



# **Do current regulatory frameworks in the EU support innovation and security of supply in electricity and gas infrastructure?**

Country Report - Luxembourg



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## EXECUTIVE SUMMARY

### Assessment of the NRF and the regulatory practice of the electricity and gas sector in Luxembourg

The Luxembourg NRF and regulatory practices for electricity and gas have many similarities, for this reason in this summary no distinction is made between electricity and gas.

#### The NRF in Luxembourg

The NRF in Luxembourg is characterised by a revenue cap (maximum allowed income), which allows for added remuneration for projects with high added value for consumers. Significant investment projects (i.e. above 1 Mio Euros for electricity, above 0.5 Mio Euros for gas and cross-border projects) are individually assessed. Moreover, in the current regulatory period additional financial rewards have been permitted for Creos, the (gas and electricity) TSO, to carry out individual investments, such as the fitting out of the medium and low voltage stations with remote and control systems; the integration with the German balancing market; and the insertion of an advanced tariff structure to improve the network user's participation in the efficiency of the system. There are several non-controllable operating expenses specified which are taken into account when determining the maximum allowed income, such as R&D costs, which may be included in the network tariff up to 1% of the maximum allowed income.

In Luxembourg, we have not found evidence of explicit duties to innovate, but we have found explicit reference to innovative technologies, innovative investments and concepts linked to innovation in the regulatory framework. There is a modernisation agenda-targeting introduction of smart grids and new technologies: the NRA has defined particular projects with financial benefits if the projects are fulfilled. The tariff methodology includes pass through of R&D costs related to TSOs activities, which may be included in tariff up to a cap of 1% of the maximum allowed income. However, the Electricity Law does not provide specific duties to encourage innovation for the ILR or the Ministry.

The NRA, ILR, does not have specific duties relating to security of supply – instead, the Ministry is solely responsible i.e. the Ministry monitors the balance between supply and demand, the existing and planned production capacities, the necessary investments and the safe operation of the networks. Creos is required to contribute to the security of supply through having adequate transmission capacity.

#### The regulatory practice in Luxembourg

The NRF works well in general, but stakeholders identified potential barriers and possibilities for improvement. Barriers mentioned encompass disincentives to invest in OPEX solutions (especially smart grid solutions replacing planned grid investment) due to a CAPEX bias in the regulation. Moreover, the requirement to stay within costs/budget, timeframe and a certain CAPEX-OPEX ratio is perceived to increase the riskiness of innovative projects.

The share of innovative projects is low according to respondents, being less than 10%. The stakeholders noted that there are not many regulatory incentives for innovation in place. The monetary incentives for special innovative projects relate predominantly to DSO activities. The stakeholders criticize that there are no incentives for market integration, no incentives for storage projects and power to gas projects. Lastly, the stakeholders believe that there is a need for a long-term investment plan for innovation.

In contrast, around 80% of the projects are related to security of supply. The NRF is considered adequate to support security of supply investments.

#### Options for improvement

Although the NRF seems well designed for security of supply, using the issues drawn from the above summary, the following options for improvement could be applied:

- i. Bonus system for meeting deadlines: the perceived riskiness for (innovative) projects can be lowered by making deadlines more flexible or by removing penalties attached to these deadlines for defined risky or innovative projects. In addition, a bonus system for meeting deadlines could be introduced to provide an incentive to meet deadlines for risky and innovative projects;
- ii. Incentives for specific OPEX-based solutions, e.g. financial incentives for IT-technologies;

- iii. Statutory requirement to consider alternatives;
- iv. Statutory reference to innovation as a duty of the network operator; and
- v. Consultation on investment plans on the national plan and on a project level. Stakeholder consultation can also be used to determine OPEX solutions to be favoured from option (iii) and help shape the long-term perspective on innovation of option (iv).

We consider that, with the exception of the options (iii)-(v), the above mentioned changes could be implemented using legal powers already available to the NRA or others under the existing NRF.



## 1. INTRODUCTION

The present Country Report is a deliverable of the study “Do current regulatory frameworks in the EU support innovation and security of supply in electricity and gas infrastructure?”

