ENTSO-E Position Paper

Innovation uptake through Regulation

June 2022

ENTSO-E Mission Statement

Who we are

ENTSO-E, the European Network of Transmission System Operators for Electricity, is the **association for the cooperation of the European transmission system operators (TSOs)**. The 39 member TSOs, representing 35 countries, are responsible for the **secure and coordinated operation** of Europe's electricity system, the largest interconnected electrical grid in the world. In addition to its core, historical role in technical cooperation, ENTSO-E is also the common voice of TSOs.

ENTSO-E **brings together the unique expertise of TSOs for the benefit of European citizens** by keeping the lights on, enabling the energy transition, and promoting the completion and optimal functioning of the internal electricity market, including via the fulfilment of the mandates given to ENTSO-E based on EU legislation.

Our mission

ENTSO-E and its members, as the European TSO community, fulfil a common mission: Ensuring the **security of the interconnected power system in all time frames at pan-European level** and the **optimal functioning and development of the European interconnected electricity markets**, while enabling the integration of electricity generated from renewable energy sources and of emerging technologies.

Our vision

ENTSO-E plays a central role in enabling Europe to become the first **climate-neutral continent by 2050** by creating a system that is secure, sustainable and affordable, and that integrates the expected amount of renewable energy, thereby offering an essential contribution to the European Green Deal. This endeavour requires **sector integration** and close cooperation among all actors.

Europe is moving towards a sustainable, digitalised, integrated and electrified energy system with a combination of centralised and distributed resources.

ENTSO-E acts to ensure that this energy system **keeps consumers at its centre** and is operated and developed with **climate objectives** and **social welfare** in mind.

ENTSO-E is committed to use its unique expertise and system-wide view – supported by a responsibility to maintain the system's security – to deliver a comprehensive roadmap of how a climate-neutral Europe looks.

Our values

ENTSO-E acts in **solidarity** as a community of TSOs united by a shared **responsibility.**

As the professional association of independent and neutral regulated entities acting under a clear legal mandate, ENTSO-E serves the interests of society by **optimising social welfare** in its dimensions of safety, economy, environment, and performance.

ENTSO-E is committed to working with the highest technical rigour as well as developing sustainable and **innovative responses to prepare for the future** and overcoming the challenges of keeping the power system secure in a climate-neutral Europe. In all its activities, ENTSO-E acts with **transparency** and in a trustworthy dialogue with legislative and regulatory decision makers and stakeholders.

Our contributions

ENTSO-E supports the cooperation among its members at European and regional levels. Over the past decades, TSOs have undertaken initiatives to increase their cooperation in network planning, operation and market integration, thereby successfully contributing to meeting EU climate and energy targets.

To carry out its **legally mandated tasks**, ENTSO-E's key responsibilities include the following:

- Development and implementation of standards, network codes, platforms and tools to ensure secure system and market operation as well as integration of renewable energy;
- Assessment of the adequacy of the system in different timeframes;
- Coordination of the planning and development of infrastructures at the European level (Ten-Year Network Development Plans, TYNDPs);
- Coordination of research, development and innovation activities of TSOs;
- Development of platforms to enable the transparent sharing of data with market participants.

ENTSO-E supports its members in the **implementation and monitoring** of the agreed common rules.

ENTSO-E is the common voice of European TSOs and provides expert contributions and a constructive view to energy debates to support policymakers in making informed decisions.

Table of Contents

Executive summary

European Electricity Transmission System Operators (TSOs) are currently engaged in an unprecedented transition as they operate in an increasingly complex, digitalised, decentralised, volatile and uncertain environment. This has been particularly highlighted by recent events in Europe, which have contributed to high energy prices, inflation and imploding supply chains. Achieving the goals of the European Commission's ambitious EU Green Deal not only requires further investment in the European Electricity Transmission Grid but also relies heavily on the development and integration of innovative solutions by TSOs. The latter will be crucial given the need to maximise the use of existing infrastructure and to accompany the ongoing and expected transformations of the energy system.

The importance of the development and use of innovative solutions is widely recognised not only by TSOs and solutions providers but also by regulators and policymakers. Significantly, ACER published a position paper on the subject of "incentivising smart investments to improve the efficient use of electricity transmission assets" in November 2021.[1] All assessments conclusively agree on the need to identify the most appropriate tools to support the uptake of innovative solutions, as current regulatory incentives are not sufficient for solutions that could contribute to a more efficient use of the transmission infrastructure.

The situation calls for TSOs, adequately supported by regulation, to accelerate the development and integration of innovative solutions into the electrical transmission grids and to develop bold, agile strategies together with policymakers and stakeholders that address the urgent challenges associated with the Fit-for-55 objectives and prioritise key research, development and innovation activities relating to power transmission.

With this in mind, ENTSO-E is calling for clear, coherent regulatory frameworks that will accelerate the development and deployment of innovative solutions. These frameworks necessitate taking a holistic approach towards incentivising TSO innovation and digitalisation, from early-stage RDI projects through to the wide-scale uptake of mature solutions. In this paper, ENTSO-E proposes a menu of options available to regulators for the adequate support of TSO innovation, depending on the solutions targeted and the maturity of the existing regulations.

