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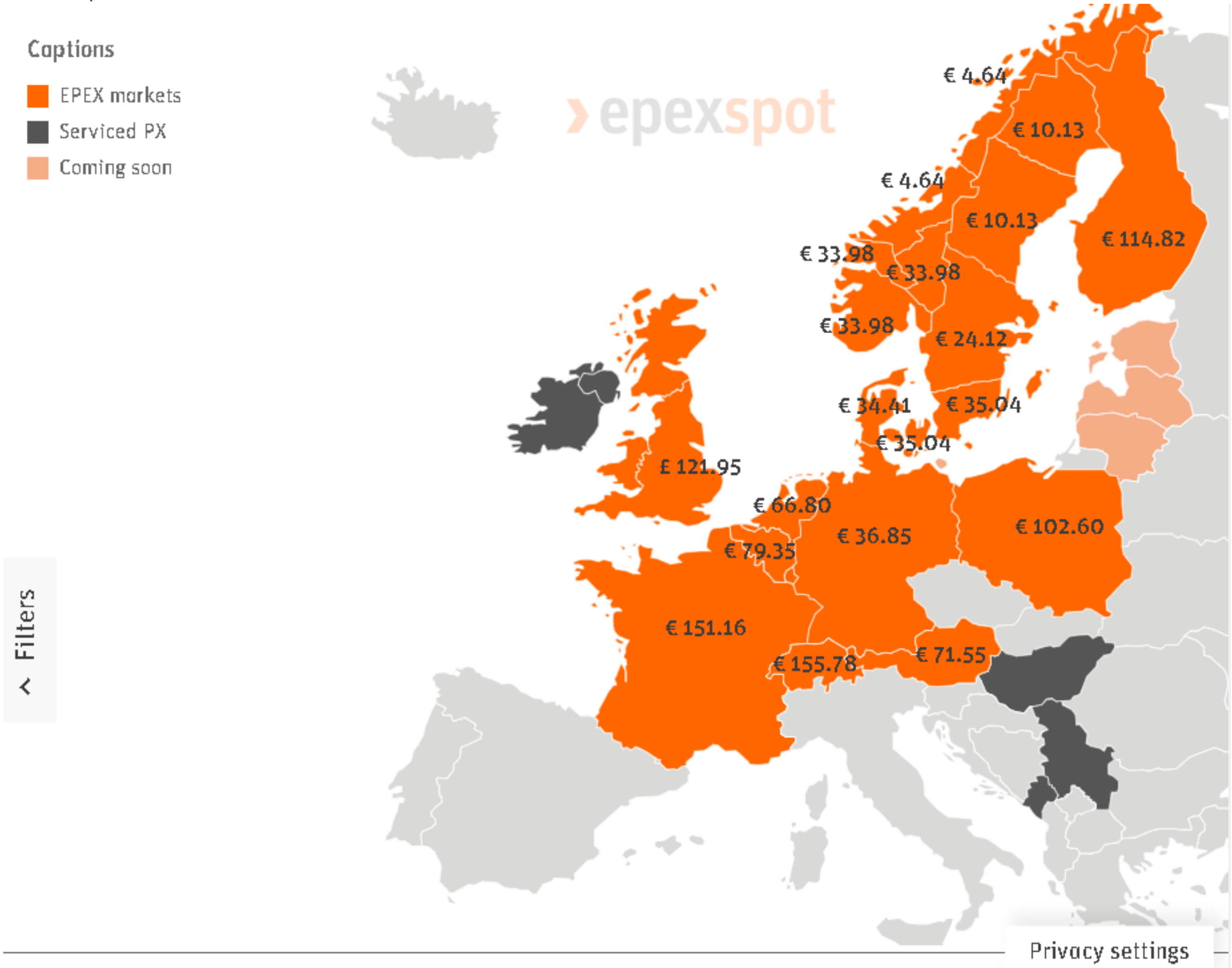
Grid Enhancing Technologies supporting TSOs to achieve the 70% target

CurrENT
Enabling Network Technology throughout Europe

Introduction

Two and a half years after the launch of Europe´s Green Deal and three months after the beginning of Russia´s war against Ukraine, it is more important than ever to have a well-functioning energy market, with reliable and secure energy that is affordable for everyone, and to take ambitious steps towards Net Zero. Europe is seeing incredible electricity price spikes, with big differences among European Member States.

