LUND UNIVERSITY

Policy Brief
AUGUST 2024

Circular Economy Integration in Smart Grids

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INTRODUCTION

We need to modernise our ageing electricity grid to enhance the efficiency and reliability of our electricity supply. The grid must also be able to operate with an increasing use of renewable energy sources. At the same time, we need to reduce our carbon footprint, and we face growing environmental and resource challenges.

The objective of our research was to analyse how Circular Economy (CE) principles could be integrated into smart grid developments. This was researched through a literature review and interviews with key stakeholders and intermediaries. Integrating CE into smart grid developments offers opportunities to create an energy system that is not only more sustainable but also more resilient. Hence, if policymakers and industry stakeholders collaborate, we can create a smart and circular energy future.

Key findings

▶ SMART GRID CONCEPT AND DEFINITIONS

A clear and consistent definition of smart grids is still missing. Overall, it refers to electricity networks that can contribute to a more efficient, reliable and flexible electricity distribution. Smart grid developments can be cost-effective compared to traditional grid expansion and enable consumers to manage and reduce their energy use and minimise costs (being active users). Technologies can, for instance, be used for advanced metering infrastructure, different energy storage systems, microgrids, distribution and demand response systems, increased use of renewable energy, EV charging infrastructure or two-way digital communication.

All these technologies require the use of different grid components to enable the "smartness" of the grid, for example, sensors, meters and wiring, transformers and batteries. Moreover, natural resources are required to manufacture these grid components.

▶ THE SMART GRID AND ITS POTENTIAL FOR RESOURCE EFFICIENCY

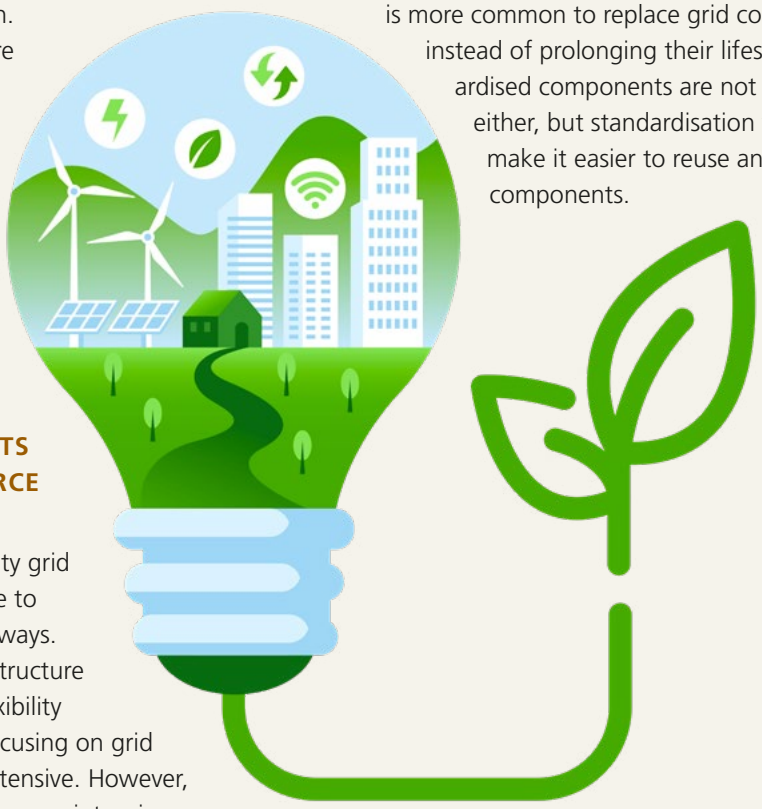
Developing the current electricity grid into a smart grid can contribute to resource efficiency in different ways. For instance, the existing infrastructure can be optimised and more flexibility introduced instead of simply focusing on grid expansion, which is resource intensive. However, smart grid solutions are also resource-intensive; thus, it is important to integrate CE principles into smart grid developments.

▶ CE INTEGRATION INTO SMART GRIDS

CE principles are currently not directly integrated into developments of smart grids. The focus is usually on energy efficiency, and there are limited, or no, considerations of material impacts or natural resource use related to new grid solutions. The integration of CE principles into smart grid systems is a discussion in its infancy, but there is a growing interest in the industry and among policymakers for these issues.

▶ BARRIERS TO INTEGRATING CE PRINCIPALS INTO SMART GRID DEVELOPMENTS

Key barriers to integrating CE principles and measures - such as reducing resource use or increasing recycling efforts – stem from the fact that current regulatory frameworks usually prioritise capital-intensive investments. There are therefore limited financial incentives to consider circular business models such as leasing or renting grid components or increasing maintenance of existing components. The discussion on how to support resource efficiency in the sector is in its infancy, and this can also be translated into grid maintenance practices as it is more common to replace grid components instead of prolonging their lifespan. Standardised components are not common either, but standardisation would make it easier to reuse and repurpose components.