Finally, ENTSO-E wishes to highlight the following action points:

i. A properly designed regulatory framework and the incentivising of innovative solutions are necessary to **avoid lengthy acceptance debates** between National Regulatory Authorities (NRAs) and TSOs.

ii. The attractiveness of these (often OPEX-based) innovative solutions, which can benefit the overall cost efficiency of planning and operating the system, needs, therefore, to be adequately recognised.

iii. The gains associated with innovative approaches can be uncertain or hard to quantify ex-ante. As such, deciding whether or not to use a Cost-Benefit Analysis-based approach would need to very carefully weigh the risk of sub-optimal expenses due to error-prone forecasts.

iv. Alternatively, a more holistic approach to incentivising innovation should aim to accompany both the **development of solutions with lower Technology Readiness Levels (TRLs) and their uptake when they achieve sufficient maturity.**

v. Once mature, these solutions will require targeted incentives, which could be based on objective Key Performance Indicators (KPIs).

1 See ACER's Position Paper here.

1 R&D and Innovation Uptake: Two Faces of the Same Coin, though Different Regulatory Approaches are Needed

To achieve climate neutrality before 2050, sustained innovation and the development and deployment of digital solutions are essential for unlocking the potential of the energy transition, though they also imply increased uncertainties and risks.

TSOs within the ENTSO-E community currently deploy a range of innovative technologies relating to Digitalisation and Communication, System Security and Operation, System Flexibility and Markets, Cross-Sector Integration and Scenarios, along with Assets and Technologies, and will do so in the future in even more extensive ways. The deployment of these solutions is highly dependent on the maturity of projects (Technology Readiness Level, or TRL), which also results in the increased potential of different applications.

It should be noted here that ENTSO-E's use of the term innovation comprises a wide range of maturity levels and use cases, from purely OPEX-based spending in R&D activities, designing and implementing prototypes or integrated pilots, to investments in CAPEX-based asset solutions. Innovative CAPEX-based solutions will be equally important in achieving a better-functioning, smart, integrated and interconnected energy system.

The ENTSO-E Technopedia provides an up-to-date overview of these technologies. Projects with different readiness levels require different regulatory incentives that specifically take into account the distinct risks associated with each TRL. These projects can be clustered around three (partly overlapping) stages of innovation:

- **RDI programmes and projects, along with early innovation phases that relate mainly to development and testing, characterised primarily by low(er) TRLs (in the ranges of 1–7).**[2] The described projects are exploratory in nature, with an inherent risk of failure. TSOs should, however, be encouraged to participate in the development and testing of these solutions regardless of the risks. Successful innovation initiatives can bring disruption and potential solutions to achieving the energy transition goals, while "failed" projects bring added value through knowledge building.[3] Treatment of these costs should thus reflect this value, for instance through full cost recovery with no general or individual productivity factors applied.[4]

- **First-of-a-kind projects, which are normally based on rather mature technologies with a TRL of 6–8**, being deployed for the very first time as real-life projects. The risk is still high and needs to be mitigated through the remuneration framework in combination with the support provided by public research and innovation programmes. These first-of-a-kind projects may require regulatory sandboxes that allow for testing in a real-life environment by granting temporary derogations to national (or sometimes EU) regulation for a limited period. Furthermore, WACC or RoE-adders can also provide targeted support for priority investments, be they CAPEX- or OPEX-based.

- **Uptake of innovative solutions with a TRL of 8–9**, referring to the upscaling and replication of already mature solutions (for which the expected benefits can be estimated), which can complement conventional infrastructure investments and accelerate the energy transition. These solutions need to be positively incentivised and adapted to the local environment while taking into account national legislation. While the risk of failure (i. e., the innovative solution failing to reach the targeted objectives) is lower than for less mature projects, it cannot be entirely excluded. The wide-scale implementation of innovative solutions also poses additional risks to the operation of the power system. For example, the first-time use of a new technology can lead to temporarily higher redispatch costs. Already today (and even more so in the future) the major focus will be on curative measures[5] and the efficient use of existing assets, based on the use of innovative flexibility solutions. This might push TSOs to operate the systems of the future **even closer to their limits**, which in turn would increase the risk to TSOs significantly. Regulatory frameworks must recognise the uncertainty associated with innovation projects and reflect the perceived value for consumers and society at large.[6]

Since the risk of classic incentive regulation driven by cost efficiency is that it may lead to innovation being sacrificed for the sake of cost reduction, regulators should focus specifically on the societal and environmental benefits that innovation generates while ensuring the safety and continuity of system operation in dynamically changing conditions. Therefore, national regulatory frameworks should be adapted based on a more holistic and value-based approach. Significantly, this would be in line with the priorities set in the Electricity Directive, which prescribes specific tasks for NRAs regarding the development of a smart grid that promotes energy efficiency and integration of renewables.[7]

---

2 For more information about Technology readiness levels, please see the Annex G of the Horizon 2020 Work Programme 2014–2015

