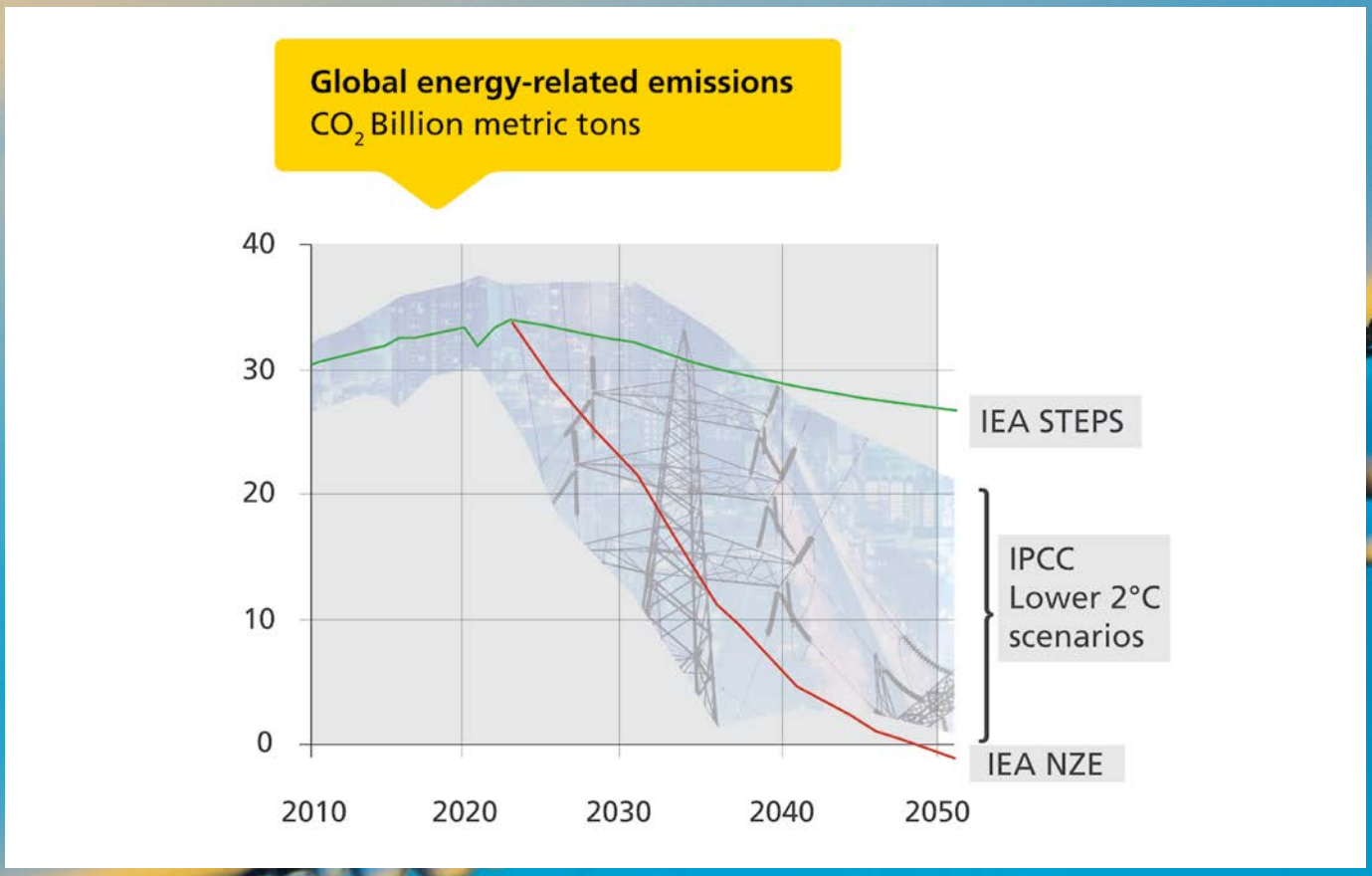
We need to act sooner rather than later because everything we have already committed to doing will not be enough to reach net zero in 2050

Return on the sustainability of the new transformer liquids – beyond price!

