Ecodesign, Reuse, Repair, Prolonging Lifetime and New Technology – Is it the new paradox?

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The European Ecodesign is well known for energy related issues such as energy efficiency and standby energy consumption, and many detailed articles have been written on this topic. As one of the key elements of the European Green Deal strategy there is another, less well-known aspect to Ecodesign that's about reducing waste and granting consumers the 'Right to Repair' thus prolonging the lifetime of equipment. Clearly the time is right for 'Right to Repair' to be addressed, initially for consumer products that are the visible part of the iceberg, forming part of the much bigger problem of changing our way of working and dealing with the issue of prolonging the lifetime of equipment whilst developing a circular economy. Many business segments will be highly influenced by the new European Directives and will need to figure out new ways to deal with obsolescence.

So how will the power supply industry embrace this change and how could it contribute to prolonging the lifetime of equipments and to reduce waste?

New EU rules to make sustainable products the norm.

As announced in the EU Circular Economy Action Plan, the Commission has proposed new rules to make almost all physical goods on the EU market more environmentally friendly, circular, and energy efficient throughout their whole lifecycle from the design phase through their daily use, repurposing, and end-of-life. As part of the Action Plan dated June 2023 the Environment Committee put forward a proposal to make products in the EU ready for those conditions by developing a strategy to prolong the lifetime of equipments and to protect consumers. An important part of this proposal is to set common rules promoting the repair of goods, advancing towards the objective of sustainable consumption under the European Green Deal (Figure 01).

Developing a repair approach will reduce e-waste and reduce the environmental impact, resulting in significant savings for consumers and all of society. As part of that and similar to how it is for Ecodesign energy consumption labeling, France has proposed the use of a similar label bearing a reparability index to inform consumers about the possibility of repairing a product whilst consumers should have access to repair guidelines.

As proposed in the scope of the project, on December 4 2023 the European Parliament and Council provisionally agreed an update to the 'ecodesign' rules, aiming to improve various aspects of products throughout their lifecycle to make them more durable, reliable, easier to reuse, upgrade, repair and recycle, use less resources and energy and water.

The proposal covers consumer goods and concerns defects that may occur in them, whether or not still under legal guarantee. The producer will have an obligation to repair goods for five to ten years after they were purchased. Goods for which reparability requirements currently exist include household products such as washing machines, washer-dryers, dishwashers, refrigeration appliances, electronic displays, welding equipment, vacuum cleaners, and servers and data storage. Mobile phones, cordless phones and tablets are also listed in the recent draft, and EV chargers have been considered in the latest discussions. All of these products use power supplies and manufacturers need to keep future legislation and regulations in mind and monitor their evolution.