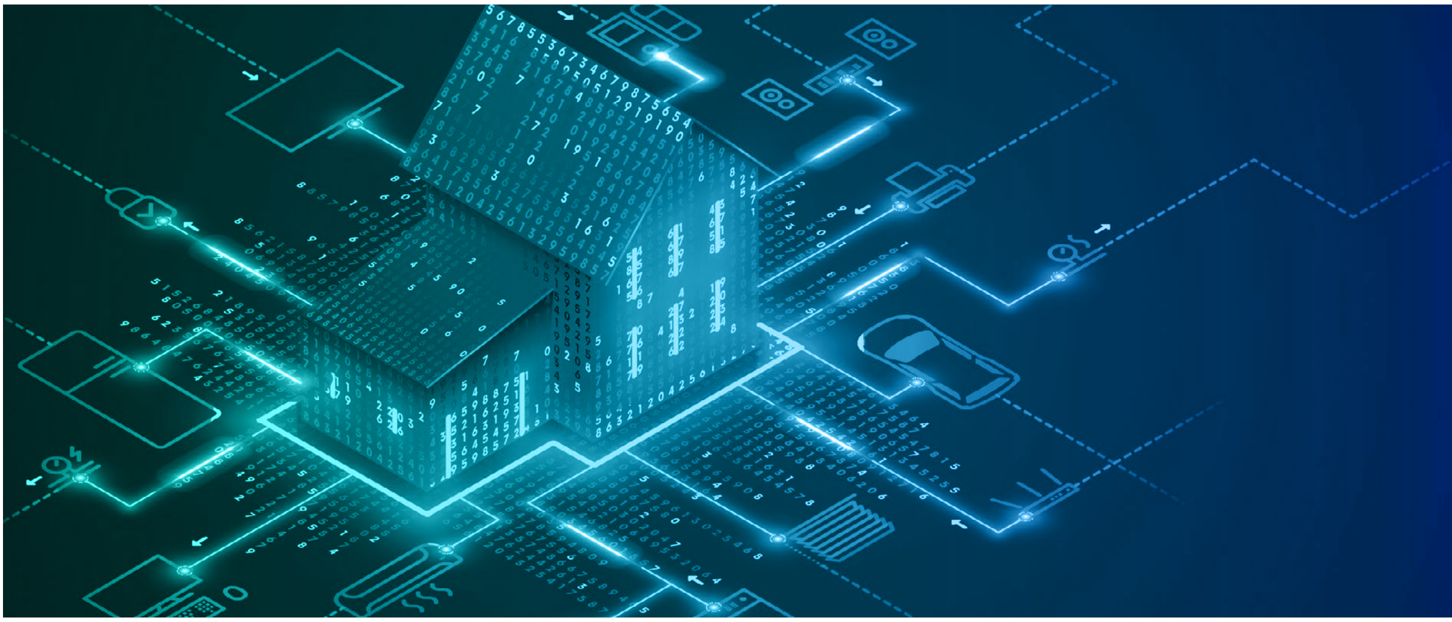
3 For more information, please see the ENTSO-E Technopedia

4 According to a 2020 survey this costs represent in average 0.5% of TSOs yearly budget turnover.

5 Curative measures are a form of remedial action taken by the TSO after the occurrence of a contingency event. They can include redispatching or countertrade measures, the activation of reactive power and network topology changes.

6 ENTSO-E (2021): European Electricity Transmission Grids and the Energy Transition – Why remuneration frameworks need to evolve.

7 EU Directive 2019/944, Article 59.1 (l).



2 Benefits of TSO Innovation

TSOs are **currently** deploying innovative solutions and will continue to do so in the **future**. Innovative solutions are the key to enabling new technological, operational and market options, which TSOs could use to **maximise the use of existing infrastructure and to support the necessary transformations of the energy system in order to achieve** the energy transition.

The "ENTSO-E RDI Roadmap 2020–2030" and the "RDI Implementation Report 2021–2025" shed light on innovation priorities in three RDI areas and six flagships for TSOs in the current decade:

i. **One System of Integrated Systems**

- Flagship 1: Optimise cross-sector integration
- Flagship 2: Develop an ecosystem for deep electrification

ii. **Power Grid, the Backbone of the Energy System**

- Flagship 3: Enhance grid use and development for a pan-EU market

iii. **Cyber-Physical System**

- Flagship 4: Enable large-scale offshore wind energy into the grid
- Flagship 5: Enable secure operation of widespread hybrid AC/DC grid
- Flagship 6: Enhance control centres' operation and interoperability

TSOs' progress towards the completion of the RDI Roadmap will enhance the **optimisation of grid capacity**, leading to a more **efficient electric system**. Future innovation concepts will bring value to all system users through i) higher cost efficiency, ii) maintained reliability of supply, iii) reduced asset environmental footprint, and iv) acceleration of the energy transition (including more timely new connections, the capability to make better use of new technology, and the de-risking of priority investments). In this sense, both society and grid operators benefit from innovation.