The gap between what is really achieved and all the net zero scenarios already available will depend on the speed of our actions. As seen in the image below, there is a huge scattering between the International Energy Agency STEPS scenario (IEA STEPS) - reflecting the assessment of current policies in place or announced by governments around the world - and the 311 scenarios from the United Nations Intergovernmental Panel on Climate Change (IPCC). This means the only certainty we can have is that we need to act sooner rather than later because everything we have already committed to doing will not be enough to reach net zero in 2050 (IEA NZE).

Independently of which of the above scenarios reveals itself as the most realistic, we also know that the electrical infrastructure is already playing and will keep playing a leading role in this decarbonization route. No matter the route, the world is going electrically either directly (in the case of electrical mobility) or indirectly (in the case of



Source: Nynas AB

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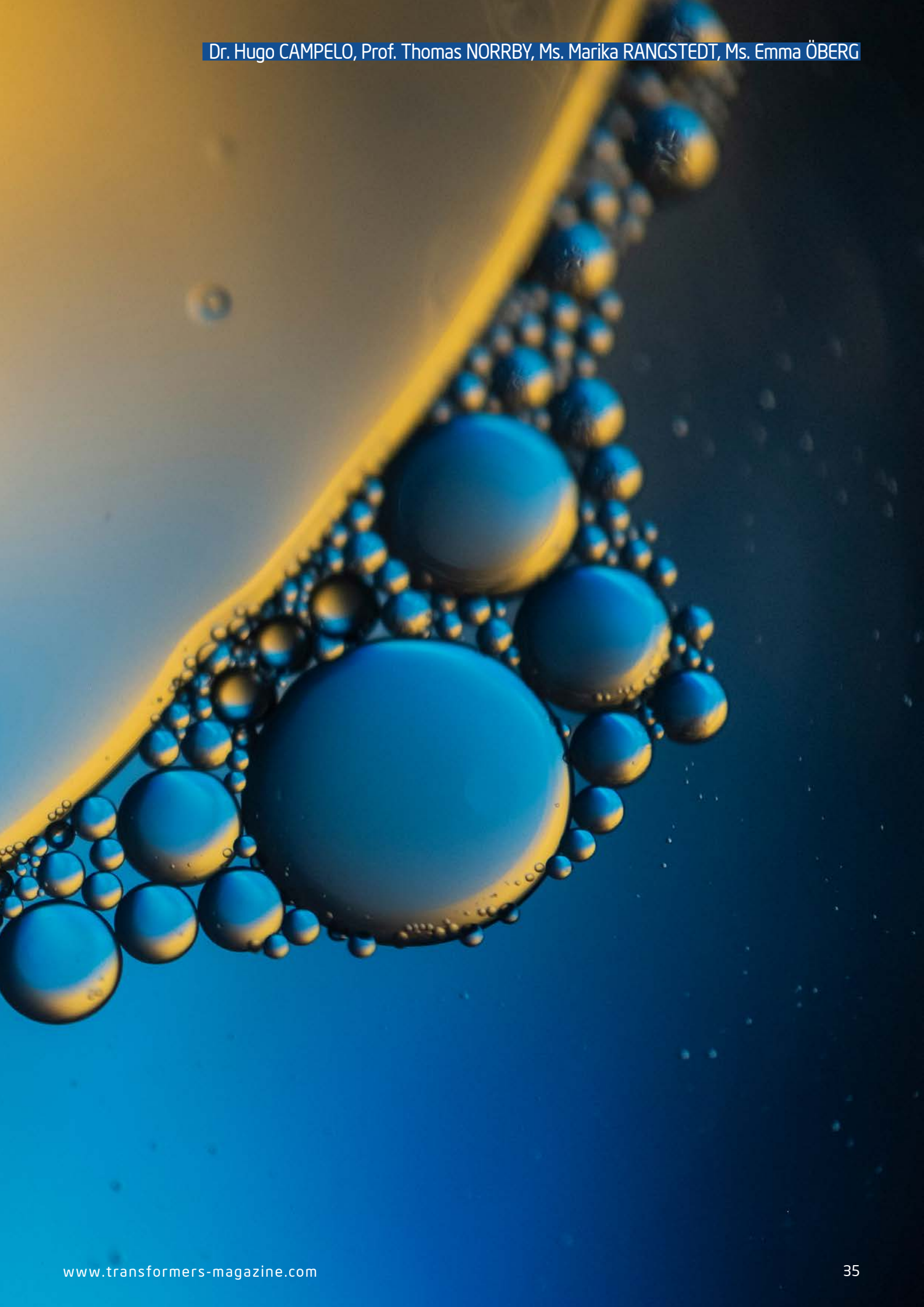

