25 years [1, Table 2-1, p.87]. Consequently, the energy savings potential will be delayed for a long time if sub-optimal cables continue to be installed.

5. Future evolution of the load

To create a future-proof buildings, robust estimates about the evolution of electrical load patterns are required. Efforts to reduce energy consumption could reduce the load, but many emerging applications (such as heat pumps and electric vehicles) are powered by electricity, which could lead to an increase in the load. Moreover, rises in the ambient temperature caused by climate change may increase the need for forced cooling and, in turn, the load on the associated electrical circuits. These possible changes need to be taken into account when estimating the load for economic cable conductor sizing.

ANNEX

Net electricity generation in the EU in 2017 was 3,100 TWh/a [2].

Total distribution and transmission loss in the EU in 2017 was 185 TWh/a [3, p. 158].

Energy losses from behind-the-meter networks are 2.04% [**Error! Bookmark not defined.**, p.28] or 64 TWh/a.

A Japanese study demonstrated that about 20% (13 TWh/a) of these losses can be attributed to residential buildings and 80% (51 TWh/a) to non-residential building [4, p. 28]. We can assume this division to be similar in the EU. Indeed, this last figure is in line with that of total cable losses in non-residential buildings given in the Ecodesign Preparatory Study (50 TWh/a) [**Error! Bookmark not defined.**, p. 343].

REFERENCES

[1] Preparatory Studies for Product Group in the Ecodesign Working Plan 2012-2014: *Lot 8 - Power Cables, Task 1 -7 report* (VITO). Retrieved from: http://erp4cables.net/

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