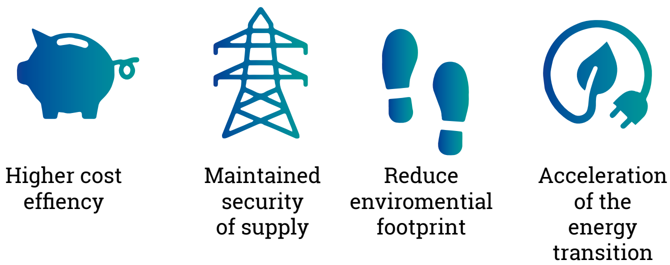


Figure 1: Benefits of TSO innovation (source: ENTSO-E)

3 Quantifying the Benefits of Deploying Innovative Solutions

As shown above, the deployment of innovative solutions can achieve many different benefits, which will ultimately contribute to the achievement of the energy transition. A question remains open, however, when trying to prioritise projects and expenses: how should these benefits be quantified?

It is important to note that the full benefits of any given solution in the system will only be exposed several years after their deployment on a large scale. Even then, isolating the benefits of a single innovative solution may prove to be highly error-prone. This challenge constitutes a key point to be taken into account when designing the necessary adjustments to remuneration frameworks and incentive schemes and thus deciding how to efficiently share the risk of innovation between TSOs and network users.

The quantification of benefits through "monetisation" is not straightforward and neither is the link between incentives for all innovative solutions and the measurable benefits they bring. The use of incentives to encourage TSOs to engage further in the wide-scale deployment of innovation should, therefore, be balanced against the following points:

› **Firstly**, in many cases, an innovative solution can only reach its full potential once widely applied, in which case its real value to society cannot be reliably assessed at the pilot or demonstration phase.

› **Secondly**, due to the fundamentally complex environment in which TSOs operate, the value generated by new investments is hard to predict since it may vary significantly from year to year or even fail to achieve the expected outcome, due to the effects of factors outside the TSO's control. This poses an important challenge under a CBA-based ex-post sharing of benefits and makes it necessary to make assumptions regarding the surrounding environment for a given target year in order to forecast the expected value of investments. Such assumptions may turn out to be true, or not.

› **Thirdly**, not all benefits can be monetised. Innovative technologies can bring benefits that cannot—or can only with a high number of assumptions and uncertainties—be quantified, such as an increase in acceptance, increased safety and decreased risks to maintenance technicians, environmental impact reductions, acceleration of the energy transition or even growth of the industrial innovative ecosystem.

Making a decision based on monetised benefits alone may lead to setting the wrong priorities.

Thus, while TSOs may estimate only some of the expected benefits from deploying innovative solutions, the ex-post measurement of the isolated benefits of the deployed innovative solution may prove to differ significantly from the ex-ante assessment. Determining ex-ante as part of the incentive rules the portion of these benefits to be allocated to the TSO would, then, be a significant unknown, falling short of ENTSO-E's first criterion for good incentive design[8] and failing to provide a clear incentive at the time of the decision to engage in the project (usually 3–5 years prior to implementation).

The challenge of quantifying the expected benefits of deploying innovative grid solutions also has implications for the potential application of a Cost-Benefit Analysis (CBA). As mentioned above, the full benefits of these solutions are only known after their deployment on a large scale has been achieved. Therefore, basing a CBA on an eventually error-prone ex-ante quantification of these benefits may not capture the full picture and lead to suboptimal prioritisation. Finally, the application of a CBA needs to be carefully considered with regard to its effect on the initialisation and implementation of innovative projects, especially where it may lead to a disproportionately high administrative workload in comparison with its value to society.

We suggest that NRAs and TSOs find a common understanding (and even define principles) regarding the real opportunities that performing a CBA would in fact generate. The Technology Readiness Level should also be considered when deciding whether to apply a CBA.

8 See page 22

4 Regulatory Framework Needed: From Sandboxes to Research and Development Plans

A majority of European TSOs and NRAs[9] see room for improvement within the current regulatory frameworks to foster and realise innovative solutions, especially given the need to accelerate the pace of innovation uptake as well as the **new risks** this may pose. Today, most TSOs are faced with enormous investment programmes needed to achieve policy objectives, with which they have trouble coping within the frame of tariff decisions taken by their respective NRAs. In effect, while TSOs already choose the most **efficient solution within the network planning processes**, these constraints may not always be a sufficient catalyst for the necessary innovation uptake.

European regulatory frameworks currently remunerate mostly capital-intensive activities. However, as has recently been observed,[10] future TSO investments will require significant OPEX-based spending on innovative and digital solutions. In addition, most TSOs face situations where their OPEX is subject to efficiency restrictions, and may therefore not be fully recovered, let alone remunerated or rewarded. The attractiveness of these OPEX-based solutions, which can support overall cost efficiency of, among other things, planning and operating the system, therefore needs to be adequately recognised and incentivised by the regulatory framework. Regulation should also target cooperation, especially where positive externalities across network operators can better be captured, thereby leading to more efficient decision-making. Asset-based solutions, which can be CAPEX-intensive, especially at higher levels of maturity (e.g., DLR, STATCOM), will also require a level of remuneration that reflects their potentially higher risks.

9 See CEER (2020): "Report on Regulatory Frameworks for Innovation in Electricity Transmission Infrastructure".

10 See ENTSO-E (2021), "Why remuneration frameworks need to evolve"; also ACER (2021), "Position on incentivising smart investments to improve the efficient use of electricity transmission assets".