By providing an Environmental Cost Indicator for their project, the contractors can receive a fictional discount on their offer, and as a result, the offer with the lowest environmental costs receives the highest discount

hydrogen and other renewable fuels/molecules). This means that electrical infrastructure is growing and diversifying every day, and electrical transformers play a huge role in this development.

Electrical transformers are no longer just centennial highly efficient static electrical machines, the existence of which most people do not even notice. Electrical transformers are a recurring topic in the latest news reports. News about the ongoing transformer shortage, ultra-long delivery lead-times, and announcements of new investments in new or upgraded transformer factories around the world are becoming common. This reflects a steadily growing surge in the demand for new electrical infrastructure on top of the 'normal' needs pulled by the Paris Agreement and by the massive societal challenge we are already facing. It is important to note that global warming is accelerating more than forecast, and the highest temperatures ever registered on Earth were consecutively registered last year, every month. This is already increasing costs, such as additional costs to deal with extreme weather events, energy costs, and societal costs or shadow costs to which every person or collective contributes more or less intensively. In principle, a product or project such as an electrical transformer, which is the focus of our article, may be produced in such a way and using varied materials that can result in different shadow costs. A transformer with a higher carbon footprint or higher toxicity to human life has higher shadow costs, meaning those should also be considered by the ultimate owner when buying, operating, or refurbishing an electrical transformer. Including this criterion in the investment decisions is a level playing field to achieve the critical societal goals we face, and the traditional return on investment indicators used to make investment decisions need to adapt. The solution, even though discussable, is already out there and is called the Environmental Cost Indicator (ECI). The Dutch government introduced the ECI in 2004, meaning

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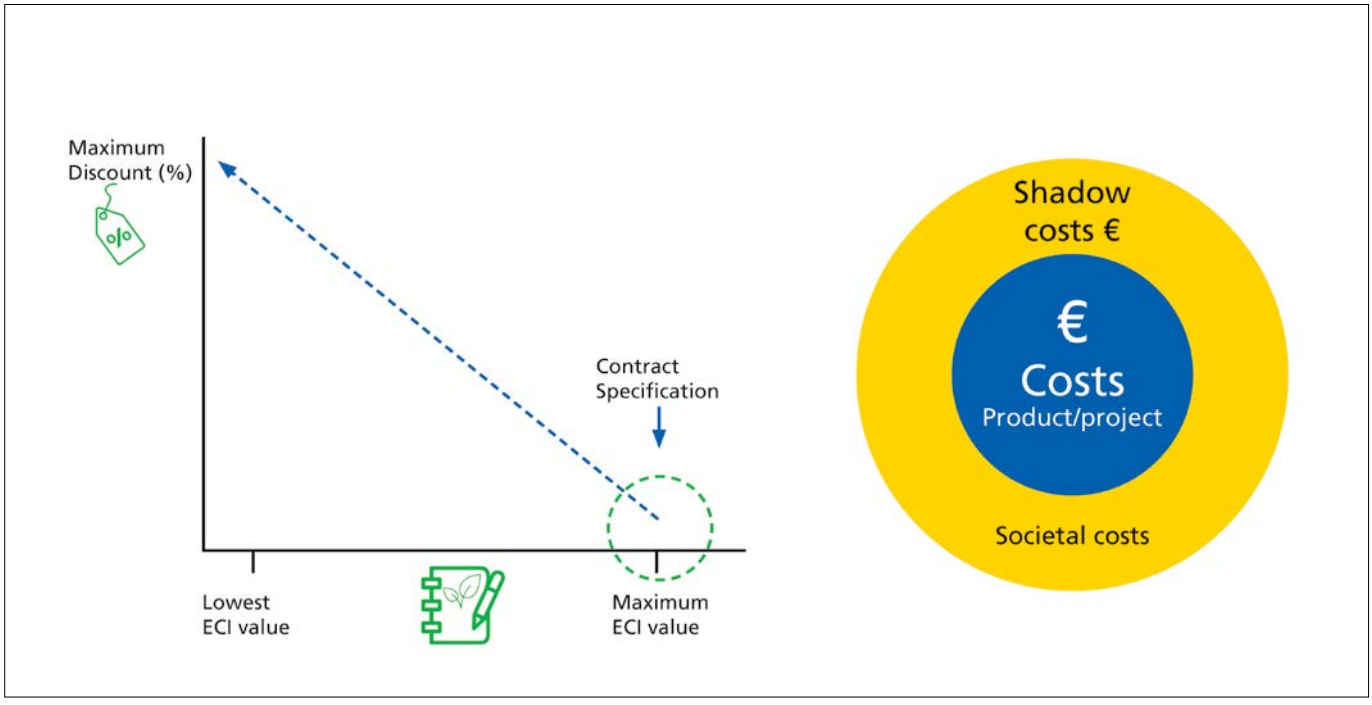

