EXPERT WORKSHOP 26 JUNE 2024
CLOSING THE CIRCLE
Supply chains and circularity approaches for delivering a decarbonised energy system
EEB Office, Brussels
Renewables Grid Initiative
PAC Paris Agreement Compatible Scenarios for Energy Infrastructure
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EEB European Environmental Bureau

Expert Workshop – Summary report

Closing the Circle – Supply chains and circularity approaches for delivering a decarbonised energy system

DISCLAIMER

All statements in this document have been summarised by the Renewables Grid Initiative, based on the common understanding of the discussions carried out during the workshop[1]. The opinions expressed in this document are independent to the PAC project consortium and shall not be used to reflect the view of specific participants.

Context and relevance

As part of the Paris Agreement Compatible (PAC) Scenarios Project, RGI continues its Expert Exchange Workshop Series, leveraging the current debate on the EU's Strategic Agenda 2024-2029. Within the EU's strategy for the next term, energy security, resilience, and competitiveness emerge as pivotal priorities. In this sense, securing the EU's renewable energy and electricity grid supply chains and implementing circular approaches throughout the energy sector offer opportunities for tackling these challenges.

The EU policy discussions also intersect with global ambitions, including the COP28 resolution of tripling renewables by 2030. Moving from a fossil fuel-based towards a decarbonised energy system implies increasing resource use, especially critical and strategic raw materials. In this sense, the energy transition is a material-intensive transition, which impacts supply chains linked to the deployment across all parts of the energy system.

In particular, safeguarding the availability of strategic and critical raw materials will be essential to support the build-up of the needed infrastructure to reach worldwide climate and energy goals. However, the increased demand for such materials in an international context poses a challenge to European competitiveness and industry expansion in the context of a just energy transition. The EU Green Deal thematic files, specifically the Critical Raw Materials Act, and the Net Zero Industry Act, seek to tackle such challenges while guaranteeing socio-economic benefits for European citizens and industry.

To address the challenges of establishing secure supply chains, while also tackling environmental and social aspects, different elements should be considered. On the

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[1] All materials presented at the workshop have been circulated among the participants and are available at the dedicated page on RGI website.

one hand, it is necessary to understand the readiness and criticalities of EU supply chains as a whole – from sustainably delivering the materials and resources for the chain, to securing component manufacturing and assembly capacities required for the substantial infrastructure expansion. On the other side, improving both the planning and operation of the renewable energy and electricity grid infrastructure will allow for a resource-efficient system.

Specifically, there is a need to embed both constraints of supply chains and aspects of circularity into energy system modelling and planning exercises. A more detailed modelling would allow for more feasible pathways towards a decarbonised system. At the same time, it would also allow for energy system planning processes to consider the uncertainties and sensitivities related to resource scarcities and optimisation. Within this context, the PAC Scenario, aiming at 100% renewable energy-based energy system by 2040, provides insights into how managing energy demand and promoting societal behaviour changes could support a more efficient and sustainable energy system.

Finally, industrial stakeholders and grid operators can further support a more circular and resource-efficient system by adopting strategies that reduce material footprint and simultaneously consider the environmental and social responsibility of their entire supply chains.

Addressing all these different elements, on **26 June 2024 from 09:30 to 16:30 CET**, RGI organised the Expert Exchange Workshop "Closing the circle – Supply chains and circularity approaches for delivering a decarbonised energy system" under the umbrella of the PAC Project. Throughout the different sessions, experts representing Transmission System Operators, NGOs, as well as policymaking, research and innovation centres shared their knowledge, experience and insights on the topic. This document summarises the main points discussed during the workshop.

Summary of discussions

Key takeaway 1: Supplying the material demand for achieving the EU decarbonisation targets can lead to considerable environmental and social impacts. Analysis for policymaking should account for these effects and seek to avoid them.

Limitation of resources, especially critical and strategic raw materials, can create social and environmental inequalities between different world regions. From a socio-economic perspective, material scarcity can exacerbate existing inequalities between world regions, specifically related to material distribution between the Global North and South. In this sense, material scarcity can drive Global North countries to further explore critical material from the Global South countries. In return, this can expand environmental and social impacts to the latter group, threatening their and perpetuating neo-colonialist practices. In this process, Global North countries will not face the environmental consequences of extracting such materials, but reap the economic benefits of the processing, manufacturing and assembling stages.

Similarly, resource constraints can lead to an uneven energy transition where some countries have access to material resources and can further build their infrastructure, while others do not. At the same time, limited resources can restrain economic growth worldwide. Currently, disparities between different countries' income groups are staggering. Material footprint in high-income countries is six times higher than in low-income countries. According to the Global Resources Outlook 2024, environmental impacts are rising exponentially, surpassing international agreements' thresholds.