This paper identifies a list of possible incentives for regulators to consider, clustered by TRL. This categorisation of solutions aims to propose a holistic approach to the intensification of innovation development and uptake. In this regard, incentives aimed specifically at the development of early innovative solutions and first-of-a-kind projects could form part of a wider Research and Development Plan (see textbox on page 13), enabling not only the full recovery of R&D costs but also a more coherent and holistic regulatory approach to incentivising investments in priority innovation areas.

4.1 For RDI Programmes and Projects (TRL 1–7)

4.1.1 Extra Budgets for Research and Development

Additional budgets on top of the business-as-usual OPEX allowance could provide a potential solution for electricity Transmission System Operators carrying out individual research projects or additional tasks to reduce the pressure caused by efficiency restrictions. Such budgets would show the support and commitment of regulators and society to TSO-led initiatives and projects. Non-refundable extra budgets based on approved operating costs at budget values are a first step toward incentivising TSOs to undertake innovative projects; while TSOs would not earn any reward for demonstrating innovation in this process, regulators would at least prevent the risk of business-as-usual operations consuming the entire operational cost allowance and the danger that TSOs sacrifice innovation efforts to the advantage of efficiency gains encouraged by efficiency incentives or revenue cap systems.

Budget allocation and evaluation could be carried out as part of the annual cost audit. The innovation budgets may be returned to tariffs when not (or only partially) used.

However, the introduction of such budgets alone does not provide a significant incentive to grid operators to investigate and implement innovative solutions, in the sense that their level of return on equity is neither better nor worse whether they do or do not opt for innovative solutions. Incentive schemes based on the attribution of a bonus on top of fair remuneration may be needed to trigger a stronger appetite for risk and uncertainty that are inherent to innovation.

Between 2016 and 2019, an average of 0.5% of the annual TSO budget was spent on RDI activities. These RDI activities involved, on average, 0.36% of the total number of employees fully dedicated to RDI. Moreover, the highest percentage of employees fully dedicated to RDI activities with respect to the total number of employees was 1.65%.[11] Recalling the EC objective established in 2000 whereby Member States shall dedicate 3% of GDP to R&D (a value that stood at 2.3% in 2020), the aforementioned figures clearly show how important the remaining gap is. Accelerating the pace of TSO spending on R&D&I activities will have a key leveraging effect on achieving the energy transition objectives.

11 Source: "ENTSO-E's RDI Roadmap 2020–2030".

4.1.2 Experiment Budget

RDI projects often take the form of collaborative projects, developed jointly by TSOs and third parties (e.g., network users). The involvement of third parties may also be necessary to test the solutions developed. There is, however, a current lack of incentives for many third parties to participate in such experiments, even for participants experiencing disadvantages.

An experimentation budget would endow the TSO with an ex-ante defined budget available for third-party participants in an experiment to incentivise greater participation. Unlike a "general extra budget" that can be used for any kind of R&D project, this would be limited to incentivising third parties to participate in collaborative projects. Through this concept, ENTSO-E hopes to draw attention to the potential for improved coordination between market participants and the need for testing this kind of approach in advance. Under this approach, TSOs could benefit from additional freedom in designing the budget, by determining the subject of the experiment, the number of participants, and their incentives.

Approval from the regulatory authorities would be necessary for determining the amount of the budget ex-ante and controlling its usage ex-post. Particular care should be taken to balance the aim to incentivise participation and the need to avoid undue costs.

Such an experimentation budget could also be designed for collaborative projects between grid operators (TSOs and DSOs), in which case the respective budget would be factored into the grid operator's cost calculation.[12]

4.1.3 Pioneer Bonus

The basic idea behind the pioneer bonus is that several grid operators collaborate on an innovative activity with one grid operator (the "pioneer") actually conducting the activity. The selected innovating grid operator receives a (pro-rata) payment to cover the costs of their innovation activity (the "pioneer bonus") from the other participating grid operators. The resulting outcome of the innovation can then be used by all other participating grid operators.

Broadly speaking, there are two options for financing the costs of the "pioneer" undertaking the innovation:

- A group of grid operators (e.g., in the same geographic area or sharing common characteristics, making it easier to replicate the solution or capture spillovers) could **finance the innovative activity through cross-subsidisation**. The costs would be borne by the grid users.
- The concerned grid operators would pay into a **common innovation fund**, with proportional amounts determined in terms of an objective criterion such as turnover. Grid operators would then submit a project application, with the selection process for the most promising innovation being carried out by the NRA(s). The costs would be borne by the grid users.

In both cases, the concerned grid operators can be both TSOs and DSOs, either on a regional basis or between countries with similar environments and/or existing cooperation frameworks.[13]

12 For more information on this proposal, see the study conducted by Jacobs University and Oxera for TransnetBW in 2021
13 Idem.

4.2 For First-of-a-kind Projects (TRL 6–8)

4.2.1 Regulatory Sandboxes

In addition to technological innovations or new business models, innovations relating to the regulatory framework may also be required. Regulatory experimentation aims for the temporary removal of regulatory barriers, generally involving an exemption of selected actors from rules or responsibilities. This allows these actors to temporarily implement and test innovative solutions in real-world conditions, thereby becoming aware of the true conditions associated with the deployment of such solutions, while also generating regulatory learnings, which can eventually lead to an actual change of regulation where needed.

