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Unleashing the full potential of Europe's electricity grids

Policy Recommendations for a Clean Industrial Deal and a Competitive Europe

CURRENT
Enabling Network Technology throughout Europe

Executive summary

Europe has rightly recognized that electricity grids have a crucial role in decarbonising its economy, in achieving energy independence, and driving competitiveness. CurrENT is now calling for urgent action on the deployment of innovative grid technologies to unleash the full potential of Europe's electricity grid at the lowest cost to consumers. Innovative grid technologies include grid-enhancing technologies that get more out of the existing grid, technologies that enable operation of a power system with a high penetration of renewables, and high-capacity conductors that offer up to ten times the transfer capacity of traditional conductors and significantly reduce network losses.

It is essential that electricity grids feature prominently in the Clean Industrial Deal. CurrENT recommends policymakers include the following key elements:

1. A strategy for a mass deployment of innovative grid technologies in Europe, including grid-enhancing technologies and high-capacity conductors.
2. Specific and SMART grid targets to measure whether Europe is on track to deliver the grids needed, e.g. decreasing the curtailment of renewables, decreasing the cost of grid capacity expansion in EUR per GW-km, increasing grid capacity in GW-km, increasing the efficient use of the grid, reducing losses, and decreasing raw materials per GW-km.
3. Financing mechanisms that enable the mass deployment of innovative grid technologies, e.g. benefit-sharing incentives that reward system operators for expanding their toolbox of technologies to save consumers money, guarantees that alleviate grid operator financial risks specific to trialling new technologies, dedicated grid technology calls under the Innovation Fund and other research and innovation programmes.
4. Anticipatory investments that look at fully decarbonised scenarios and that are guided by the NOVA principle, prioritising the optimisation and reinforcement of the existing network over grid expansion while promoting and demonstrating new high capacity and high efficiency conductor technology.

These recommendations give Europe a realistic chance to decarbonize the power system before 2040, which will be needed to reach net zero by 2050.

Introduction

There is a broad political consensus that robust and resilient electricity grids are a key foundation for a competitive and decarbonised Europe. To take just one sentence often quoted from the Draghi report "*If there is one horizontal area in the energy sector whose importance cannot be overstated, it is the EU's energy grids*."[1] This has also been rightly recognized by the Energy Council in May 2024, where the Energy Ministers have unanimously agreed on the need for a "*fully integrated, interconnected, and synchronised European power system*", and that this "*can only be achieved if the EU's electricity grid infrastructure is deployed and used as effectively and efficiently as possible for exchanges of energy*".

It has been widely acknowledged that achieving net zero by 2050 will require a decarbonization of the power system well before 2040[2]. It is also understood that this will require an unprecedented effort on the part of grid operators, governments, financial institutions, electricity producers, and consumers. Importantly, Energy Ministers in May 2024 have also asked the Commission to propose a strengthened governance and grid planning process, including a grid needs assessment and planning that complies with the EU climate and energy targets.

The importance of anticipatory grid investments, changes in permitting, management of supply chains, enhancement of skills, and appropriate financing have rightly been emphasised by many stakeholders. CurrENT would like to emphasize the urgent need for innovation: both the wide-scale deployment of technologies that are commercially available, as well as the development of new transmission and distribution technologies with ten times the transfer capacity of the currently best-in-class technologies. Deploying innovative grid technologies will increase the utilisation of existing infrastructure, while significantly reducing the cost, time and delivery risk of new grids during the next decade. Meanwhile, lost European competitiveness can be reversed by pursuing both a meshed alternating current (AC) and direct current (DC), pan-European grid, enabled by high-capacity conductors, that is built using a fraction of the critical raw materials consumed by conventional copper and aluminum grid technology. To achieve this the pace, ambition, and rapid acceptance of new innovative technologies needs to be scaled up.

The benefits of innovative grid technologies (including grid-enhancing technologies and high-capacity conductors – see the box on the next page for a full overview) are well documented.[3] They are already being deployed by grid operators all over the world. CurrENT's concern is that it is not happening fast enough in Europe. We cannot afford these technologies to suffer from 'death by pilot' and a reluctance

[1] The future of European competitiveness – A competitiveness strategy for Europe, September 2024.
[2] European Scientific Advisory Board on Climate Change, Scientific advice for the determination of an EU-wide 2040 climate target and a greenhouse gas budget for 2030–2050, 15 June 2023.
[3] See for example the study by Compass Lexecon, Prospects for innovative power grid technologies - Final report, 17 June 2024.

to adopt technologies already tested and deployed in other parts of the world. The enormity of our grid challenge does not allow for grid operators to reinvent the wheel and repeat the work of others.