Across most country groups, resource use is increasing dramatically, while extraction productivity stagnates. At the same time, extracting and processing materials are leading to considerable environmental impacts, including water pollution and biodiversity loss. At this pace, material supply will not be able to meet the expected demand needed to ensure climate targets are reached.

Different country groups also experience disparities in terms of climate impacts such as biodiversity loss, greenhouse emissions and other environmental consequences. On one hand, the climate impacts caused by upper-middle-income countries originating from the extraction and processing stages have risen sharply over the last 30 years. However, climate impacts caused by high-income countries still have a much larger share, amounting to almost double the upper-middle-income countries, and ten times more impacts per capita than low-income countries.

Therefore, when analysing supply chains for clean technologies, social aspects and environmental protection measures should play an important part in criticality assessments. This encompasses analysing sustainability and social justice aspects in different countries and addressing how an unfair distribution of supply chain activities can deepen disparities between global regions and within local communities.

However, considering the different world regions' contexts that must be reflected in these types of analysis, including such considerations in scenario building and system planning might prove difficult. Specifically, due to the multifaceted interconnections between the different supply chain steps, including material extraction and processing, components manufacturing, and clean technology assembly. Furthermore, approaches to automate the analysis of these constraints, through the development of more intricate models, are hindered by a lack of quality data, capacity and time.

Nevertheless, such efforts should be overcome as integrating fairness- and climate-sensitive constraints into decision-making processes and modelling exercises could support more realistic and feasible planning while considering the correlation between climate change, social aspects and supply chain disruptions.

Key takeaway 2: Modelling and planning processes should enable a more resource-efficient and resilient energy system through strategies for energy and *material demand reduction, circular approaches, and wider socio-technical transformations.*

While some models seek to forecast the resource demand of critical and strategical raw materials considering technological needs to meet decarbonisation targets, socio-technical transformations are not fully reflected in most of the modelling tools. In particular, behavioural changes and efficiency measures can lead to reduced demand and, in consequence, to a more sustainable system. At the same time, incorporating circularity into such analyses can affect both energy demand and raw materials estimations. Therefore, modelling parameters that reduce material demand, incentivise second-life use, promote sustainable supply chains and consider socio-technical changes are crucial to enable a more realistic energy system planning.

Looking at the Scenario modelled within the Global Resources Outlook 2024, optimising the energy system while ensuring human needs are met, could lead to mitigating future material demand by 30% until 2060 in comparison to historical trends. At the same time, such measures could reduce energy demand by 25% from current levels within the same timeframe. Specifically in the mobility and construction sectors, there is considerable potential for reducing demand through behaviour changes and efficiency measures.

As other world regions strive to meet their own climate goals and guarantee human needs, they are forecasted to significantly increase their respective material intensity, reaching resource use patterns similarly observed in the EU and North America. Against this background, scenarios that outline ambitious material reduction pathways through efficiency gains and behavioural changes within the EU are needed. This would also allow the Global North to explore policy options that guarantee a just green transition.

Currently, most EU-wide modelling exercises fail to analyse the correlation between the reduction of resource demand, and behaviour and efficiency changes. There are some notable examples, such as models from the US and Spain, which estimate reductions from 50 to 90% of lithium demand according to ambitious behavioural modifications mainly in the transportation sector. From another perspective, by considering different measures, such as efficiency and behaviour changes, the PAC Scenario provides a pathway for reaching climate neutrality by 2040 and reducing energy demand by 51,2%.

However, implementing policies aimed at facilitating climate-friendly socio-technical transformations can be challenging in the current EU political landscape. In the aftermath of the European elections, an increasing backlash against the EU Green Deal and a higher focus on supporting the European industry could antagonise measures related to climate action. Nevertheless, coupling resource efficiency with competitiveness and a sectorial approach could prove to be valuable and allow the EU to reach climate goals while still promoting economic benefits.

In this sense, generation and transmission capacity expansion models can support optimised and feasible energy system planning through the inclusion of exogenous factors in the technology-related aspects. For example, considering policies, macroeconomic trends and raw materials availability as constraints to lead times, operation steps and costs. Depending on the chosen parameters, technological deployment strategies can differ significantly. By including considerations of circularity, such as increased recycling rates or higher requirements for recycled content, models would also be able to optimise energy and material resources.

Job creation will be crucial to bring citizens along with industry decarbonisation efforts, as it can provide public support and acceptance towards the EU Green Deal, and broadly to the energy transition and climate action. Therefore, modelling and planning processes should also consider the potential impact on the job market.