Regulatory experimentation can take various forms, ranging from more controlled regulatory pilots where NRAs target a specific solution and approve projects on a case-by-case basis, to so-called pilot regulation, where a derogation to a specific regulation is defined, thereby avoiding case-by-case selection by the NRA. Regulatory sandboxes offer an even more open approach, in which both regulated entities and market players may propose their own projects and suggest their own regulatory derogations, rather than the regulator.[14]

The sandbox approach offers several benefits compared to the other options outlined above. Aside from the wider potential range of actors and activities involved, the scope of the granted exemption itself can be broader, since it is proposed by these same actors rather than narrowly pre-defined by the regulator. For instance, regulatory sandboxes could be used to help address situations where TSOs have themselves developed R&D solutions but are unable to implement them due to applicable procurement rules. In this sense, the experiments are innovator-led. Innovators, including grid operators, have an information edge over regulators in terms of identifying promising new technologies and estimating their true costs. On the other hand, however, this approach also requires additional effort and capability on the part of the regulator, who needs to assess applicants and proposed exemptions on a case-by-case basis.

Recent experience with sandboxes is proving to be largely positive, with an increasing number of countries adopting this approach. One barrier to the implementation of regulatory sandboxes, however, concerns the interaction—or rather lack thereof—with EU regulations. Indeed, the sandbox approach, decided on by the national regulator, is only able to confer exemptions to national regulation. This means that any EU provision applicable to a specific technological field or use case automatically constrains the potential for national experimentation unless an exemption procedure is already included in the European regulation. As a possible solution, ACER and CEER note in their "Bridge Beyond 2025 Conclusion Paper" that an "EU umbrella for the sandbox approach" may be beneficial. Under this approach, one option could be to allow NRAs with approval from ACER to set up sandboxes allowing for deviation from selected provisions in EU regulation.

4.2.2 WACC or RoE-adders

In its 2021 paper on remuneration frameworks,[15] ENTSO-E has already noted the following:

WACC and RoE-adders applied to selected, well-defined projects considered of outstanding importance (inter alia those with a direct impact on national or European decarbonisation and sustainability targets or fulfilling other crucial operational objectives) could represent viable means and are actually already implemented in some cases to remedy the detrimental effects caused by an artificial low-interest-rate environment.

For grid users, the attribution of an additional remuneration is seen as a win-win agreement with the TSO. While grid users dedicate a modest amount to that additional remuneration, they receive a guarantee, under the regulator's surveillance, that the necessary efforts will be made toward the implementation of new methods and technologies that will provide higher network security and reliability, greater cost efficiency and/or better market functioning.

14 The distinction between regulatory pilots, pilot regulation and sandboxes is further described in Schittekatte, T., Meeus, L., Jamasb, T. & Llorca, M., 2021. "Regulatory experimentation in energy: Three pioneer countries and lessons for the green transition". Energy Policy, Volume 156, 112382. and is also mentioned in the EUniversal project, Deliverable 10.3 (2022).

15 See ENTSO-E (2021) "Why remuneration frameworks need to evolve", page 27.

These adders, which are complementary to the base remuneration of TSOs, may be used for two different types of innovation projects:

› Innovation projects that primarily involve operational costs (OPEX): Exploration, research and development phases (typically the scoping of the concept and its applications), validation through a proof of concept, prototyping and laboratory test phases (typically TRL 1–7).

› Innovation projects that primarily involve capital costs (CAPEX): Industrialisation phases, typically the creation of an industrial pilot in a representative environment and the implementation at both small and large scales (TRL 6–8 or even 8–9).

WACC/RoE-adders for OPEX-based Projects

In order to provide a stronger encouragement to TSOs to explore alternative options to business-as-usual solutions and to engage in innovation projects, regulators may decide to grant additional equity remuneration in return for the commitment of the TSO to dedicate the necessary OPEX and make a targeted effort to develop new solutions. The rationale for such remuneration adders is that new, unproven methods present uncertainties and risks whereas conventional methods do not. Uncertainties and risks are about the outcome (and chances of success), the complexity, the timing and the required resources, among other things. A WACC/RoE adder provides the impulse that helps the TSO take such risks despite the uncertainties, costs and efforts the project entails.

WACC/RoE-adders for CAPEX-based Projects

Even when an adequate and rigorous investigation has been carried out by the TSO itself, even when prototyping phases have proven successful, roll-out on an industrial scale remains a challenge. Also, even when a technology has already been implemented by a neighbouring TSO, it remains an innovation for the TSO that has no experience with it and a riskier option than business-as-usual technologies. Improving the remuneration for such projects to reflect their potentially higher risk will provide the necessary incentive for the TSO to engage on a more challenging route than usual, for the benefit of society. WACC/RoE-adders should apply for more than one regulatory period (but for the full accounting lifetime of the assets) since there is no possibility of withdrawal once the investment is made.

Research & Development Plans

The incentive solutions mentioned for both early RDI programmes and projects and first-of-a-kind projects could be part of a wider framework at national level, to be assessed on a case-by-case basis, ensuring a coherent and holistic regulatory approach to supporting TSO innovation.