Power price differences across EU



Source: EPEX spot, 27 May 2022 [Market Data | EPEX SPOT]

Despite these challenges, the EU has declared repeatedly and rightly Russia, it will not deviate from its trajectory towards climate neutrality but will rather raise its ambitions even further and scale up renewables. Finally, the successful emergency synchronisation of Ukraine into the Continental Europe Synchronous Area proves that swift action is possible when needed.

Renewables are key to reducing import dependency and fulfilling climate targets. This has been reconfirmed by the REPowerEU plan that was released on May 18, 2022.[1] At the same time, renewables require powerful electricity grids to be developed hand in hand. This has also been recognised in the proposed amendment to the Renewable Energy Directive which the Commission published alongside the REPowerEU plan, which recognises renewables and related grid infrastructure as a matter of overriding public interest. Since time is of the essence, and massive investments are needed, making use of all available solutions is crucial and should also be considered a matter of overriding public interest. This is also particularly important now, as customers are already burdened by unusually high energy prices and Europe needs to do everything in its power to keep the energy transition affordable.

Grid enhancing technologies (GETs) are key to achieving Net Zero. GETs are tools such as Dynamic Line Rating, Power Flow Control devices, software solutions, and superconducting cables, all of which make the grid function more efficiently. Using GETs, the existing grid can transport more energy, react faster, and adapt to new circumstances. In most cases, introducing GETs is not an alternative to needed network expansion or reinforcement, but is complementary. The advantage is that they can be deployed much more quickly than other solutions and deliver results faster.

The advantages of using GETs have been flagged in several studies: ENTSO-E Technopedia[2], the BMWI Operational devices study[3], the IEA Technology Guide,[4] IRENA's Innovation Landscape Report on Enabling Technologies[5], ETIP SNET's Knowledge Sharing Platform[6], and RGI's best practices database[7] . Furthermore, there are a number of highly respected studies, such as those by Consentec[8], Brattle[9], the WindEurope Paper on Grid Optimisation,[10] THEMA Consulting,[11] RWTH Aachen[12] or the ACER paper on infrastructure efficiency.[13]

[1] Joint European action for more affordable, secure energy (europa.eu) Key documents: REPowerEU | European Commission (europa.eu)
[2] https://www.entsoe.eu/Technopedia/
[3] https://www.bmwi.de/Redaktion/DE/Publikationen/Energie/netzbetriebsmittel-und-systemdienstleistungen-im-hoch-und-hoechstspannungsnetz.html
[4] https://www.iea.org/articles/etp-clean-energy-technology-guide
[5] https://www.irena.org/publications/2019/Sep/Enabling-Technologies
[6] https://tools.etip-snet.eu/search.html
[7] https://renewables-grid.eu/activities/best-practices/database.html?L=0
[8] Consentec. 2021. *The Benefits of Innovative Grid Technologies.*
[9] https://watt-transmission.org/wp-content/uploads/2021/02/Brattle__Unlocking-the-Queue-with-Grid-Enhancing-Technologies__Final-Report_Public-Version.pdf90.pdf
[10] https://windeurope.org/wp-content/uploads/files/policy/position-papers/20200922-WindEurope-Grid-optimisation-technologies-to-build-a-greener-Europe.pdf
[11] https://heimdallpower.com/wp-content/uploads/2021/08/Report_Thema_Consulting_Group.pdf
[12] https://www.iaew.rwth-aachen.de/go/id/hyjix
[13] Infrastructure efficiency: the role of regulation in incentivising smart investments and enabling the energy transition | www.acer.europa.eu

Yet, despite this abundance of reports GETs are insufficiently referred to as a solution when addressing the EU market integration and decarbonisation targets. How are GETs considered in Member States strategies towards reaching the 70% MinRAM? currENT, with this paper, shares its analysis of the six publicly available Action Plans.