Machine learning and Artificial Intelligence (AI) could play an important role in anticipating risks, mitigating potential impacts and delays within the energy infrastructure supply chain, and guaranteeing the timely delivery of the decarbonised energy system. In this context, instead of developing new modelling applications, the integration of AI and other tools in existing modelling platforms could allow for models to consider the different modelling parameters effectively.

Key takeaway 3: The EU depends highly on imports for critical and strategic raw materials. Creating and implementing a policy framework that supports a resilient, and sustainable value chain, while tackling potential resource scarcity will be paramount for the energy transition.

Investigating the supply chain of technologies for different strategic sectors, the EU highly depends on imports. According to JRC's Foresight analysis, while assembly and manufacturing stages are mostly secured within the European context, the EU's share in the global production of raw materials has never been higher than 7%. This disparity leads to a systematic dependence on raw and critical materials imports.

Beyond a question of security of supply, according to the JRC's study, the EU demand for critical raw materials is expected to overgrow the current supply several times even in lower-demand scenarios. Therefore, strategies towards incorporating circular and recycling approaches, while reducing material demand and increasing efficiency, can minimise this dependency and provide more resilient value chains.

In this sense, both the Net Zero Industry Act (NZIA) and the Critical Raw Materials Act provide a framework to strengthen clean technologies' value chains and EU industries, while reducing strategic dependencies. However, detailed and disaggregated data is still needed to better analyse the value chain of clean technologies, their components and needed resources.

At the same time, an exercise of prioritisation should ensure that crucial supply chain steps are further developed within Europe. For critical clean technologies, incentives such as non-price criteria could promote people- and nature-positive renewables and grid infrastructure. Regulation could also help boost competitiveness and capacity by adding minimum requirements for product content from EU industries.

A thorough analysis should identify which key technologies should be given easier access to finance and be strategically promoted within the EU. To assess the strategic value of specific technologies, different elements come into play. An analysis carried out by Trinomics assessed clean technologies regarding their contribution to the European energy and climate goals within the Fit For 55 package, as well as the security of supply, including the growth of EU manufacturing, the need for imports, their competitiveness and other vulnerabilities.

Further analyses will be needed to ensure that a prioritisation strategy avoids only considering the low-hanging fruits of a sustainable value chain but also assesses the criticality and the highest-added value of the different processes. At the same time, these analyses should provide information on the impacts of such prioritisation. These impacts could consider social and environmental concerns including those related to European activities that generate inequalities for Global South regions, as mentioned in Key takeaway 1.

At the same time, the market competitiveness of the value chain should be taken into account in such prioritisation analyses, and it should be examined whether the relocation of a segment of the value chain to a different world region might lead to the transfer of the entire value chain to that location. Similarly, disaggregated analyses should understand the role of the different 27 EU Member States within the steps of the value chain, allowing for diversification and cohesion measures within an integrated, European strategy.

Lastly, to operationalise these in-depth assessments, transparent data sharing is needed. In the EU context, a database of which components and resources are necessary for different technologies could prove useful to allow for EU-wide and national analyses. As an example, the US Renewable Energy Materials Properties Database can be taken, created by the US National Renewable Energy Laboratory (NREL). Standardisation of the data used for the analyses would also allow for comparison between studies. This could prove useful specifically for technologies with different design possibilities.

Key takeaway 4: Investments and incentives from public and private sectors are needed to upscale manufacturing capacity to meet the future increased demand.

Increasing manufacturing capacity worldwide will be crucial for accelerating the energy transition. However, upscaling manufacturing requires a surety of investments and demand growth. After the stagnation in global markets caused by the COVID-19 pandemic, some suppliers limited their production without a clear signal from the market. Reductions in manufacturing capacities can hinder the energy transition as a whole. More specifically, in recent years the limited manufacturing capacity of grid technologies and delayed delivery of main suppliers have hindered grid deployment in different countries. In consequence, the integration of renewable energy sources has been slowed down, leading to a halt in the energy transition. Nevertheless, public-private partnerships can ramp up the production of critical clean technologies and their components.

Beyond national and EU-wide policy frameworks towards resilient supply chains mentioned in Key takeaway 3, developers, manufacturers and transmission system operators can incentivise the needed resource capacity expansion through different measures. For example, Hitachi Energy's efforts to increase capacity to meet the growing demand reflected considerable investments both financially and towards the workforce. Specifically seeking to tackle the high lead times for grid transformers, the company increased its transformer manufacturing capacity in Europe with financial and modernisation efforts.

Key takeaway 5: Private sector stakeholders' strategies can support optimised and resilient value chains by promoting energy demand reduction, resource efficiency and circularity.