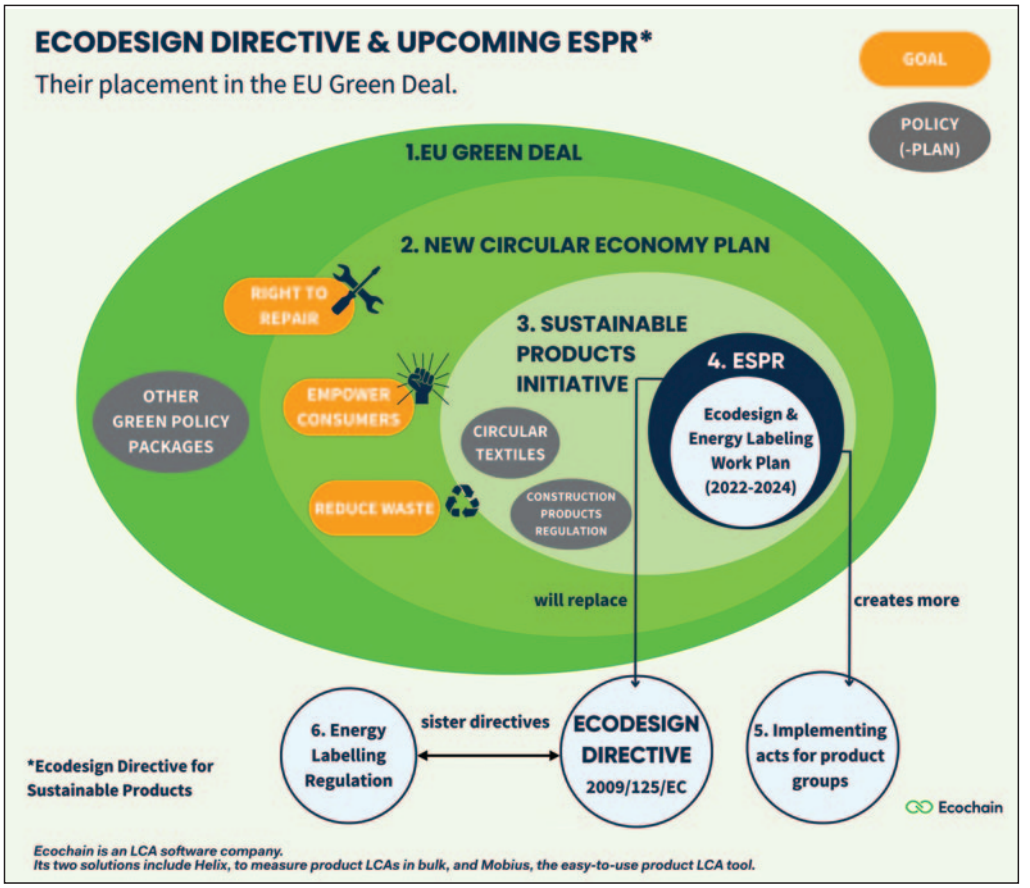


Figure 01 Left - Green Deal policy framework around ESPR (green) and the ESPR's relationship to the Ecodesign directive (blue). (Source:PRBX/Ecochain)

Why the new Ecodesign rules will matter for the power industry.

This introduction may appear to give the impression that it's mostly the consumer segment that will be the subject of future legislation but in fact, inspired by the Ecodesign workgroup a lot of activities are taking place within industry to prolong lifetime and this is where it becomes an interesting area for the power supplies industry.

Regarding consumer applications for power supplies, they are either built-in the equipment and part of the overall system, or external such as USB chargers, and the legislator is working on a classification of the level of reparability in making it environmentally and economically a good idea to repair instead of replace. This is part of the 2024 workgroup that is working in parallel with the industry to define reasonable classifications for the benefit of end users and the environment.

Considering the high levels of integration and current building practices, e.g., the use of sealed plastic products such as external adapters, these may not be classified as repairable but the manufacturers might still have the obligation to guarantee support and service for ten years. Also, for embedded power supplies to listed equipments power supplies, manufacturers will be obliged to guarantee the availability of spare parts during the service period.

At higher power levels, as for the energy consumption Ecodesign regulation, servers and data storage are already included in the proposition, and power supplies manufacturers are working in close cooperation with the European representatives to develop power solutions meeting the reparability needs, but also to guarantee longer life time in operation.

When considering the circular economy, up to 80% of a product's environmental impact can be determined at the design phase. When designing a power supply for a datacenter we always take into consideration energy efficiency, and power designers use the latest technologies such as Wide Bandgap Semiconductors in order to deliver the highest levels of performance. Regarding prolonging lifetime there is a lot of work going on to select components able to keep their original performance for more than ten years in operational conditions, but designers must also include reparability in the mechanical design, which could imply a modular concept easing maintenance, and when end of life arrives, recycling.

For many designers it will be a new way of working but for those used to developing power solutions for refurbishing and system modernization it's nothing really new and a lot of the best practices deployed in this industry are already meeting future Ecodesign regulations.

Before Ecodesign regulation, Reuse, Repair and Prolong Lifetime was already the norm in the railway industry!

Outside of what the Ecodesign is aiming for in consumer segments, many industrial applications require power supplies manufacturers to provide power solutions for refurbishing and systems modernization. Among many, the transport industry and especially the railway are the best examples to illustrate what might be applicable to other segments when it comes to Reuse, Repair and Prolonging Lifetime.

One good example is the French railway state-owned operator, 'Société National des Chemins de Fer (SNCF)', which in September 2023 announced that as part of its commitment to sustainability, SNCF Voyageurs and its Rolling Stock Division are committed to optimizing the use and lifespan of their trains at every stage of their life cycle: mid-life and end-of-life refurbishment to extend their service life and combat obsolescence, and recycling and reuse of spare parts, etc. To achieve that goal, the SNCF has announced the commencement of a major refurbishing project to restore and upgrade 104 high speed trains, 'Trains à Grande Vitesse (TGV)' to "combat obsolescence" (Figure 02).