Similarly, a focus on true innovation is required. To do this it is key that we redefine what is considered an innovative technology, to ensure the pace and support for real game changing technologies is adequate to meet the urgent needs of our grids. Often older technologies that have been in use globally for several decades are miscategorised as innovative by grid operators who have not previously used them on their own network. Focusing on older technologies slows the adoption of truly innovative technologies and is very significantly impacting the speed at which Europe is building out its grid. While many focus on the risk of new technologies, failing to innovate will cost Europe much more in terms of jobs, competitiveness, and European industry.

What are innovative grid technologies:

- Grid enhancing technologies (e.g. Dynamic Line Rating, Advanced Power Flow Control, Storage as a Transmission Asset,)
- High-capacity and high efficiency conductors (e.g. Advanced Conductors, High Temperature Superconductors)
- Grid Inertia Measurements
- Digital Twins & Flexibility Management solutions

Benefits

Taking all of these innovative technologies together, Compass Lexecon studied the benefits that these innovative grid technologies could bring to the European electricity grids. With a steady annual deployment of the innovative grid technologies mentioned above, this could benefit the European energy users in the following ways:

- Increase overall network capacity: By 2040, the deployment of these technologies can increase the overall network capacity between 20-40%
- Get network capacity faster: By deploying innovative grid technologies in combination with conventional technologies Europe can
    - Accelerate transmission grids expansion by 5 to 8 years
    - Accelerate distribution grids expansion by 4 to 7 years
- Get network capacity more cost-effectively: Achieve overall gross savings of 700 Bn€ in conventional expansion costs by 2040

Source: Compass Lexecon, Prospects for innovative power grid technologies - Final report, 17 June 2024.

Policy Recommendations for the Clean Industrial Deal

The Draghi report correctly states: "*If there is one horizontal area in the energy sector whose importance cannot be overstated, it is the EU's energy grids*." Powerful electricity grids are the backbone of European competitiveness, affordability, and clean industrialisation, and must be a key component in many of the upcoming legislative initiatives as was stipulated under the Political Guidelines for the next 5 years presented by Ursula von der Leyen in July 2024.[4]

The Clean Industrial Deal must therefore include:

1. A strategy for a mass deployment of innovative grid technologies in Europe, including grid-enhancing technologies and high-capacity conductors.
2. Specific and SMART grid targets to measure whether Europe is on track to deliver the grids needed, e.g. decreasing the curtailment of renewables, decreasing the cost of grid capacity expansion in EUR per GW-km, increasing grid capacity in GW-km, increasing the efficient use of the grid, reducing losses, and decreasing raw materials per GW-km.
3. Financing mechanisms that enable the mass deployment of innovative grid technologies, e.g. benefit-sharing incentives that reward system operators for expanding their toolbox of technologies to save consumers money, guarantees that alleviate grid operator financial risks specific to trialling new technologies, dedicated grid technology calls under the Innovation Fund and other research and innovation programmes.
4. Anticipatory investments that look at fully decarbonised scenarios and that are guided by the NOVA principle[5], prioritising the optimisation and reinforcement of the existing network over grid expansion while promoting and demonstrating new high capacity and high efficiency conductor technology.

The following paragraphs offer a deep-dive on some of these recommendations, as well as a reflection on how Europe can achieve an optimal pan-European grid.

[4] Ursula von der Leyen, POLITICAL GUIDELINES FOR THE NEXT EUROPEAN COMMISSION 2024–2029, 18 July 2024.
[5] An explanation of the NOVA principle can be found for example on the Transnet website.