Figure 1. ECI.
Source: Luc Hillege, "Environmental Cost Indicator - Ecochain - LCA (Life Cycle Assessment) software company" (https://ecochain.com/blog/environmental-cost-indicator-eci/)".

Transformer liquids can be a relevant part of this new environmental equation because, besides the vital role of enabling transformer operation, they can also help to reduce the environmental footprint of a transformer

it has been around for over 20 years. It is not a label or certification scheme but a calculation method aimed to stimulate green public procurement by using a 'language' everybody knows and is used to communicating in euros.

"By providing an Environmental Cost Indicator for their project, the contractors can receive a fictional discount on their offer. As a result, the offer with the lowest environmental costs receives the highest discount. This means that, even if the actual price of the offer is higher, a better environmental performance increases the chance to win the tender." In other words, the transformer with the highest price (and, thus, likely with the best materials) can be ranked first and win the tender.

In the Netherlands, circularity and green public procurement are becoming increasingly important and increasingly more common. Large-scale contracts for new transformers have already been awarded last year, including an ECI.

As a single-score indicator, ECI simplifies and unites different environmental data into one monetary number. That environmental data can be weighted based on the shadow price method, which can be the highest cost level acceptable for governments per unit of emission control (prevention costs). As a result, we are left with one single indicator that can be used to compare different transformers and even various products across different industries.

Transformer liquids can be a relevant part of this new environmental equation because, besides the vital role of enabling transformer operation, they can also help to reduce the environmental footprint of a transformer in many diverse ways – either through lighter designs, reduced temperatures or losses or by enabling full recyclability by collecting and re-refining them instead of burning at the end of their lives.

Nynas rolled over to the market over the last years an inclusive and comprehensive portfolio of transformer liquids with enhanced sustainability credentials to fit a distinct set of purposes