Internal strategies that incentivise more sustainable and circular approaches could be implemented by grid operators to support a more resilient value chain within their operations. Foremost, a wider Corporate Social Responsibility policy could provide a framework for long-term planning, considering foresight analyses and stakeholder engagement, daily operation of the infrastructure, and general optimisation of the system. Within this general strategy, resource reduction and circular approaches were identified as crucial elements of the sustainability strategies, alongside measures to reduce greenhouse gases' emissions in the value chain.

Particularly, embedding circular measures systematically throughout the whole value chain through a dedicated sustainability strategy can support the optimisation of the energy system, while reducing resource needs and strategic dependencies. Recycling steel, aluminium, copper and other raw materials, reusing materials from decommissioned assets, repairing, formalising waste management strategies, and other similar actions can reduce operators' environmental footprint. Such actions can be operationalised through lifecycle assessments (LCA) that help quantify the environmental impacts of grid components, enabling a comparison of different technologies within the dimensions of resource efficiency.

A further possible measure is the inclusion of specific sustainability criteria into procurement processes, which would incentivise suppliers to adhere to or even surpass certain sustainability standards. In this context, robust monitoring and reporting mechanisms are crucial for the process to be effective. At the same time, financial mechanisms can play a role in providing incentives for lower emissions while penalising higher emission operations.

Finally, the private sector could also leverage such socio-technical transformations to support the efforts described in Key takeaway 2. For example, private sector stakeholders, such as electricity retailers or grid operators, could incentivise dynamic electricity pricing and smart meters to support behaviour changes through public engagement activities. Including these measures in a broader strategy for sustainability could prove effective, generating a system-wide change. In the French context, the use of a mobile application incentivises customers to reduce their consumption during the most critical hours, ensuring the balance of the power system.

Next steps

- The insights from this workshop will feed further into RGI's workstreams related to decarbonisation strategies, infrastructural needs of large energy consumers, supply chains and circular approaches in the energy system.
- This knowledge will also support the development of RGI public activities, including a webinar and communication materials.
- Further discussions of the workshop findings will be a vital component of the upcoming expert workshops under the PAC project umbrella, including potentially deeper discussions on specific raw materials.

Please do not hesitate to reach out with interest or opportunities to collaborate further!

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Read more about RGI's work on energy system modelling and planning and access the workshop presentations here.

Relevant literature

- JRC: Supply chain analysis and material demand forecast in strategic technologies and sectors in the EU – A foresight study
- Energy Transitions Commission: Better, Faster, Cleaner: Securing clean energy technology supply chains
- UN International Resource Panel: Global Resources Outlook 2024
- Fraunhofer: IND-E – Decarbonization and Electrification Potentials of the German Industry
- Research Paper: Electrify everything! Challenges and opportunities associated with increased electrification of industrial processes
- EUROFER: Low-CO2 emissions projects in the EU steel industry
- Fraunhofer: Supply chain risks in the EU's clean energy technologies
- Mckinsey: Global Energy Perspective 2023: Industrial electrification outlook
- World Economic Forum: Modernizing Industrial Energy

Workshop Agenda

09:30 – 10:00	**Registration and coffee**
10:00 – 10:15	**Welcome, agenda and the workshop's objectives** (RGI)
Session 1: Supply Chain Dynamics in Energy Infrastructure	
10:15 – 10:35	**Setting the scene: Supply chains and circularity approaches for delivering a decarbonised energy system** Diego Francesco Marin (EEB)
10:35 – 10:55	**Grid technologies & the Net Zero Industry Act** Mark van Stiphout (European Commission)
10:55 – 11:15	**Supply chain analysis and material demand forecast in strategic technologies and sectors in the EU** Nicola Magnani (JRC)
11:15 – 11:35	**Supply Chain Risks in the EU's Energy Technologies** Mohammad Ansarin (Trinomics)
11:35 – 12:15	**Discussion**
12:15 – 13:15	**Lunch Break**
Session 2: Embedding Supply Chain and Circularity in Modelling and System Planning	
13:15 – 13:35	**Integrating Supply Chain within Energy System Modelling Activities** Alexandre Oudalov (Hitachi Energy)
13:35 – 13:55	**Paris Agreement compatible scenario for Europe until 2040: leveraging circularity for reflections on supply chain implications** Joni Karjalainen (CAN-EU)
13:55 – 14:15	**Global Resources Outlook 2024: Insights for the energy transition** Rebecca Nohl (SYSTEMIQ)
14:15 – 14:45	**Discussion**
14:45 – 14:55	**Coffee Break**
Session 3: TSO Best Practices Showcase	
14:55 – 15:10	**Driving circular economy in supply chain** Marcela Mantilla (RTE)
15:10 – 15:25	**Best practices towards sustainable supply chains and circularity – CO2 pricing** Tor Solberg (Statnett)
15:25 – 15:50	**Discussion**
15:50 – 16:00	**Wrap-up and Final remarks** (RGI)