The key objective of the study is to analyse how the existing national regulatory frameworks (NRFs) in the EU guide and incentivise the electricity and gas transmission project promoters to undertake investments. The focus of the study is both on investments in new innovative technologies and investments to increase security of supply. The main objective of the study is to map how the regulatory frameworks in the MSs support such investments and how these frameworks ensure that the necessary investments are made.

This Country Report provides an overview of both the current legal frameworks and their implementation practice related to investments in gas and electricity transmission infrastructure. As part of this analysis, selected specific infrastructure projects in electricity and gas are discussed. Based on this research, options for improvement have been formulated, both relating to the implementation practice and to legal changes.

The Country Report is based on previous study deliverables and analyses. It is divided into two main sections, Section 2, which is related to electricity, and Section 3, which is related to gas. Each of these sections examines the legal framework (Section 2.1 for electricity and Section 3.1 for gas), including specific rights and duties of relevant parties, such as TSOs and NRAs (hereafter also referred to as stakeholders), mechanisms for the financing of investment projects and the regulatory rules regarding innovation and security of supply in particular. Having studied the legal regulatory framework, Section 2.2 for electricity and Section 3.2 for gas examine the regulatory practice in Luxembourg, drawing specifically on stakeholder interviews, and paying particular attention to the regulatory practice related to innovation and security of supply. The functioning of the legal framework and the regulatory practice are illustrated by selected specific projects in Luxembourg. Lastly, options for improvement of the regulatory practice and the regulatory framework are discussed in Section 2.3 for electricity and Section 3.3 for gas.

These options for improvement are taken from a long list of best practises that the project team has compiled based on the analysis of regulatory frameworks in all Member States. We acknowledge that we have not carried out a full analysis of all the costs and benefits of the suggested options. Therefore, some of these options are conditional and there might be reasons that we did not take into consideration not to implement them.

The focus of this report is not primarily on R&D investments and projects, but rather on “innovative” transmission infrastructure related investments. In order to define what “innovative” is in the context of this report, we have introduced the notion of “typological investments” (see Annex I and II). The goal of selecting “typological investments”, which, in our understanding, are categories of investments, was to make the discussion concrete and the investments comparable across countries. The term “typological investment” relates to technical solutions that TSOs can adopt to provide the transmission capacities needed to cover the transmission demand of grid users.

Thus, a typological investment is meant to be a type of solution that can be implemented, in principle, by any TSO in situations in which these solutions are appropriate to provide the desired benefit. Hence, typological investments are not specific to a concrete location or a particular TSO. Annex I provides a list of typological investments in the electricity sector, whereas Annex II provides the same for gas.

Ultimately, these technical solutions contribute to fulfilling the objective to improve or maintain the level of security of supply. It has to be noted that the degree of innovativeness of typological investments can be quite diverse, ranging from construction of conventional assets like AC overhead lines or pipelines with conventional materials and construction methods down to novel concepts of system automation and operation based on recent R&D achievements. Innovation aims at providing the desired level of transmission capacity – determined by the objectives of security of supply (see above) – in a way that is in some way superior to the conventional way, e.g.:

- i. by immediately reducing overall cost as compared to a conventional solution;

- ii. by prospectively reducing overall cost in the future, subject however to a “learning curve” as to the cost level of the innovative solution;
- iii. by accelerating the process of transmission capacity expansion and thus reducing social welfare loss caused by temporarily insufficient transmission capacities; or
- iv. by providing improvements with respect to other criteria that are often difficult to monetarise, like environmental or public acceptance aspects.