The 70% target: background on legislation

To increase the efficiency of the European internal electricity market, Member States have agreed that at least 70% of electricity interconnector capacity should be made available for cross-zonal trading. This would both ensure a competitive European electricity market, in which consumers get the best possible deal, increase security of supply, and enhance the integration of renewable sources[14]. Those objectives enable consumers to benefit from sustainable and competitive energy, while operational security is safeguarded through the 30% of the capacity set aside for operational purposes and uncontrollable flows. The introduction of a cross border target for market-based flows is the result of several years of discussion in which ACER and DG ENER have repeatedly stated that TSOs favouring internal flows results in limitations of cross-border flows, which is detrimental to consumers interest.

The binding 70% target went into force on 1 January 2020, with the possibility of exemption for countries that need more time.[15] As stated in article 14 of the Electricity Regulation[16], where a Member State has identified structural congestion, it may adopt an Action Plan and outline the steps to be taken to reach the 70% target in a linear manner by 1 January 2026. Multinational plans are also possible according to the regulation, yet there is no evidence of a member state applying this option. In addition, as stated in article 16.9, the relevant NRAs may grant derogations to the 70% target for either one or two years, if operational security is at risk. This derogation needs to be approved by the NRAs of neighbouring countries, and TSOs must also develop a long-term strategy towards achieving the 70% target.

The EU-27 Member States have chosen a variety of approaches towards achieving the 70% target, also referred to as the margin available for cross-zonal trade (MACZT), depending on the specific situation in each country. Luxembourg and Cyprus, for example, are generally granted an exemption as their market is too small: following that logic they also don´t need to comply with the 70% target. Six countries (Austria, Germany, Hungary, Netherlands, Poland and Romania) have already opted for Action Plans due to structural congestions; Croatia plans to adopt an Action Plan by the middle of 2022. Other countries have gone for a direct implementation of the 70% target, while derogations can be requested in the case of operational risks.

This paper takes a closer look at how Member States are progressing towards the 70% target, and how GETs

[14] ACER, Report on the result of monitoring the margin available for cross-zonal electricity trade in the EU in the second semester of 2020, 2021

[15] EUR-Lex - 32019R0943 - EN - EUR-Lex (europa.eu)

[16] Regulation (EU) 2019/943 on the internal market

are considered in achieving this. In this context, the Action Plans provide a very valuable source of insight, which is why we have chosen to analyse those in detail. Have the six countries that published an Action Plan considered the use of innovative technology solutions to address underlying structural congestion challenges? It should be noted that our paper exemplifies our more general statement on the benefits of using GETs through those six action plans, simply because they are transparently available. This does not mean indeed that all the others should not be equally put under scrutiny in terms of whether they use technology solutions. Our paper concludes with recommendations for policy makers, regulators and system operators.

Action Plans 70% transmission capacity available for cross-zonal trade

According to the Electricity Regulation,[17] Member States are allowed to adopt transitory measures, i.e., Action Plans or derogations, to gradually reach the minimum 70% target by 1 January 2026 at the latest.[18] Transmission System Operators, that are responsible for the security of supply and efficient network use in their respective countries, prepare the first drafts for those Action Plans.

The intermediate targets, as well as the final 70% target, should be met at all times and are monitored by ACER.[19] ACER and NRAs release their monitoring reports on an annual basis, with ACER looking at the European level, and NRAs monitoring the progress in the respective Member States.[20]

Figure 1: Action plan process

Landscape of action plans, immediate implementation, and derogations

According to the latest monitoring report by ACER, six countries have currently adopted and published Action Plans, with the Hungarian still being in the finalisation phase, and the Croatian Action Plan expected to be published by the middle of 2022. All other countries have gone for an immediate implementation,

[17] Text of Electricity Regulation EUR-Lex - 32019R0943 - EN - EUR-Lex (europa.eu)
[18] Ibid 2.
[19] ACER, Monitoring the margin of capacity available for cross-zonal trade pursuant to Article 16(8) of the Electricity Regulation, 2022
[20] Ibid.

with several of them benefiting from derogations. The latter means that several of the ´immediate implementation countries´ are not meeting the 70% target for now, as ACERs assessments show.