▶ STAKEHOLDER PERSPECTIVES ON CE AND THE SMART GRID

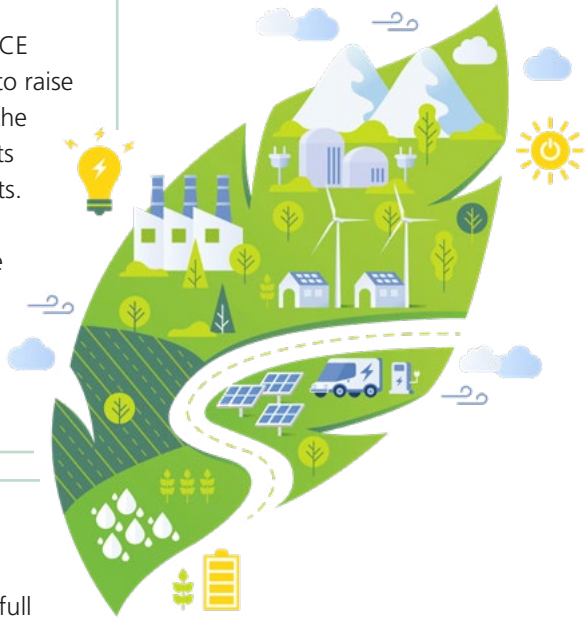
Some of the interviewees stated that CE is increasingly discussed in connection to smart grid developments, but is not yet a priority issue, whereas for most interviewees it was not commonly discussed (yet). Overall, the different interviewed stakeholders and intermediaries are at different stages regarding the integration of CE principles into smart grid developments; however, all interviewees highlighted that it would be increasingly important in the future to consider – and address – natural resource use related to smart grid solutions.

Policy recommendations

▶ INCREASED EDUCATION AND RESEARCH

There is interest, but still a lack of general awareness, about the CE and the smart grid or energy sector. It would thus be important to raise awareness among different stakeholders by educating them on the benefits of integrating CE principles into smart grid developments and the resource use required when using smart grid components.

We further recommend increasing the support for different research and development projects, and pilot projects, to explore innovative CE solutions for smart grid developments and the energy sector. This can help shed light on the potential impact of different technologies and solutions to encourage resource efficiency and sustainability.



▶ LIFECYCLE CONSIDERATIONS FOR SMART GRID SOLUTIONS

It is important to encourage stakeholders to consider the full lifecycle of smart grid technologies and grid components to be able to optimise resource use and minimise environmental impacts. This includes raw material extraction, usage, and disposal phases.

▶ REGULATORY SUPPORT

We recommend that regulatory frameworks should be revised to support total expenditure (TOTEX) models, which balance capital and operational expenditures. This promotes investments in durable and maintainable technologies and grid components. Actors who procure grid solutions should pay more attention to not only upfront costs, but also costs of maintenance, and the economic benefits of longer-lives grid solutions.

▶ PROMOTE CIRCULAR BUSINESS MODELS

It is vital to start considering and adopting circular business models. These could be, for instance, leasing, renting, and reusing different grid solutions. This can contribute to extending the lifespan of needed technologies or grid components for smart grids and thus reduce waste.

▶ IMPROVED RECYCLING AND REUSE

It is also possible to improve the environmental footprint of smart grids by improving recycling practices for grid solutions by, for instance, using recycled materials in the manufacture of smart meters or reusing old batteries for energy storage.

Are you interested in finding out more?

The research article this brief is based on:
https://link.springer.com/article/10.1007/s43615-024-00375-5

The overall project:
https://portal.research.lu.se/en/projects/electricity-transition-through-intermediaries-consultants-in-the-

A blog post based on the article:
https://iiieeenergyblog.wordpress.com/2024/05/28/circular-economy-in-smart-grid-developments-a-pathway-to-sustainable-energy-systems/

A related blog post based on smart grids:
https://iiieeenergyblog.wordpress.com/2024/01/31/the-story-of-electricity-and-the-grid-on-its-way-to-becoming-a-sustainable-and-smart-grid/

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ACKNOWLEDGEMENTS:
This brief is based on the study "Circular Economy Integration in Smart Grids: A Nexus for Sustainability" written and conducted by Katharina Reindl, Carl Dalhammar, and Emma Brodén. This research was supported by the Swedish Energy Agency, 50538-1 and the Mistra REES (Resource Efficient and Effective Solutions) programme and funded by Mistra (The Swedish Foundation for Strategic Environmental Research).

Open-access funding is provided by Lund University.