Under this approach, TSOs **would agree with their NRAs on specific areas of innovation for the regulatory period** where new solutions should be investigated. The resources that TSOs dedicate to the identified priorities would in return be subject to a range of favourable regulatory tools, be they dedicated budgets, financial incentives, added remuneration or regulatory trials based on the type of innovation concerned and the maturity level (see above). This would provide a dedicated incentive for TSOs to invest in less CAPEX-intensive, more efficient solutions which may not yet be well suited to a CBA methodology.

The proposed Research & Development Plans (RDPs) would, in this regard, complement the existing range of incentives and regulatory mechanisms available to regulators. By capturing the wider system benefits of deploying innovative solutions and thus enabling forward-looking investments in priority areas that support long-term policy objectives, TSOs and NRAs can promote positive outcomes for customers and market participants in the context of a rapid transition towards an electricity system with a large penetration of renewable energy.

Such RDPs would be national in scope, meaning it should be the national regulator and network operator agreeing on the priority areas. However, RDPs could also further benefit from regional cooperation across countries, such that lessons can be shared and certain innovations are not unnecessarily replicated. They may even be supported at an EU level, especially when an exemption to EU regulation may be needed.

The design and implementation of such RDPs would be on a case-by-case basis and need to take into account the maturity of the regulation, the parties involved (TSOs, regulators and stakeholders) and the amounts at stake. The interrelationship with already existing regulatory tools also needs consideration to enable meaningful incentive regulation. RDPs should always be the outcome of constructive exchanges with stakeholders and NRAs such that a sustainable environment for TSO innovation can be maintained.

4.3 For the Uptake of Innovative Solutions with a TRL of 8–9

4.3.1 KPI-based Incentives

As mentioned in ENTSO-E's 2021 "Paper on Remuneration Frameworks", incentive regulation has proven to be a very effective tool, with increasing interest shown both by network operators (be they TSOs or DSOs) and regulators alike.

While accurately predicting the benefits of TSO innovation faces by definition a number of barriers, as described above, these barriers are reduced when a solution comes closer to full maturity. In such cases, regulators can identify objective metrics based on which the usefulness of projects that have yet to be deployed on a wide scale can be observed and measured.[16] Defining Key Performance Indicators (KPIs) can in turn support the setting of "efficient, reliable and controllable" output-based incentives.[17]

The following examples could be considered as performance or reliability KPIs: Fulfilment of norms, receiving test seals from independent testing committees, the reduction of pollutant emissions (CO_2, noise, etc.), reduction of unscheduled interruptions, the increase of transmission capacities, and so on.

In comparison to a CBA, which is a comprehensive analysis based on a wide and numerous range of criteria but does not necessarily assess if the projected costs are justified, KPI-based incentives can aim directly and efficiently at achieving a specific target (e.g., reduction of noise by a certain percentage).