Overview countries with immediate application of 70%, exemptions *with or without Action Plan*

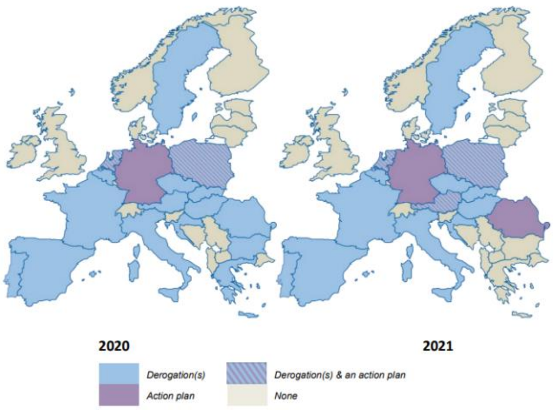


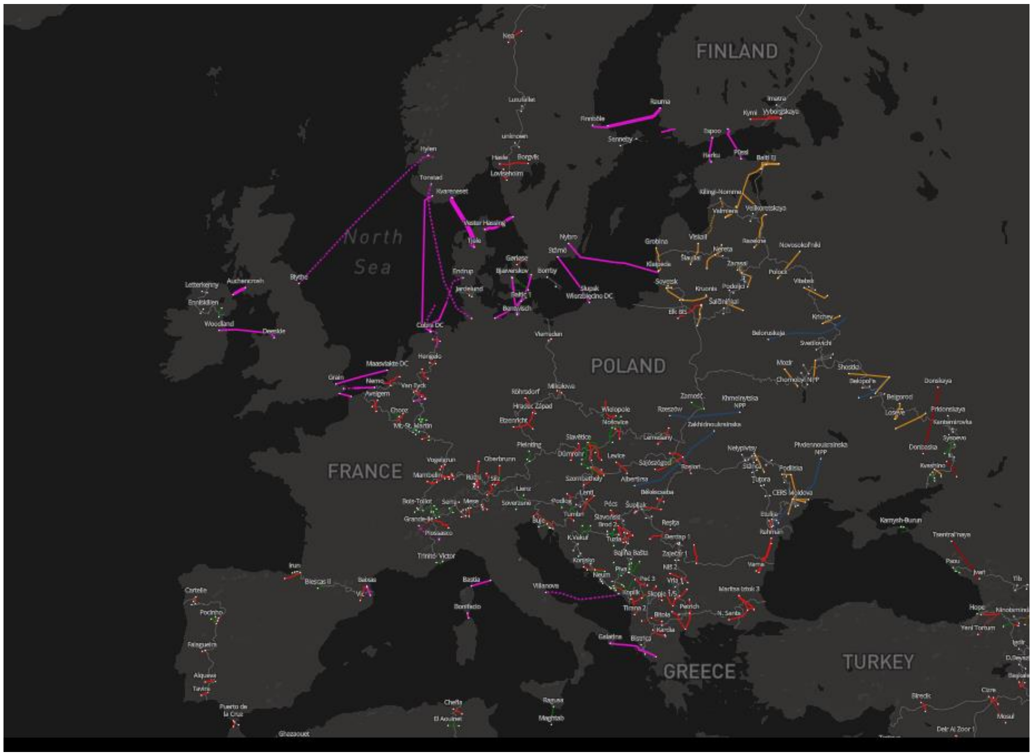
Figure 2: Overview of derogations and action plans for 2020 (left) and 2021 (right), source: MACZT report - S1 2020.pdf (europa.eu)

The complete list of derogations and Action Plans is available here [annex where action plans and derogations are listed]

Results from the 2021 last ACER MACZT Report

The role of ACER is to monitor the European internal electricity market, identify the scope for improvement to meet the minimum 70% target and produce reports with the identified progress. The ACER report distinguishes indeed between AC and DC borders: Europe has a densely meshed power network that has mainly AC networks with 50 Hertz and different voltage levels (110 kV-220kV-400 kV) for high voltage grids. DC networks with zero frequency are mainly used for the transport of large amounts of electricity from one region to the other, or as subsea cables. It should be noted that it is much easier to reach the 70% target on a DC grid as DC grids have excellent flow-controlling properties, different from the AC grid. The AC links pose greater challenges with respect to reaching the 70% target. The map below shows the AC and DC interconnections.