Figure 02 –SNCF is renovating 104 TGVs with the aim of expanding the current fleet's lifespan. (Source: PRBX/SNCF)

Figure 03 Left – Power supplies required by railway companies when refurbishing trains is very large and going from low power modules to high power converters up to hundreds of kilowatts. (Source : PRBX/Shutterstock/E CO LENS)

These 104 eligible trainsets have been assessed during the 4th quarter of 2023 and 1st quarter of 2024. A number of criteria will be taken into account when deciding the fate of each train set, including the condition of the structure of the train set, its metal components, the boiler, the bogies and the electrical installations including power supplies. Based on these criteria, the trainsets will be classified into three categories:

1. Those in perfect condition that will continue to be in service, but will undergo renovation to improve their comfort.
2. Those that require more extensive reliability and renovation work due to their advanced age.
3. Those that will be withdrawn from service due to obsolescence of parts (electronic components or state of the chassis). These written-off trainsets will be used as parts banks as they contain up to 3,000 potentially recoverable components that can be reused to repair other trainsets.

illustrates within an industrial environment what Ecodesign Reuse, Repair and Prolong Lifetime is aiming for. Reusing parts to reduce waste and optimize resources has been part of the SNCF life cycle process for a long time as rather than buying new, checking and repairing 500,000 TGV spare parts every year represents a saving of half a billion euros a year.

Designing power supplies for refurbishing – New technology paradox.

The variety of power supplies required by railway companies when refurbishing trains is very wide and covers from low power modules to high power converters up to hundreds of kilowatts (Figure 03). In a train, many power supplies are embedded within sub-assemblies e.g., LED lighting with built-in power supplies and drivers, but a number of systems require standalone power solutions meeting the latest legislative requirements.

In general, refurbishing contractors are using referenced part numbers approved by the train manufacturers, and about 80% of the need is available as Commercial off-the-shelf (COTS) from certified power supplies manufacturers, complying with railways standards. However, when refurbishing and modernizing trains that might have been manufactured decades ago, 20% of the power supplies will require extra features, higher power density, lower energy consumption and many more things, often with the need to fit into an existing box that's specific to the application (Figure 04).

When refurbishing or modernizing, the railway industry is following the same pattern as the others, and with the increased demand for higher power density and lower power consumption, power designers are now investigating the implementation of Wide Bandgap (WBG) switching semiconductors, Gallium Nitride (GaN) and Silicon Carbide (SiC).

SiC diodes have been used in railway power supplies for decades, but power switching transistors are relatively new in railway applications. Considering that the lifetime of railway equipment could be greater than 20 years, reliability and supply chain sustainability are a must, and implementing a new technology requires a thorough technical evaluation and the need to ensure that the supply chain is able to guarantee product support for more than 20 years.

In the process of validating a new technology for highly demanding railway

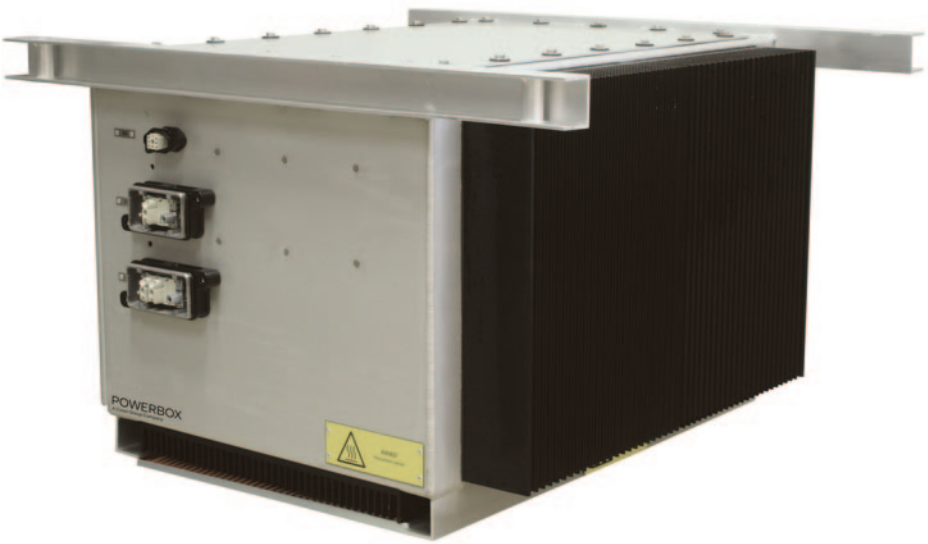


Figure 04 Left – PRBX 110VDC, 10kW Nickel-Cadmium battery charger for refurbishing when replacing Lead-Acid batteries in railway applications. (Source: PRBX)