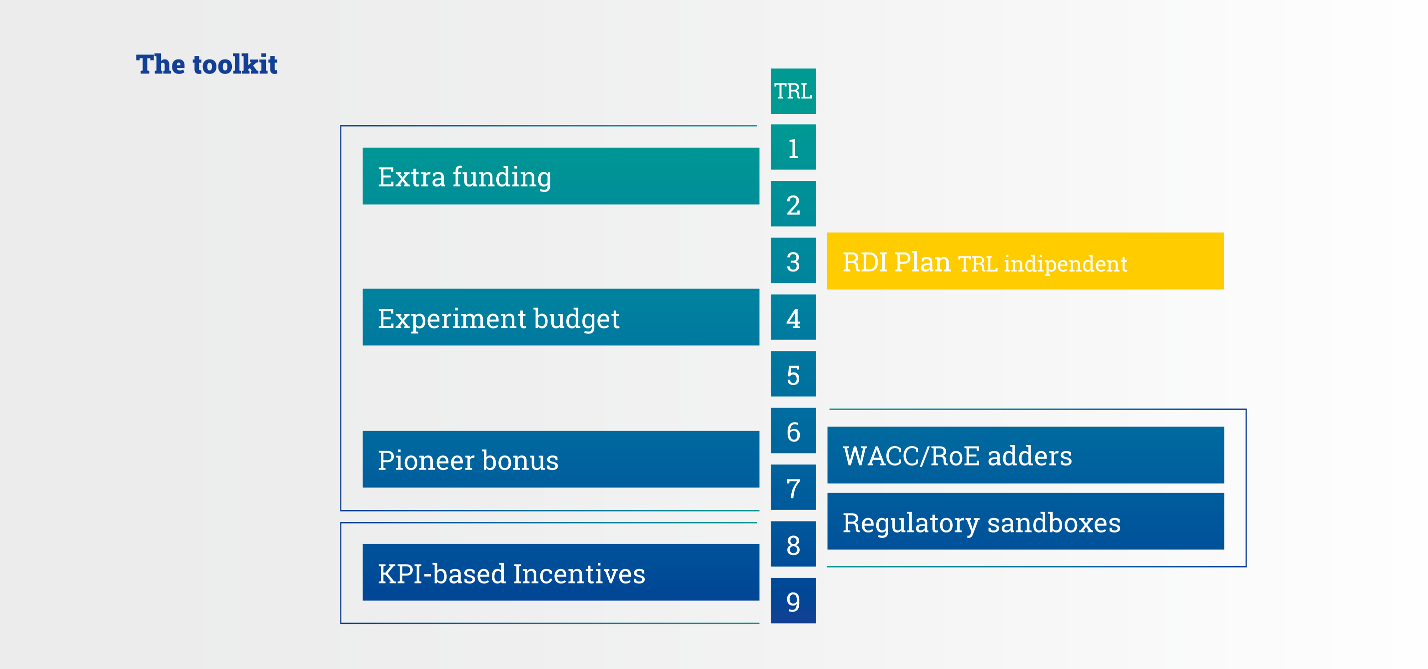


Figure 2: A holistic view of incentivising innovation uptake in Electricity Transmission Infrastructure (source: ENTSO-E)

16 Rious and Rosetto (2018). Continental incentive regulation, in Electricity Network regulation in the EU, edited by L. Meeus and J-M. Glachant.
17 CEER (2017). Incentives Schemes for regulating DSOs, including for Innovation. Consultation Paper.

5 Conclusion and Action Proposals

In this paper, ENTSO-E has aimed to demonstrate that while TSOs are developing innovative solutions, more substantial resources need to be dedicated than previously to achieve the expected benefits and ultimately meet long-term decarbonisation goals.

The focus of incentive regulation on innovation should not, however, be solely on already mature solutions that need to be deployed on a wider scale but should instead adopt a more holistic view of innovation across the various stages, from early RDI programmes to innovation uptake. Doing this will ensure that both TSOs and society as a whole benefit from the integration of the most efficient solutions, not only in the coming decade but also in the following ones as the planning and operation of the system become even more complex.

In this regard, ENTSO-E has proposed a toolkit for regulators, consisting of potential regulatory tools ranging across a broad spectrum, from regulatory experimentation to financial incentives. Moreover, given the importance of accompanying solutions to higher levels of maturity such that they can be deployed on a wider scale, Research and Development Plans could support a more holistic regulatory approach to innovation.

Finally, ENTSO-E wishes to highlight the following actions needed to adequately incentivise innovation:

1. A properly designed regulatory framework and incentivising innovative solutions are needed to avoid lengthy acceptance debates between National Regulatory Authorities (NRAs) and TSOs.

2. The attractiveness of these (often OPEX-based) innovative solutions, which can support the overall cost efficiency of planning and operating the system, needs, therefore, to be adequately recognised.

3. Gains from innovative approaches are uncertain or hard to quantify ex-ante. As such, deciding whether or not to use a Cost-Benefit Analysis-based approach needs to carefully weigh the risk of suboptimal expenses due to error-prone forecasts.

4. Instead, a more holistic approach to incentivising innovation should aim at accompanying both the development of solutions with lower Technology Readiness Levels (TRLs) and their uptake when having achieved sufficient maturity.

5. Once mature, these solutions require targeted incentives, which could be based on objective Key Performance Indicators (KPIs).

Abbreviations

ACER	The European Union Agency for the Cooperation of Energy Regulators
CAPEX	Capital Expenditure
CBA	Cost-Benefit-Analysis
CEER	Council of European Energy Regulators
CBA	Cost-benefit Analysis
DSO	Distribution System Operator
ENTSO-E	European Network for Transmission System Operators in Electricity
KPIs	Key Performance Indicators
NRA	National Regulatory Authority
OPEX	Operational Expenditure
R&D	Research and Development
RDI	Research, Development and Innovation
RoE	Return on Equity
TRL	Technology Readiness Level
TSO	Transmission System Operator
WACC	Weighted Average Cost of Capital

Technology Readiness Levels

Technology Readiness Levels (TRLs) are a method for estimating the maturity of technologies. The use of TRLs enables consistent, uniform discussions of technical maturity across different types of technology. A technology's readiness level is determined during a Technology Readiness Assessment that examines program concepts, technology requirements, and demonstrated technology capabilities.

TRLs are based on a scale from 1 to 9 with 9 being the most mature technology. Please find the definition of each level in the following list:

› **TRL 1** – Basic research: basic principles are observed and reported

› **TRL 2** – Applied research: technology concept and/or application formulated

› **TRL 3** – Critical function, proof of concept established

› **TRL 4** – Laboratory testing of prototype component or process

› **TRL 5** – Laboratory testing of integrated system

› **TRL 6** – Prototype system verified

› **TRL 7** – Integrated pilot system demonstrated

› **TRL 8** – System incorporated in commercial design

› **TRL 9** – System ready for full scale deployment

Source: ENTSO-E Technopedia TRLs

Publisher

ENTSO-E AISBL
8 Rue de Spa | 1000 Brussels | Belgium
www.entsoe.eu | info@entsoe.eu

© ENTSO-E AISBL 2022

Design

DreiDreizehn GmbH, Berlin | www.313.de

Images

cover: iStockphoto, ipopba
page 5: iStockphoto, Black_Kira
page 7: aerogondo – stock.adobe.com
page 9: MASAFUMI – stock.adobe.com
page 10: iStockphoto, petmal

Publishing date

June 2022

European Network of
Transmission System Operators
for Electricity