AC and DC interconnections in Europe



Source: ENTSO-E Grid Map (entsoe.eu)
Legend: pink= DC links, red= AC links

Below is a summary of the findings from the latest ACER report:[21]

- On the DC borders, the 70% target was mostly met except for the Polish borders with Lithuania and Sweden, the border between Denmark1 and Sweden3 (Konti-Skan), the border between Germany and Sweden4 (Baltic Cable), and the border between Great Britain and the Irish single energy market (SEM).[22]
- On the AC borders the situation is slightly different, with high differences among Member States, stretching from 5-70% minRAM, and all in all a significant margin for improvement. The monitoring of the MACZT relies on TSOs and their ability of providing robust and extensive data. When comparing the data to the first semester of 2020, the quality has improved but further upgrades are still necessary.[23]

[21] ACER, Report on the result of monitoring the margin available for cross-zonal electricity trade in the EU in the second semester of 2020, 2021
[22] Ibid.
[23] Ibid.

- Austria, Germany, Hungary, Netherlands, Poland and Romania have published their action plans; Croatia plans to adopt an action plan by the middle of 2022 and the Hungarian one is in the final consultation phase.[24]

Technology Solutions referred to (or not) in the plans

In their plans, national governments outline the actions to be taken on how to reach the 70% target in a linear manner. These actions could consist of building new lines, applying technological solutions, or taking regulatory steps such as splitting a country into bidding zones. To ensure that these targets are achieved in the fastest and most cost-efficient way, it is important to consider all technologies that are commercially available. One should also note, besides the fact that GETs contribute to achieve the static 70% target, they can also increase the line capacities overall. In such a case they also increase the absolute value of the 70% target. For GETs, this increase of capacity should not be reflected in the 70%, as the latter should reflect only the static thermal limits of interconnectors.

Are innovative technology solutions considered in the action plans?

The following chapter describes how Grid Enhancing Technologies are considered in the six publicly available Action Plans. Some countries (Poland, Romania) do not refer to technology solutions at all but describe grid development and implicitly accept the price for delayed grids and non-action through high congestion costs. Others (Austria, Hungary, the Netherlands, and Germany) mention a selected and limited number of technologies. currENT believes that they should refer to ENTSO-E's Technopedia, which includes a comprehensive list of all technologies, and has been developed by the TSO community. Other authoritative sources of available technologies could also be considered; it is key here that that are developed and consulted transparently. After presenting key actions a table with quotes from the action plan texts can be found on the end of this subchapter.

1) **Austria:** The Action Plan refers to two technologies for reducing structural congestion and achieving the 70% target: network optimization and infrastructure development. With regards to network optimization, some ongoing and planned future Dynamic Line Rating (DLR) projects are mentioned. Phase shifting transformers (PSTs) are identified as possible remedial actions across bidding zones. CurrENT believes that Austria should also refer to other available Grid Enhancing Technologies (GETs).

2) **Germany**: The first section of the Action Plan describes the measures foreseen for reducing congestion and improving cross-border redispatch. In addition to the importance of grid expansion, the optimisation of the existing grid is addressed through the implementation of PSTs only. These

[24] ACER, Action plans: Overview and main characteristics, 2022

conventional devices are presented in a dedicated sub-paragraph where their benefits in managing cross-border flows are explained through best practices. Furthermore, a detailed summary is included, where some additional remedial measures are listed, such as the digitization of power networks, the introduction of weather-dependent overhead power line operation and test reactive operations management. While currENT welcomes the second part beyond PSTs the association encourages German TSOs and BNETZA to consider the full toolbox of GETs.

