Systemic and Operational Perspectives on Circular Economy: Implications for Carbon Accounting and Decarbonization Pathways

Context

This contribution draws on a technology roadmapping exercise on circular economy and sustainable industrial systems, based on the combined analysis of scientific publications and patent activity from 2021 to 2025. The objective of this submission is to share implementation-relevant insights that may support the COP30 Presidency Roadmap for *Transitioning Away from Fossil Fuels in a Just, Orderly and Equitable Manner*, particularly with regard to the operationalization and measurement of emission-reduction outcomes.

By strengthening the link between circular economy strategies and measurable emission-reduction outcomes, these insights directly support implementation pathways for transitioning away from fossil fuels in industrial and energy-intensive systems.

Institutional Context – SENAI Innovation Institute for Green Chemistry

The SENAI Innovation Institute for Green Chemistry (ISI Química Verde) is part of the SENAI innovation ecosystem in Brazil, which focuses on applied research, technological development and innovation to support the sustainable transformation of industrial systems. ISI Química Verde works primarily at the interface between industry, science and policy, with an emphasis on decarbonization, circular economy, bioeconomy and resource efficiency. Its activities are oriented toward translating scientific knowledge into scalable technological solutions, supporting industrial implementation through pilot projects, technology validation, life-cycle assessment and performance measurement. This positioning enables the Institute to contribute evidence-based, implementation-focused insights to discussions on the transition away from fossil fuels in energy-intensive and industrial contexts.

Key Insight: Two Complementary Perspectives on Circular Economy

The analysis reveals that the circular economy is articulated through two distinct and complementary analytical perspectives, depending on the nature of the underlying knowledge base.

Scientific publications tend to adopt a macro-level, systemic and multiscalar perspective. They emphasize governance arrangements, policy integration, cross-sectoral coordination and long-term transition pathways. In this body of literature, circular economy is primarily framed as a transformation of economic and production systems, closely connected to sustainable development goals, institutional capacity and strategic planning.

By contrast, patent activity reflects a more local, operational and solution-oriented perspective. Patented innovations are typically associated with specific processes, materials, equipment or technological routes, focusing on technical feasibility, operational performance and applicability within concrete production contexts. In this perspective, circular economy is expressed through discrete interventions that can be deployed within existing industrial or infrastructural systems.

These two perspectives do not represent divergent interpretations of circular economy, but rather operate at different levels of implementation and address distinct needs of the transition process.

Implications for Carbon Measurement and Decarbonization

From a climate mitigation standpoint, this distinction has important implications.

The systemic orientation observed in scientific publications plays a critical role in defining long-term decarbonization trajectories, informing policy coherence and supporting integrated strategies across sectors and value chains. However, these approaches often operate at a level of abstraction that makes the direct attribution and measurement of emission reductions more complex.

In contrast, solutions emerging from patent activity are generally closely linked to industrial processes, treatment systems, material substitution routes, fuel substitution options or efficiency-enhancing technologies. As a result, they tend to be more readily integrated into greenhouse-gas inventories, life-cycle assessments (LCA) and monitoring, reporting and verification (MRV) frameworks, enabling more direct quantification of emission-reduction outcomes.

This suggests that while scientific research provides the system architecture for a circular transition, patented solutions contribute to the measurable building blocks of decarbonization at the operational level.

Considerations for the COP30 Presidency Roadmap

Based on this evidence, the following considerations may enhance the implementation focus of the COP30 Presidency Roadmap:

1. **Recognize the complementarity between systemic and operational approaches**
   Effective decarbonization through circular economy depends on aligning long-term systemic strategies with deployable, measurable solutions on the ground.

2. **Link circular economy strategies to carbon accounting frameworks**
   Greater emphasis on connecting circular interventions with LCA, GHG inventories and MRV systems can strengthen their credibility as mitigation measures.

3. **Support the translation of systemic insights into operational solutions**
   Bridging the gap between macro-level transition planning and process-level implementation is critical to achieve verifiable emission reductions before 2030.

Concluding Remark

Circular economy contributes most effectively to climate mitigation when systemic transition agendas and operationally measurable solutions are jointly mobilized. Recognizing and articulating the distinct roles of scientific research and patented innovation can help connect strategic ambition with verifiable carbon-reduction outcomes, supporting the implementation objectives of the Paris Agreement and the global effort to transition away from fossil fuels.