Innovative investments, especially those whose benefits fall into category ii., iii. and iv. named above, can face certain barriers and market failures. We have identified five categories of innovative projects which might encounter potential regulatory barriers (see also Annex III for more explanation):

- a. Capital intensive projects resulting in uncertain future OPEX gains (efficiency improvements / cost reductions) are not incentivised by the regulatory framework;
- b. Projects with potential significant benefits, which would benefit primarily the wider society and where the concerned TSOs are not incentivised;
- c. A roll out and investment in smart grids substituting planned physical investments may provide a reduction in the regulated asset base, but might not be realised due to an increase in tariffs or regulatory disincentives;
- d. Projects with few or no commercial benefits to justify the investment, but with positive social impacts;
- e. Projects, which result in a lower TSO TOTEX, but bring about a shift in the CAPEX/OPEX ratio, which is not incentivised by the regulatory framework.

Our understanding of innovative investments and typological investments, and the categorisation of investment projects in relation to possible regulatory barriers are the basis for the research done in the context of the analysis of the implementation practice in this report.

## 2. ELECTRICITY

### 2.1. Legal analysis of the NRF in Luxembourg

#### 2.1.1. Overview of the regulatory framework of Luxembourg – legal rules

The “transmission” of electricity, for the purposes of the Legal Framework in Luxembourg, means the transmission on the high voltage and high voltage power line interconnected for the purpose of supply to the end consumers or distributors<sup>1</sup>. The Luxembourg electricity grid, being connected to the German grid, is routed via two 220 kV2 high-voltage double lines (220,000 volts).

The law of 1<sup>st</sup> August 2007 on the organization of the electricity market (the “**Electricity Law**”)<sup>3</sup> is the main piece of primary legislation governing the Legal Framework in Luxembourg.

L’*Institut Luxembourgeois de Regulation* (“**ILR**”)<sup>4</sup> (a public institution having a legal personality<sup>5</sup> and the independent regulator) and the Government Commissioner for Energy<sup>6</sup> (the “**Ministry**”) have duties and objectives derived from the Electricity Law.

As far as relevant to the transmission network development, the duties and objectives are as follows:

- ILR: (i) promotes a competitive, secure and environmentally sustainable internal electricity market within the EU, an effective market opening for all consumers and suppliers in the EU and ensures the appropriate conditions for electricity networks to operate effectively and reliably, taking into account long-term objectives<sup>7</sup>; (ii) removes the barriers for electricity trade between the Member States, including by the establishment of sufficient cross-border transmission capacity in order to meet the demand and strengthen the integration of the national markets, which should allow for a secure supply of electricity for the whole EU<sup>8</sup>; (iii) ensures that network operators and network users receive sufficient incentives, both on a short and long term, enabling them to improve the network performance and promote the market integration<sup>9</sup>; (iv) monitors the investment plans of the transmission system operators and provides, in its annual report, an analysis of the investment plans of the transmission system operators in terms of their consistency with the 10-year network development plan for the transmission system in EU<sup>10</sup> and recommendations for their improvement<sup>11</sup> and (v) contributes, in cooperation with the Ministry, to ensuring compliance with the rules governing the safety and reliability of the network and for assessing its past performance, and to defining or approving the standards and requirements to be met for the quality of service and supply<sup>12</sup>;
- The Ministry monitors the general estate of networks and interconnections as well as the security and the quality of supply<sup>13</sup>. Said monitoring covers, *inter alia* the balance between the supply and demand on the national market, the quality and level of the maintenance and the security of the networks, the level of investments required for the current and future functioning of the infrastructure as well as all aspects concerning the quality of electricity<sup>14</sup>. In addition, the Ministry is in charge of drawing-up (i) a two year reports on all aspects of security and the quality of supply, including without limitation

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<sup>1</sup> Item (50) Article 1 of Law of 1st August 2007 on the organization of the electricity market.

<sup>2</sup> <http://www.creos-net.lu/creos-luxembourg/infrastructure/reseau-deelectricite.html>.

<sup>3</sup> The Electricity Law was further amended by the law of 18 December 2009, the law of 17 December 2010, law of 7 August 2012 and law of 19 June 2015.

<sup>4</sup> <https://web.ilr.lu/FR/ILR>.

<sup>5</sup> Article 1 of the law of 30 May 2015 regarding the organization of ILR.

<sup>6</sup> Article 11 of the Electricity Law.

<sup>7</sup> Article 54 (1) letter (a) of the Electricity Law.