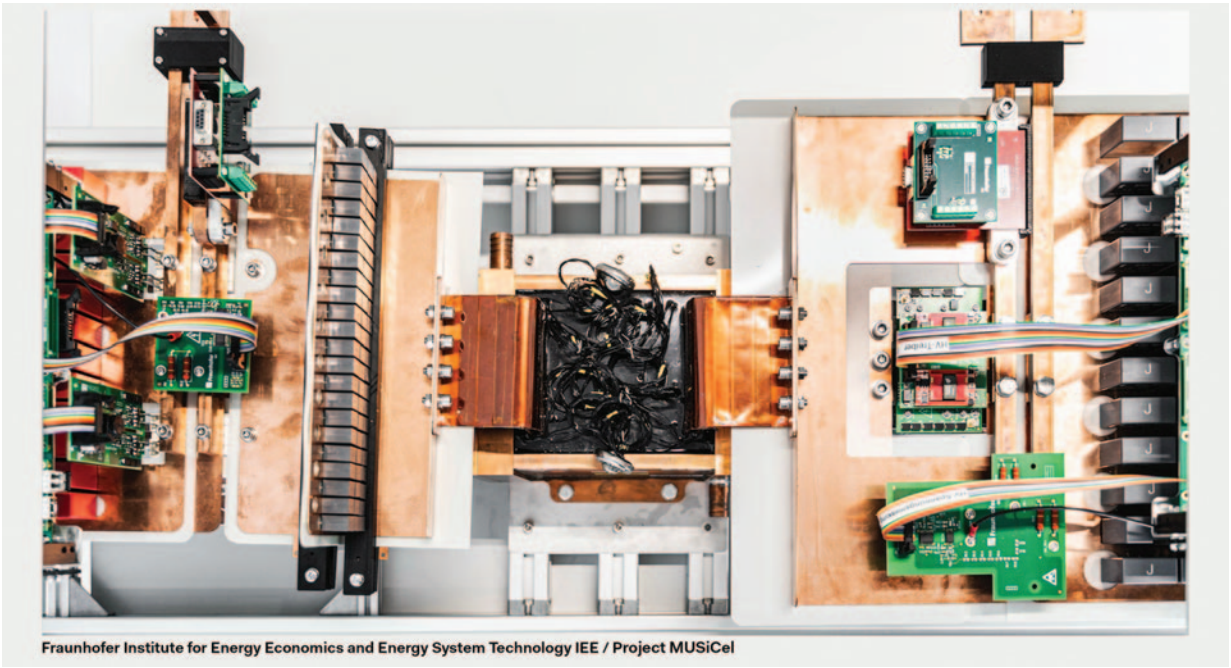
applications, the parallel, ongoing process to electrify other transportation and machinery applications is contributing to accelerate market adoption and confidence in WBG and especially SiC. A lot of research has been conducted by the automotive industry to validate WBG technology and the adoption of SiC and GaN in power-trains and battery chargers thus setting a ground base for other segments to adopt the technology.

In high power switching conversion many projects utilize SiC MOSFETs instead of IGBTs and it's worth mentioning the Fraunhofer Institute for Energy Economics and Energy System Technology's MUSiCel research project which by using innovative SiC wide-band-gap semiconductors managed to deliver 250 kW at a switching frequency of 50 kHz with an efficiency across the entire power range exceeding 98 % (at 100 kW, an efficiency of even 98.8% was measured!) (Figure 05). Originally the MUSiCel research project was aimed at the electrification of agricultural and construction machinery, although it can equally apply to railway high power conversion systems and there's no doubt that such research will contribute to the adoption of SiC in future designs.

The research of feasibility, reliability and benefits compared to previous technologies is very important, but for railway manufacturers it is crucial that long term supply chain sustainability is guaranteed for the lifetime of the final equipment. As it was for MOSFET technology, WBG semiconductors manufacturers have invested in volume manufacturing facilities or partnerships, but we also see a number of acquisitions e.g., Infineon acquiring GaN Systems, and Renesas acquiring Transphorm. The WBG supply chain for SiC and GaN is now entering a mature phase, thus securing a much-needed long term components availability situation.

In conclusion:

To the question: Ecodesign, Reuse, Repair, Prolonging Lifetime and New Technology – Is it the new paradox? The answer is not "Yes" or "No" but as for the railway industry we have given as an example, industry as a whole will have to consider all those aspects when designing new products. The EU Ecodesign is setting a new way of working, and from higher energy efficiency to prolonging the lifetime of final equipments, power electronics will play an important role. One thing is for certain, it is a wonderful opportunity for power designers to explore new frontiers.



Fraunhofer Institute for Energy Economics and Energy System Technology IEE / Project MUSiCel

Figure 05 – SiC 250 kW DC-DC converter developed as part of the Fraunhofer IEE project MUSiCel. (Source: PRBX/Fraunhofer IEE)