3) **Hungary**: In addition to traditional network development projects, the introduction of High Temperature Low Sag (HTLS) conductors in crucial transmission lines is explicitly mentioned in order to increase the ampacity level on those lines. Additionally, the replacement of an endpoint current transformer is highlighted to reduce local congestions.

4) **Netherlands:** Remedial measures include the substitution of old conductors with High Temperature Low Sag (HTLS) conductors and the introduction of Phase Shifting Transformers, as for the German plan. According to the TenneT Structural Congestion Report, traditional grid investments could sometimes create new or increase existing congestions. Consequently, in addition to new infrastructure development, the substitution of conductors with HTLS for increasing the transmission capacity of the network (up to + 33 %) is highlighted for the interconnections NL-DK and NL-BE.

5) **Poland**: Two measures are identified to achieve the MACZT target: the first one is network investment, and the second one is redispatching. Grid enhancing technologies are not mentioned at all in the list of measures. There is a strong focus on the two interconnectors projects, Sweden-Poland and Lithuania-Poland.

6) **Romania**: Similar to Poland, redispatching is considered as one of the main measures for increasing the capacity, together with traditional grid investments. Redispatch indeed comes with high costs to society.

Country	Technology Solutions for the grid: quotes from text
Austria	• P.11 - 1.a. Network reinforcement/optimization: *In the coming years, a number of existing transmission lines and substations are planned to be reinforced or optimized. This includes especially the preparation for the application of* ***dynamic line rating*** *(hereinafter: 'DLR').* • P.15 - 2.b Utilization of remedial actions: *Remedial actions change the power flow pattern and may include measures, among others changing tap position of* ***phase shifting transformers****, adapting the topology of the power grid and especially redispatching.* • P.19 - V. Annex: Table 2: Planned commissioning of network development and optimization projects including **DLR.**
Germany	• P. 15 - 2.3 Optimize the existing network: *Higher transport capacities can be achieved by means of consistent implementation of state-of-the art technology, such as* ***phase shifting transformers.*** • P.30 - 4.2 Better control cross-border network flows with phase shifting transformers: list of some use cases. • P.38 - 2.3 Optimization of the existing network: **summary of the different points**
Hungary	• P.11 - Table with the new projects and their date of implementation including one endpoint current transformer and HTLS.
Netherlands	• P.26 - It is underlined how new grid infrastructure development could not only decrease congestions, but they could also create new congestions or increase the existing ones. • P.26 - The possibility of substituting old conductors with HTLS to increase the transmission capacity (up to 33 %) is considered for interconnections together with traditional investments in the grid.
Poland	• There is no mentioning of GETs neither in the primary nor in the secondary measures adopted to achieve the capacity targets. • P.11-12 - List of the investment project in the grid, interconnectors Sweden-Poland and Lithuania-Poland.
Romania	• P.8 - Real time transmission capacity monitoring solutions are introduced as potential measures for increasing the cross-border capacity, but no further indication is provided of which solution could be introduced. • P.9 - The list of grid investment projects is presented without the consideration of any bridging solution.

Table 1: Austrian, German, Hungarian, Dutch, Polish and Romanian action plans

Conclusions and Recommendations

GETs can contribute to achieving the 70% target, to lower system costs and higher security of supply. Yet, despite this fact they are hardly mentioned in the Action Plans, as our analysis has shown.

Our paper has identified two groups of countries with respect to their approach on how to reach the 70%. The first group includes countries like Poland or Romania that don't mention technology solutions at all. While currENT members are aware that both countries are exploring and trialling such solutions already, they have not made it into a more general and formal consideration as a key enabler for addressing congestion.

The second group includes countries like Germany, Austria, Hungary and the Netherlands. Those countries limit their reference to GETs to two rather established technologies: PSTs and DLR. While PSTs are a specific type of Load Flow control (LFC), there are other LFC solutions available. As for DLR it is important to opt for the latest available technologies and related highest possible efficiency. In addition, other legislation that constrains DLR use needs to be aligned with the broader internal energy market integration approach.