<sup>8</sup> Article 54 (1) letter (c) of the Electricity Law.

<sup>9</sup> Article 54 (1) letter (f) of the Electricity Law.

<sup>10</sup> As referred to in Article 8 (3) (b) of Regulation (EC) No 714/2009.

<sup>11</sup> Article 54 (2) letter (h) of the Electricity Law.

<sup>12</sup> Article 54 (2) letter (i) of the Electricity Law.

<sup>13</sup> Article 11 (1) of the Electricity Law.

<sup>14</sup> Article 11(2) of the Electricity Law.

the operational safety of the network and (ii) a prospectus on the security of supply for next 5 up to 10 years and the investment projects<sup>15</sup>.

### **2.1.2. Specific legal rights and duties**

#### **Role of the TSO**

Transmission system operation (the SO) and transmission ownership (the TO) roles belong to the same entity. Luxembourg has one transmission system operator (for electricity transmission), namely Creos Luxembourg SA (the "TSO"). The TSO also operates the interconnection with the Belgian transmission grid.

The main objective of the TSO<sup>16</sup> is to ensure the management and operation of the transmission and distribution electricity network, including its maintenance and the development of the networks. To this end, the TSO may: (i) carry out any investment necessary to ensure the security of energy distribution / delivery and build or maintain a viable infrastructure and / or infrastructure with an optimal operation and performance and (ii) procure, either directly or indirectly all authorizations and concessions in connection with the development of the network. In addition to securing electricity supply and monitoring the electricity market, the TSO is targeting the introduction of smart grids and new technologies over the coming years.

The Electricity Law sets out various obligations for the TSO(s) which are specific to the security of supply, including without limitation:

- Obligation for the TSO to establish the technical safety criteria and the minimal technical requirements such as the design, construction, operating or operation of the connection of production plants, networks and electricity works to be carried out at the directly connected the consumers, interconnection circuits and direct lines. Where necessary, the TSO shall consult the TSOs of the neighbouring countries<sup>17</sup>; in case of issues, the TSO needs to inform the other concerned TSOs, the Ministry and as well the ILR;
- The TSO (and where appropriate in conjunction with other concerned TSOs) shall: (i) guarantee the long-term capacity of the network to meet reasonable demands for electricity transmission capacity, operate, maintain and develop, under economically acceptable conditions, safe, reliable and efficient networks; (ii) contribute to the security of supply through adequate transmission capacity, by the rehabilitation of the network and by securing operation of said network; (iii) manage the flow of energy in the network taking into account the exchanges with other interconnected networks; and (iv) draw-up, by consulting the Ministry and ILR, a safeguarding code<sup>18</sup> and a reconstitution code<sup>19</sup>;
- The TSO is required to measure and document the quality of the electricity, namely the voltage and the continuity of supply, the latter being assessed, in particular, by the degree of unavailability, the quantity of electricity not supplied, the average duration and the probability of interruption<sup>20</sup>.

#### **Undertaking of investments**

The TSO is required to carry out any investment projects in order to comply with the legal obligations as described above. The projects are meant to strengthen the interconnections of electricity transmission networks with those of the neighbouring countries (as described in the subsection on the role of the NRA below) and to increase the security of supply in Luxembourg.

#### **Role of NRA regarding investment projects undertaken by the TSO**

The 10 year development plan shall include an estimate of the potential evolution of electric load and investments to be considered in the network development. The TSO said, "*The results of all our calculations show a massive increase in grid load and the pressing need for the future development of the transmission grid*"<sup>21</sup>. The TSO is currently running a public consultation for a

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<sup>15</sup> Article 11 (3) of the Electricity Law.

<sup>16</sup> [http://www.te.public.lu/fr/participations/societes\\_droit\\_priv%C3%A9/non\\_cotees\\_en\\_bourse/creos.html](http://www.te.public.lu/fr/participations/societes_droit_priv%C3%A9/non_cotees_en_bourse/creos.html).

<sup>17</sup> Article 8 (1) of the Electricity Law.