Measuring progress: better grid targets and indicators

An important step to solving Europe's grids challenge is measuring where we are now, how far we have left to go, and whether we are we going fast enough to get there in time. Up until now the numbers that are shown have primarily focused on the euros to be invested (e.g. 584 billion in the Grids Action Plan[6]), and the kilometres of grids to be built (the IEA calls for 80 million km of grids to be added or replaced world-wide by 2040[7]). While this is a good indication of the scale of the problem, and an important first step, Europe is in desperate need of more meaningful metrics to show whether we are using our resources as efficiently as possible. In the following section, CurrENT makes suggestions for better indicators to be considered.

1. Decrease curtailment of renewables

Europe is spending billions of euros per year on the curtailment of renewables, to the detriment of both decarbonization and affordability for consumers. In the past two years, German congestion alone has cost consumers 7.3 billion EUR[8], 190 GWh (of mainly wind and solar) was lost due to grid bottlenecks and replaced by coal and gas. In some nations, 10% of wind power is being curtailed. This is only going to get worse as we move toward a system increasingly reliant on wind and solar. This should be regularly reported at European level, both in GWh and EUR per year.

2. Decrease the cost of grid capacity expansion in euro per GW-km

If we continue to expand the grid primarily through traditional CAPEX investments, the cost for consumers is going to rise astronomically. While an increase in expenses to a certain extent is inevitable, it is absolutely vital that the cost of transporting electricity is reduced as much as possible, both by using grid-enhancing technologies, as well as by deploying much more efficient conductor technologies.

3. Increase grid capacity in GW-km

As mentioned above, grid capacity needs are often estimated in terms of km to be built, or euros of investment required. A better measurement would be a growth of grid capacity in GW-km either on new or existing assets. The higher the GW-km the better utilisation you are making of any one asset, the more efficient the flow of power and the less environmentally invasive they are. As an example of this movement in thinking, DNV in their latest report estimates the expansion of the offshore grid and the global distribution grid in TW-km.[9]

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[6] European Commission, Grids, the missing link - An EU Action Plan for Grids (COM/2023/757), November 2023.
[7] International Energy Agency, Electricity Grids and Secure Energy Transitions, October 2023.
[8] According to the Bundesnetzagentur congestion report, congestion costs were 4,25 billion EUR in 2022 and estimated to be 3,13 billion in 2023.
[9] DNV, ENERGY TRANSITION OUTLOOK NEW POWER SYSTEMS Electricity, renewables generation, and grids through to 2050, 2024

4. Increase the efficient use of the grid

Europe needs to move more power through the electricity grids that have already been built. Much of the time, there is significant unused capacity on the electricity grids. This needs to be increased, while maintaining system reliability. As has been proposed by ACER at various public fora and in its guidance, paper coauthored with CEER[10], efficient use of the grid could be measured by looking at the 'available transmission ampacity' compared to the 'standardized transmission ampacity'.

5. Decrease power losses

In its report on power losses[11] CEER estimated that the total losses (transmission and distribution) for 2015 range between 2.24% and 10.44% of total production across the European Union. In 2022 this equates to between 63-295 TWh of electricity lost in networks. To put this in context the high-end figure is equivalent to 70% of all electricity produced by wind in the EU in 2022[12] being lost in its networks. Or viewed another way, this equates to a value between the total production of Romania and the total production of Spain in 2022. High-capacity conductors such as Superconductors have extremely low losses and can reduce network losses by several orders of magnitude on the transmission and distribution system yet there is virtually no emphasis placed on reducing system losses at policy level. The infrastructure being built over the next two decades will operate for 40+ years. It is vital that policy makers focus on the sustainability of these new networks by placing incentives on the reduction of losses.

6. Decrease raw materials per GW-km

The availability of sufficient raw materials, such as copper, could be a defining factor in whether Europe reaches net zero by 2050. The problem is not only whether there are enough raw materials available, but whether they can be realistically mined in the coming decades, when very few new copper mines are being built at today's prices[13]. The Critical Raw Materials Act[14] adopted in 2024 rightly places an emphasis on innovative materials and circularity. New conductor technologies with a much higher transfer capacity can significantly reduce the demand for raw materials per GW-km. Of course, increasing grid utilisation rate, as mentioned above, will also inherently decrease the raw materials per GW-km.

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[10] ACER-CEER, Electricity transmission and distribution "smart-grid" performance indicators - an ACER-CEER guidance paper, June 2024

[11] CEER, CEER Report on Power Losses, 2017

[12] Eurostat: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Energy_production_and_imports#Electricity

[13] S&P Global, The Future of Copper: Will the looming supply gap short-circuit the energy transition?, July 2022.