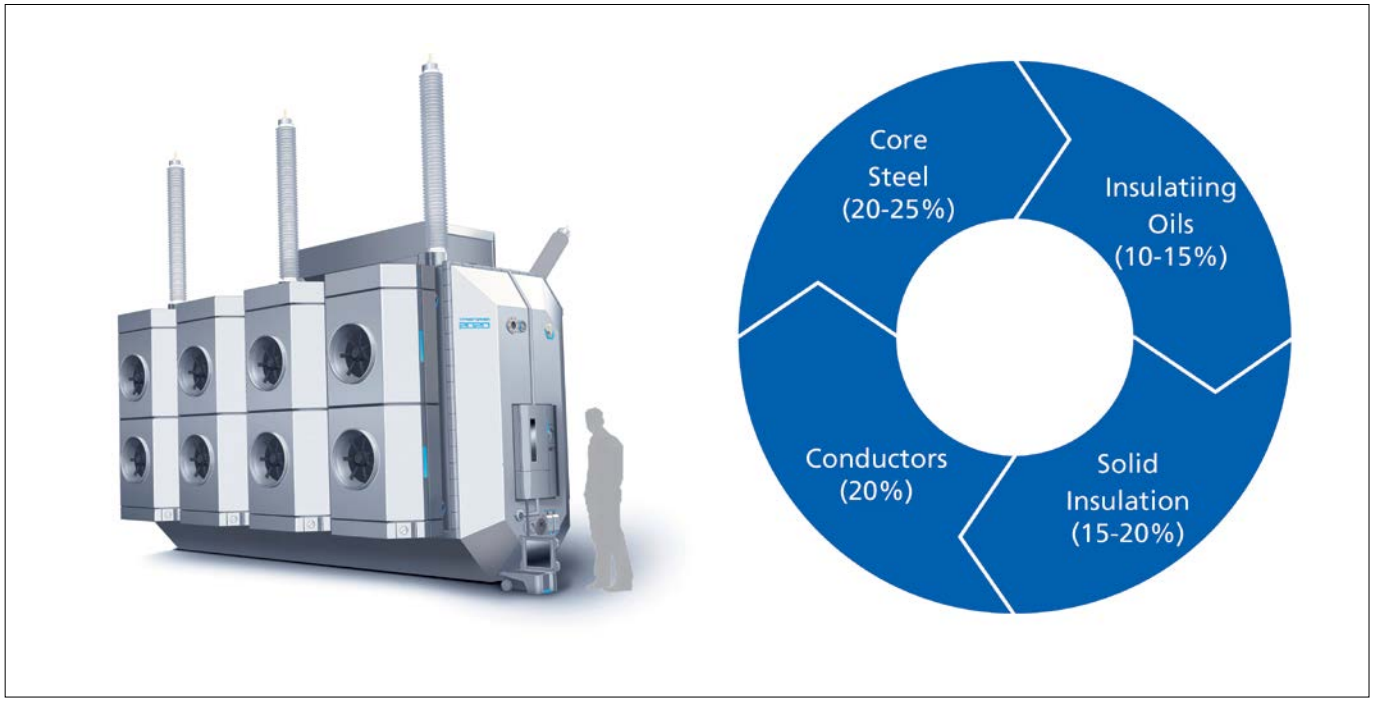

Figure 2. The relative weight of the four main materials used in electrical transformers
Source: Nynas AB

The choice, as always, depends on multiple aspects, but in the end, the most important thing is that the classic return on investment indicators start to be adapted to include use-phase, end-of-life, and the above-referred shadow costs

Transformer liquids are typically the 4th most utilized material in a power transformer, weighing tens of tons, which makes up 10 to 15% of the total weight of such equipment. The relative weight of the four main materials used in electrical transformers can be found in Figure 2. Reducing their environmental footprint – insulating oils or liquids included - can have a significant impact on the overall environmental performance of the equipment.

Historically, we used to state that an insulation system of a transformer consisted of many materials working together to do the right job and to maximize the performance of the equipment. Now, leveraged on the background herein exposed, we are also urged to minimize the environmental footprint of the equipment. If the historical functions were critical, now this is a job for the best materials and the best engineers.

With this focus, Nynas rolled over to the market over the last years an inclusive and comprehensive portfolio of transformer liquids with enhanced sustainability credentials to fit a distinct set of purposes – refer to the image below. Even the traditional NYTRO® mineral oils have been incorporating progressive reductions namely in their carbon footprint, due to enhanced production processes.