<sup>18</sup> [http://www.creos-net.lu/fileadmin/dokumente/downloads/publications\\_techniques/pdf/fr\\_info\\_code\\_reconstitution\\_sauve\\_garde.pdf](http://www.creos-net.lu/fileadmin/dokumente/downloads/publications_techniques/pdf/fr_info_code_reconstitution_sauve_garde.pdf).

<sup>19</sup> Article 9 (2) of the Electricity Law.

<sup>20</sup> Article 10 (2) of the Electricity Law.

<sup>21</sup> <http://www.creos-net.lu/actualites/actualites/article/scenario-report-2040-public-consultation.html>.

program called Scenario Report 2040. The results and documents will be delivered to the Ministry. This scenario proposes, in order to secure the electrical power supply in Luxembourg for the medium and long term to (i) replace the existing 220kV lines from Trier/Quint by stronger higher voltage level lines (400kV); (ii) reinforce the existing 220kV lines coming from Bauler/Niederstedem; and (iii) extend the new 400kV grid towards the neighbouring countries (Belgium).

The TSO started a network development study aiming to investigate an optimal long-term network strategy for the Luxembourg grid. The TSO in cooperation with the neighbouring TSOs, in particular Elia, Amprion GmbH (Amprion) as well as RTE Réseau de Transport d'Electricité (RTE), analysed several potential long-term network solutions to ensure that the Luxembourg supply is safe and secure until 2030. The TSOs also investigated potential immediate measures until 2020 for said purposes.

The decision to implement a physical interconnection between Luxembourg and Belgium (the so-called Interconnector BeDeLux) was mainly triggered by the Luxembourg security of supply considerations. Besides this, the new interconnection will contribute to European electricity market integration by connecting at physical level the transmission grids of Elia and the TSO<sup>22</sup>. The general developments in connection with BeDeLux started with the commissioning of phase shifter transformers in Bascherdange and Schiffflange<sup>23</sup> although the TSO will reuse existing infrastructure to create new interconnection<sup>24</sup>.

The Transmission System Operators (TSOs) of the PLEF region (AT, BE, CH, DE, FR, LU, NL) are cooperating in order to develop new methodologies and investigate the security of electricity supply (SoS) – the serving of electricity demand of all customers - on European regional level. This study is an important outcome of the TSO collaboration at the regional level<sup>25</sup>.

### **Institutional or procedural constraints on the performance of these roles**

For the new regulatory period 2017 -2020 (as detailed Section 2.1.3 below), the TSO has identified two important restrictions:

- (i) The first concerns the return on capital invested: Given the drop of the interest rates in the past years, ILR lowered rates on investments compared to the previous regulatory period. The TSO has also said, "Costs accepted by [ILR] will have a direct impact on the future development of [the TSO's] results. ILR is encouraging [the TSO] to reduce their costs. However a large part of these are fixed because they are tied to employee compensation"<sup>26</sup>; and
- (ii) The second concerns the strictness of the rules. The TSO has said, "The new rules implemented by ILR are at the same time more restrictive and more rigorous. Controls of [the TSO's] activities, whether for maintenance, outages or investment, are much stricter and require [the TSO] to provide more information and documentation".<sup>27</sup>

#### **2.1.3. Mechanism for financing of investment projects**

In the absence of competition in the Luxembourg energy networks, ILR should protect consumers by acting as a proxy for normal competitive forces. The tariff method regulation<sup>28</sup>, as established by ILR for the regulatory period between years 2017 - 2020, sets out the principles applicable to all network operators for determining their network costs and translating them into a tariff structure. The principle features used are the calculation of depreciation

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<sup>22</sup> [http://www.creos-net.lu/fileadmin/dokumente/Creos\\_Luxembourg/pdf/160216\\_O\\_A\\_ICBeDeLux.pdf](http://www.creos-net.lu/fileadmin/dokumente/Creos_Luxembourg/pdf/160216_O_A_ICBeDeLux.pdf).