Our recommendations below list actions that need to be taken. We would like to highlight again that we have taken the six ´Action Plan countries ´ as a pars pro toto (as those have been transparent in publishing their plans); yet our recommendations apply indeed to all EU Member States.

1 GETs can help achieve 70%: they should form part of the toolbox

GETs could effectively help reach the 70% target, as the reports mentioned in the introductory section prove. They need to be included in the actions by member States to reach the 70% target and included in TSOs tool box in a transparent manner.

2 The NOVA principle should be applied to reach the 70% target and across Action Plans and in derogations

The NOVA principle states that optimisation of the existing grid should happen before reinforcement and before expansion of the grid. currENT believes that NOVA should become a general regulatory principle across EU and European grid related legislation, including transparency and monitoring on implementation. Hence it should be applied systematically in grid planning- NDPs to TYNDPs, 70% action plans and monitoring, as well as the forthcoming NECPs. What is more, it is important that the next version of the ENTSO-E dynamic model includes those tools as well.

3. Other obstacles for GETs need to be removed

In addition to considering GETs to successfully deliver the 70% target, currENT also stresses also that there are other obstacles that need to be removed in order to facilitate the uptake of GETs more generally. We refer here to the letter by WindEurope, TD Europe and currENT sent to ACER on 9 March 2022.[25] Such

[25] See Infrastructure Forum 2022 website for background documents

obstacles include:

- The CAPEX / OPEX bias that is currently in place, as opposed to a solution-oriented incentive regulation for TSOs
- The lack of an encouraging incentive regulation that rewards TSOs and DSOs for trialling new solutions and sharing the results across EU. [26]
- The Dynamic limits that should be considered on critical network elements (CNECs) and interconnectors. It is important to note that ACER's guidelines and European regulation already somewhat recognize some types of flexible/innovative solutions.[27]

4. The European Commission should commission a study on the benefits of GETs in the 70% implementation, and a guidance for NECPs

To show the full benefit of innovative grid technologies, the European Commission, possibly with ACER, should commission a study on the benefits of Grid Enhancing Technologies for network efficiency and propose how they must be considered in network planning (TYNDP, NDPs) as well as in Action Plans or NECPs. currENT suggests that the study results are presented at the next Copenhagen Infrastructure Forum in 2023. National best practice should be flagged out here too.

currENT will also issue a separate analysis on how the NECPs account for technology solutions in power networks. These recommendations should inform the EC guidance on NECPs for the member States.

currENT is looking forward to working with TSOs, NRAs and governments to firstly get GETs into the toolbox of TSOs and take it from promise to practice. Now.

[26] For example, in Belgium, an official process is already set up for the TSO to recover their costs in implementing innovative solutions to increase cross-border capacity as part of their normal regulatory cycles. Such technologies are officially recognized and treated as a component of network infrastructure investment equal to other types of CAPEX heavy investments.
The opportunity exists for other TSOs to treat investment in GETs as a CAPEX item. However, this is not attractive, because the benefit it creates in terms of market welfare is typically not directly returned to the TSO. This is mentioned also by ACER's position paper on incentivizing smart investments to improve the efficient use of electricity transmission assets.

[27] For example, ACER's Decision 02/2019 for ID and DA proposed under Article 6 Methodology for operational security limits, how the maximum admissible current (Imax) shall be defined. Understanding that there are provisions for cases where varying limits are not possible, we applaud and strongly support the inclusion of 2 (a) ii. Dynamic limit, which means a value per ID CC MTU reflecting the varying ambient conditions.
There is a natural link with this and the Regulation (EU) 2019/943 of the European Parliament and of the Council of 5 June 2019 on the internal market for electricity (Text with EEA relevance.), that set the 70% minimum capacity allocation rule. To achieve the MACZT 70%, it is important to maximize the capacity of the CNECs which impact the possible safe trade capacities in DA and ID time frames. This was explicitly mentioned in paragraph (70) of ACER's Decision 02/2019 of 21 Feb 2019 on the Core CCR TSOs' proposals for the regional design of the day-ahead and intraday common capacity calculation methodologies document as well.