Nynas' current portfolio - represented in the above plot by the blue and yellow ellipses – includes mostly IEC 60296 compliant liquids (such as RR 900X and BIO 300X), which are hydrocarbon-based. A natural ester named NYTRO® 100 NE has been included specifically to target low-voltage, low-power, and hermetically sealed applications. Every product comprises a balance of properties, which is why they must be understood holistically. In this representation, we propose an aggregation of those properties/characteristics in two axes: the y-axis bundles together the ageing behaviour of each liquid translated by their oxidation stability, while the x-axis bundles together other sustainability criteria that go beyond the carbon footprint or the biodegradability. For instance, compatibility with older designs and materials is also a relevant criterion.

The point here is not to dive deeper into the characteristics of each fluid but to emphasize that there is no single transformer liquid to address our societal goals. The choice, as always, depends on multiple aspects, but in the end, the most important thing is that the classic return on investment indicators start to be adapted to include use-phase, end-of-life, and the above-referred shadow costs.

We believe many opportunities remain to work systematically and with a long-term perspective in transformers' and grid systems' design and deployment by including more active transformer liquid selection. The best news is that solutions already exist, meaning that they are not under research; they are market-ready, and the watch is ticking louder and faster than ever.

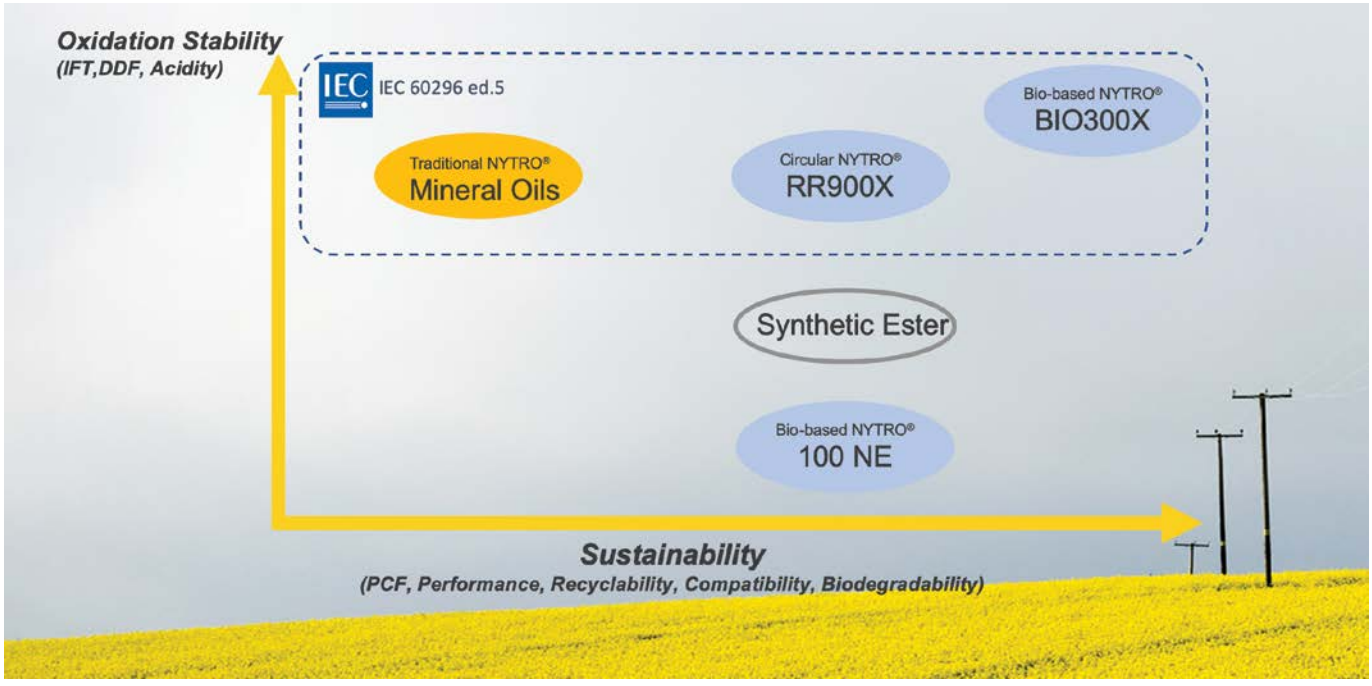

Figure 3. Nynas' current portfolio
Source: Nynas AB