<sup>23</sup> [https://assets.ilr.lu/energie/Consultations/20141103\\_developpement-decennal-RT/Plan-decennal-2014-2023-220-kV.pdf](https://assets.ilr.lu/energie/Consultations/20141103_developpement-decennal-RT/Plan-decennal-2014-2023-220-kV.pdf).

<sup>24</sup> [http://www.creos-net.lu/fileadmin/dokumente/Creos\\_Luxembourg/pdf/Website\\_OA\\_ICBeDeLux\\_final.pdf](http://www.creos-net.lu/fileadmin/dokumente/Creos_Luxembourg/pdf/Website_OA_ICBeDeLux_final.pdf).

<sup>25</sup> <http://www.creos-net.lu/actualites/actualites/article/second-report-on-generation-adequacy-assessment-within-plef-region.html>.

<sup>26</sup> [https://www.creos-net.lu/fileadmin/dokumente/downloads/rapport\\_annuels/pdf/gb\\_creos\\_annual\\_report\\_2016.pdf](https://www.creos-net.lu/fileadmin/dokumente/downloads/rapport_annuels/pdf/gb_creos_annual_report_2016.pdf).

<sup>27</sup> [https://www.creos-net.lu/fileadmin/dokumente/downloads/rapport\\_annuels/pdf/gb\\_creos\\_annual\\_report\\_2016.pdf](https://www.creos-net.lu/fileadmin/dokumente/downloads/rapport_annuels/pdf/gb_creos_annual_report_2016.pdf).

<sup>28</sup> <http://data.legilux.public.lu/file/eli-etat-leg-memorial-2016-91-fr-pdf.pdf>: See Regulation E16/12/ILR of 13 April 2016 laying down the methods for determining the tariffs for use of the transmission network and distribution for industrials and ancillary services for 2017-2020.

according to the straight-line method and based on investments made and valued at their historical acquisition value, as well as the calculation of the return on capital.

ILR has improved the financial incentives<sup>29</sup> for the network operators by clarifying the accounting for the activities that are not part of the regulated scope, optimizing the procedure of significant investment projects and setting up additional remuneration in the event of implementation of specific projects with high added value for the consumers, as further described.

Regulation E16 / 12 / ILR takes into account the partial decoupling between the actual and maximum allowed income<sup>30</sup> and an individual assessment of significant investment projects<sup>31</sup>. From 2017, the latter includes the investments which are exceeding one million euros and which are out of the ordinary framework of day-to-day management as well as investments valued at less than EUR 1 million but having a cross-border impact.

The Regulation E16 / 12 / ILR inserted new incentives<sup>32</sup>, such as (i) an incentive awarded for the development of individual projects in line with project planning while retaining the necessary flexibility for the occurrence of unforeseeable events; and (ii) a financial benefit for the network operator and users in the event of good financial management of the project. Moreover, said Regulation sets out additional financial rewards to be allowed to the TSO for carrying out individual investments, such as the fitting out of the medium and low voltage stations with remote and control systems; the integration with the German adjustment market and the insertion of an advanced tariff structure to improve the network user's participation in the efficiency of the system.

Several uncontrollable operating expenses, in determining the maximum allowed income, are to be considered in the Specified Pass Through for the year (SPTt factor, part of the computation formula below) and therefore deducted from said maximum allowed income. The research and development costs are included amongst these expenses (as per Appendix 4 item 1 letter (o) of the Regulation E16 / 12 / ILR). These costs shall arise from an external service provided to the TSO by an independent research institute and the development project must be directly linked to the activities of the network operator. The TSO's costs regarding the research and development may be included in the network's tariff up to a maximum of 1% of the maximum allowed income unless ILR has prior agreed to the exceeding of said threshold.

#### **2.1.4. Regulatory rules with respect to innovation**

##### **Specific duties of the TSO aimed at encouraging innovation**

The Electricity Law does not provide specific duties at encouraging innovation for ILR or the Ministry. Being required to maintain and develop the electricity infrastructure through e.g. a smarter grid in order to enhance the rehabilitation and efficiency TSO is indirectly supporting the development of innovation.

