I always strive to write about emerging issues in the global electricity sector, sustainability, and lesser discussed topics, all while keeping the reader at the forefront

An interview with Bhaba Das, the best author of 2023

Why did you find the topics you wrote about interesting and important, and how did you decide to write about them?

I always strive to write about emerging issues in the global electricity sector, sustainability, and lesser discussed topics, all while keeping the reader at the forefront. The requirement for a reliable electricity supply is a major contributor of greenhouse gas (GHG) emissions. While the focus has been on the electricity generation process, the electrical infrastructure that contributes to significant direct and indirect carbon emissions is less discussed or evaluated. There is still a lack of measures to assess the level of carbon emissions from the electrical infrastructure. Previous quantification work in the electricity industry has predominantly focused on electricity generation technologies, comparing the energy generated by and carbon emitted over the operational lifetime relative to the energy and carbon required to procure the fuel, build, operate, and decommission the power plants. It's high time that we focus on the carbon intensity of the power grid infrastructure as well, starting with the highest contributor, the transformer.

My role in Hitachi Energy allows me to study transformer specifications from the Asia Pacific, Middle East, and Africa regions. What I realized is that considerations on the impact of transformer technical specifications in the protection of the environment from greenhouse gas emissions have not been included yet in the majority of the cases. To counter increasing carbon emissions, clean and efficient energy technologies will need to be deployed at an unprecedented scale, with electrification becoming the backbone of the entire energy system. Transformers will contribute to this journey as they are the "spinal cords" of our electrified energy system. Hence, the selection of transformers with consideration for environmental impact is crucial, more than ever before. Transformers create environmental impacts, e.g., carbon emissions from electrical losses and mining and processing materials used in their manufacturing, as well as how transformer components are disposed of at the end of their lifecycle. Thus, it becomes crucial that these environmental considerations are included in the specification and procurement process.

Another important nexus that is currently getting little attention is the energy-metal nexus. One of the greatest factors expected to make the energy-metal nexus more important is the expansion of low-carbon energy technologies. This is because these emerging technologies – which have a significant potential to mitigate global warming – require specific metal resources in significant quantities and make resource depletion a real concern. The global demand for copper, aluminium, steel, etc., is going to increase significantly. Transformers require significant amounts of these crucial metals. Therefore, it is paramount to investigate if options are available to reduce the usage of materials in transformers while achieving the same reliability and performance from both the operational and environmental viewpoints. Again, in almost all the specification documents that I reviewed, this factor was not even considered!

Transformers Magazine provides an excellent platform for industry professionals to write about concepts in an easy-to-understand language, receive honest feedback and directly connect with readers, and I decided to utilize this platform to share my observations, findings, and ideas with the worldwide transformer community on the topic of sustainability in transformers.

Knowledge sharing and co-creation should form a part of our electrical DNA going forward

What are the biggest challenges and advantages relevant to the topics you described?

I will give you an example of an interesting challenge that I encountered during my interactions with end users.

Typically, life cycle assessments (LCA) are used to investigate the environmental impacts related to a product or a product system. This includes evaluating energy and resource consumption as well as emissions from all life cycle stages, including material production, manufacturing, use and maintenance and End-of-Life. An LCA can be used in many ways, depending on how the goal and scope are defined. Usually, the following processes are included in the system boundaries for LCA study:

- Raw material extraction and production for transformer manufacturing,
- Electricity and heat production for transformer manufacturing,
- Transportation of components to the transformer factory,
- Transportation of transformer to customer,
- Electricity production covering for power losses of operation at end user site,
- End of life management.

As can be noticed, the LCA outcome depends on many variables. It is sometimes difficult to evaluate the specific environmental impact of the change in transformer specification, for example, using alternate fluids in transformers.

Nowadays, ester fluids are gaining significant traction as an alternative to traditional mineral oil as insulation fluid in transformers. They have certain excellent characteristics which make alternate fluids promising. There are several publications claiming the sustainability benefit of using such alternate fluids. However, to the best of my knowledge, there is no publication which has investigated the carbon emissions of identical power transformers with alternate fluids under identical efficiency, impedance, and temperature rise requirements. This ensures that a fair comparison can be carried out to investigate the material carbon footprint for all the different designs, which is impacted by the change in fluid specification. It is well established that some design changes are needed to accommodate ester fluids in power transformers. Through research and development, there are now several major manufacturers who have in-depth design knowledge and can supply ester fluid power transformers to end users. However, an assessment of the environmental impact of such design change requirements is never requested as it is a common industry belief that changing to ester fluid makes the transformer more “sustainable.”