References

ACER. 2019. *Cross-zonal capacity - 70% target.*
https://documents.acer.europa.eu/fi/Electricity/Market%20monitoring/Sivut/Cross-zonal-capacity-70-target.aspx
ACER. 2021. *Infrastructure efficiency: the role of regulation in incentivising smart investments and enabling the energy transition.*
https://extranet.acer.europa.eu//Official_documents/Position_Papers/Position%20papers/Position%20Paper%20on%20infrastructure%20efficiency.pdf

ACER. 2022. *Action plans: Overview and main characteristics.*
https://extranet.acer.europa.eu/Official_documents/Acts_of_the_Agency/Publications%20Annexes/ACER%20Report%20on%20the%20result%20of%20monitoring%20the%20MACZT%20Generic/ACER%20Report%20on%20the%20result%20of%20monitoring%20the%20MACZT%20Derogations.pdf

ACER. 2022. *Practical Note - Monitoring the margin of capacity available for cross-zonal trade pursuant to Article 16(8) of the Electricity Regulation*.
ACER and NRAs practical note MACZT (2022).pdf

Bundesministerium für Wirtschaft und Energie. 2021. *Netzbetriebsmittel und Systemdienstleistungen im Hoch- und Höchstspannungsnetz. Erster Ergebnisbericht zur „Netzbetriebsmittel Studie".*
https://www.bmwi.de/Redaktion/DE/Publikationen/Energie/netzbetriebsmittel-und-systemdienstleistungen-im-hoch-und-hoechstspannungsnetz.html

Consentec 2021. *The Benefits of Innovative Grid Technologies.*
https://www.currenteurope.eu/wp-content/uploads/2021/12/currENT_Consentec_BenefitsOfInnovativeGridTechnologies_FinalReport_20211208_clean.pdf

CurrENT Europe. 2020. *Climate proof Europe's power grid: currENT's seven Recommendations to Policy Makers.*
https://www.currenteurope.eu/wp-content/uploads/2020/06/200625_currENT-Policy-Paper.pdf

ENTSO-E. 2021. *Technopedia*.
https://www.entsoe.eu/Technopedia/

European Parliament and Council. 2019. *EUR-Lex - 32019R0943. Regulation (EU) 2019/943 of the European Parliament and of the Council of 5 June 2019 on the internal market for electricity (Text with EEA relevance).*
https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019R0943&from=EN

European Commission, Directorate-General for Energy, Directorate B; Internal Energy Market Unit B.1; Networks & Regional Initiatives. 2019. *Do current regulatory frameworks in the EU support innovation and security of supply in electricity and gas infrastructure?*
https://ec.europa.eu/info/sites/default/files/reportregulatoryfw.pdf

Heimdall Power, THEMA Consulting Group. 2021. *Effects of higher available Capacity and increased Market Integration*.
https://heimdallpower.com/wp-content/uploads/2021/08/Report_Thema_Consulting_Group.pdf.

WATT, Brattle. 2021. *Unlocking the Queue with Grid-Enhancing Technologies: Case study of the southwest power pool.*
https://watt-transmission.org/wp-content/uploads/2021/02/Brattle__Unlocking-the-Queue-with-Grid-Enhancing-Technologies__Final-Report_Public-Version.pdf90.pdf

WindEurope. 2020. *Making the most of Europe's grids: Grid optimisation technologies to build a greener Europe.*
https://windeurope.org/wp-content/uploads/files/policy/position-papers/20200922-WindEurope-Grid-optimisation-technologies-to-build-a-greener-Europe.pdf

IAEW Aachen. 2020. *Modular Power Flow Control Enhancing German Transmission Grid Capacity.*
https://www.iaew.rwth-aachen.de/cms/IAEW/Das-Institut/Aktuelle-Meldungen/~ihcvs/FGE-Web-Seminar-zum-Thema-Accelerating-th/?lidx=1

Wind Europe, currENT, TD Europe, Letter to ACER 9 March 2022