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<sup>29</sup> <https://assets.ilr.lu/energie/Documents/ILRLU-1685561960-449.pdf>.

<sup>30</sup> Each year, the calculation of the maximum authorized income is made uses the following computation formula:

$$\text{MART} = \text{RAVt} * \text{WACC} + \text{Dt} + \text{COT} + \text{SPTt} - \text{RATt} + \text{Qt}$$

where:

t = year;

MART = Maximal Allowed Revenue for the year;

RAVt = Regulated Asset Value for the year;

WACC = weighted average cost of capital;

Dt = Depreciation for the year;

COT = Controllable OPEX for the year;

SPTt = Specified Pass Through for the year (to take into account as per Appendix 4 of the Regulation E16/12/ILR);

RATt = Regulatory Account Term for the year;

Qt = quality factor.

<sup>31</sup> Article 14 (1) of Regulation E16 / 12 / ILR.

<sup>32</sup> <https://assets.ilr.lu/energie/Documents/ILRLU-1685561960-448.pdf>.

### **Specific duties of the NRA aimed at encouraging innovation**

There are no specific duties of ILR to encourage innovation in terms of the statutory framework; however, a specific provision of the tariff mechanism outlined above at Section 2.1.3 aims indirectly at promoting innovation.

The Electricity Law specifies that the ILR is responsible for monitoring the investment plan of the national transmission system every two years. This plan is drawn up by the TSO according to the technical safety criteria defined in such a way as to ensure the security of supply by favouring solutions supporting sustainable development and whose costs are efficient and reasonable, and according to technical requirements ensuring the interoperability of networks to be objective and non-discriminatory. To this end the TSO, has put in place a major investment plan, which features in particular the reinforcement and modernization of its networks. New technologies are taking an important place and are facilitating the management of balance between supply and the demand<sup>33</sup>. It is worth mentioning that certain investments are innovative by nature for e.g. the commissioning of the phase shifter transformers to be added to the existing infrastructure in order to avoid doubling the investments.

#### **2.1.5. Regulatory rules with respect to security of supply**

##### **Specific duties of the TSO aiming at safeguarding security of supply**

In order to support the economic development of Luxembourg and to cope with the permanent growth of the population, regular investments in the networks (including electricity transmission) are essential to maintain a level of security and quality of supply. In addition, the modernization of networks to make them more "intelligent" and capable of managing increasingly variable flows requires certain investments in measurement, monitoring and remote control equipment<sup>34</sup>.

In order to be able to import the energy required to cover the TSO's ever-increasing load (electric mobility, data centres, etc.), projects aiming to reinforce the transmission network with those of neighbouring countries are also needed<sup>35</sup>. "According to the latest evaluations, the n-1 criterion is covered by the existing German interconnection. The need for the investment in new cross-border interconnections with Belgium, in new generation capacity and in upgrades of the internal grid is analysed by TSO in view of improving the security of supply"<sup>36</sup>. As there are insufficient emergency generation reserves in Luxembourg, load shedding might be the only viable emergency response tool<sup>37</sup>.

As a rule the development of the national electricity grid is based upon the 10-years investment plan (as per article 11 (3) letter (d) of the Electricity Law) and therefore the TSO should anticipate all changes in energy production and consumption. The first objective of the TSO's long-term planning<sup>38</sup> is the security of supply of the Luxembourg high voltage networks justified by the fact that a loss of any part of the high-voltage network would lead to a loss of consumers.

## **2.2. Regulatory practice**

### **2.2.1. Overview over regulatory practice in Luxembourg**

#### **Information about the general regulatory framework in Luxembourg**

The NRA sets the tariff methodologies and it has an obligation to include adequate financial incentives, such as a general capital expenditure incentive. The tariff calculation methodology for the regulatory period 2017-2020 has been set in April 2016. There are two separate methodologies for electricity and gas, but there is no differentiation between the TSO and DSO business.

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<sup>33</sup> <http://www.creos-net.lu/creos-luxembourg/innovation/smart-grid/reseau-du-futur.html>.