Fortunately, there are end users who believe in turning challenges into advantages. I was involved in a project for a utility where we evaluated how using alternate fluid insulation in power transformers impacts the material carbon footprint of the transformer. This helped us to understand in detail the environmental impact of fluid change in the specification. Knowledge shar-

Some current developments include increasing the share of recycled material or the use of recycled fluid in transformers

ing and co-creation should very much form a part of our electrical DNA going forward. Co-creation is a form of collaborative innovation defined as the process in which input from users and other stakeholders (e.g., customers, suppliers, industry experts, and local communities) plays a central role in the development of the product, service, or solution, with the aim of creating maximum value for all. As transformers are used in different applications and site conditions, this is where co-creation plays a central role, as one size does not fit all, and we need to work together to find the optimum solution.

In my article in the Special Edition: Sustainability in 2023, I highlighted the use of high-temperature insulation (the combination of ester fluids and high-temperature paper insulation), which proves to be an essential approach in designing environmentally and economically optimized transformers, thereby turning challenges into advantages. And I am equally happy to share that this concept has been accepted in the technical specification for one of the largest electrical infrastructure projects in the world!

What are some current developments in the industry in connection with the topic of sustainability in transformers?

There are several upcoming global developments being asked for by end users, such as:

- Increasing the share of recycled material or use of recycled fluid in transformers,
- Estimation of the recycled content in used materials as well as of the recyclability rate of the unit at its end-of-life, including underlined assumptions and data sources,
- Consideration in the use of higher temperature materials (solid and fluid insulation in accordance with IEC 60076-14, IEEE C57.154, IEEE 1276, etc..) to reduce total material use for the specified rated capacity while meeting minimum energy efficiency requirements
- Comprehensive end-of-life decommissioning guidelines supporting an environmentally friendly and safe dismantling procedure to maximize material recovery and recycling,
- Submission of preliminary LCA report (cradle-to-gate or cradle-to-grave) as self-declarations based on the preliminary design parameters as available at the tender stage,
- Quantified assessments based on the following: ISO 14040/044 LCA Standards, ISO 14025 EPD standard,
- Usage of fossil fuel free electricity supported by renewable electricity or renewable electricity procurement certificates,
- Environmental, Health and Safety programs/policies at the factory level, including waste, water and energy management programs and reduction targets,
- Company sustainability program rating, supply chain sustainability due diligence and policies and publicly declared short to mid-term climate strategies/targets are some other examples of industry trends on the topic of sustainability in transformers.

Apart from the above, a new CIGRE joint working group JWG1 A2/C3.70 has been established to:

1. Create an integrated approach to guidelines, procedures, and standards from product to system level,
2. Establish a basis for the evaluation of transformers for manufacturers, customers, and regulatory bodies,
3. Investigate the influence of different technologies, manufacturing techniques, and operational procedures on the transformers' life cycle,
4. Develop best practices and/or a framework for CO_2 reduction. As the electricity industry moves toward more sustainable practices, these initiatives will play a crucial role in contributing to lower carbon emissions, which is an existential threat to humanity.

Finally, I would like to thank Transformers Magazine for the 2023 Best author award and for providing this fantastic global platform to share ideas on the topic of sustainability. I look forward to continuing this association in the days ahead!

Dr. Bhaba P. Das is the Technical Manager, Transformer Services for Transformers Business Line, HUB (Asia-Pacific, Middle East and Africa), at Hitachi Energy, based in Singapore. He has been awarded the Hitachi Energy Global Transformers Excellence Award for Customer Cooperation for 2020 and 2021 in Sales & Marketing. Prior to Hitachi Energy, he worked as an R&D engineer for a major transformer manufacturer in New Zealand. He was awarded the Young Engineer of the Year 2017 by the Electricity Engineers Association of New Zealand for his work on the design and development of smart distribution transformers, fibre-optics-based sensors for transformers, and diagnostic software for fleet condition monitoring. He is a Senior Member of IEEE and a Young Professional of IEC. He completed his PhD in Electrical Engineering at the University of Canterbury, New Zealand.