[14] Regulation (EU) 2024/1252 of the European Parliament and of the Council of 11 April 2024 establishing a framework for ensuring a secure and sustainable supply of critical raw materials, OJ L 1252 3.5.2024

Financing: from innovation to meaningful mass deployment

While many are calling for increased investments in electricity grids, there is still insufficient emphasis on the role that innovative grid technologies can play, and the financial instruments that are needed to scale up their deployment.

Output-based incentives and benefit-sharing

In all Member States, the current network asset owner remuneration framework heavily favours large capital-intensive projects over lower-cost grid optimization solutions. In a paper by the Florence School of Regulation[15], a benefit-sharing solution is proposed to address this issue. In this methodology, the regulator defines a system need, such as increasing cross-border capacity. If the grid operator can solve the system need through a solution that costs less than building a new line (for example dynamic line rating, advanced power flow control, or storage as a transmission asset), the grid operator would be rewarded with a percentage of the cost-differential between building a new line and the lower-cost solution.

This benefit-sharing approach will create an incentive for the grid operator to investigate and develop better solutions with a great societal benefit, despite additional work and (perceived) risk for the grid operator (e.g. to engineering, delivery timelines, political/social perception, reputation and ongoing operational management). Grid operators may also need to develop new understanding, standards for modelling, planning, and inclusion into system operation and deployment. It can come with new software developments for planning and operational use, training of staff, greater work in control rooms to manage, new procurement costs, new supply chain contracts, etc., as well as the repeat work of environmental assessments, consultations, new designs, tenders, etc. to migrate to this technology.

Guarantees for performance risk

The perceived risk that a technology will not perform as expected can be a barrier for grid operators to deploy technologies that they have not deployed previously. This risk is often cited as a reason not to even trial innovative technologies let alone scale these rapidly to widespread use. This is particularly relevant for solutions with technology readiness levels (TRL) below 9. CurrENT recognises that this risk is minimal for technologies that have been tried and tested in many different countries. However, a guarantee fund could remove the perception of risk held by grid operators which is creating a bias in the decision-making process of grid operators in favour of older less efficient technologies.

[15] Alberto Pototschnig, Nicolò Rossetto, Benefit-based remuneration of efficient infrastructure investments - Final report, RSC/FSR 2024, May 2024.

Innovation Fund

Since 2020, 74% of the total funding of €3.1 billion spent under the EU ETS Innovation Fund, has gone to hydrogen (24%) and Carbon Capture and Storage (50%). Only 18% has gone to renewables and storage and 8% to other technologies including efficiency. The current methodology for weighing selection criteria is a big disservice to innovative grid technologies. While innovative grid technologies are essential for the mass uptake of renewables, by reducing permitting queues, congestion costs, and the curtailment of renewables, they do not fulfill the decarbonization criteria as defined under the selection process of the innovation fund.

The EU's flagship innovation vehicle must become increasingly focused on innovative grid technologies. For grid technologies to be competitive in the selection process, there will need to be a sector-specific call for innovative grid technology under the innovation fund, with more appropriate criteria, reflecting that grids are enabling technologies for the transition. The recent revision of the Delegated Act on the Innovation Fund allows for such sector specific calls and topics to be introduced. The European Commission should make use of this amendment by creating calls specifically targeting innovative grid technologies.

Planning: Integrated system planning for an optimal pan-European grid

In the coming decades, Europe is facing the biggest energy transformation in history, and it must happen at an unparalleled speed than ever before in history. Deploying sub-optimal infrastructure will cost jobs and European competitiveness.

Incremental investment decisions on a project-by-project basis will not lead to an optimal infrastructure. Europe must look at what an optimal infrastructure in 2050 looks like, and plan backwards from there.

The Offshore Network Development Plans are a start, but they do not yet deliver a shared vision for a system that is clean, secure, and affordable. They omit more than 80% of Europe's 2050 electricity generation since they only cover offshore wind which is assumed in the model to be less than 20% of generation in 2050. It does not consider what happens to the offshore power once it lands at the beaches of Europe, how it integrates with the onshore grid, and ultimately reaches electricity consumers.