<sup>34</sup> Item 2, ILR rapport published on 22 January 2018 regarding investments on electricity transmission <https://assets.ilr.lu/energie/Documents/ILRLU-1685561960-480.pdf>.

<sup>35</sup> <https://assets.ilr.lu/energie/Documents/ILRLU-1685561960-448.pdf>.

<sup>36</sup> <http://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX:52014SC0311>.

<sup>37</sup> <http://www.creos-net.lu/index.php?id=556>.

<sup>38</sup> [http://www.creos-net.lu/fileadmin/dokumente/Creos\\_Luxembourg/pdf/fr\\_planification\\_reseaux\\_ht.pdf](http://www.creos-net.lu/fileadmin/dokumente/Creos_Luxembourg/pdf/fr_planification_reseaux_ht.pdf).

Regarding project financing: for the DSO, the NRA monitors the procedures of how investment takes place. If the NRA agrees on the process, the DSO can recover the actual costs. The TSO's projects, on the other hand, fall under special assessment, i.e. individual investment projects are assessed. The condition that projects under 1 million Euro are not assessed, only applies to the DSO.

The regulatory framework includes a general capital expenditure incentive. Yet, the TSO has to ex-ante demonstrate that costs are efficient and that the project has a positive CBA. Then the NRA can validate the projects, judging the estimated costs and time planning. After approval, the project enters into the TSO's allowed revenue. The project is reviewed ex-post again, investment costs are compared with the ex-ante defined costs. The difference is shared between TSO and consumer. The shares are 30:70 (TSO: consumer) for both losses and benefits. The TSO is hence incentivized to realize its projects more cost efficiently than ex-ante expected. Additionally, there is an efficiency factor for OPEX.

### Main regulatory barriers

The interviewees remarked that, in general, higher TSO and DSO investments results in higher revenue, as the remuneration is based on WACC on investment. Hence, if the TSO were to invest in solutions reducing capital investments, this would not necessarily result in higher revenue. Moreover, there is an incentive regulation to reduce OPEX cost. TOTEX reducing innovations are not incentivized.

Regarding the main regulatory barriers in Annex III:

1. **Higher TSO CAPEX, lower OPEX:** this barrier is seen as quite important;
2. **Higher Capex, but benefits to wider society;** According to the stakeholders this should be no problem if the regulator is convinced by the arguments and the regulator accepts the project. There is already a requirement to submit a SCBA for large infrastructure projects. However, stakeholders hope that, in the future, projects which are commercially not viable could be approved if additional benefits for the society can be proven;
3. **Investments in smart grid aimed at replacing planned grid investments;** the stakeholders find this barrier important, especially for electricity. The higher the CAPEX investment, the better for the TSO, hence smart grid investments are actually not profitable:
  1. **Lower TOTEX, but shift in CAPEX/OPEX ratio:** although Luxembourg does not have a TOTEX regulation, there is a disincentive to invest in OPEX solutions. The TSO is penalized for deviating from CAPEX. OPEX ratio (see below).

Moreover, the stakeholders name three other barriers/elements, which are important when investment projects are done:

- costs;
- delays;
- CAPEX/OPEX ratio (which is established in each "photo" year, the next one being 2019 and relevant until 2024).

It is important to stay within costs, budget, timeframe, and not to deviate from the CAPEX/OPEX ratio, otherwise there will be penalties. These penalties can lead to uncertainty, which prevents investments in innovative demonstration projects, for instance.

An example project is of a high voltage power line, when a cable landing was not mastered well by the supplier, which led to an explosion. The project was finalized much later, resulting in additional penalties regarding the remuneration. Since then the TSO is not keen on doing innovative projects.

Another implicit barrier, which was named, was that the TSO is unable to undertake projects due to a mismatch between the European TYNDP and the German net development plan. Germany considers only projects in their NDP, if they are included in the European TYNDP. Luxembourg included the project in their NDP two years ago, but Germany did not yet. This results in a hold up of the project. Thus, a main barrier is that there is not enough cooperation with other countries.

An additional barrier is the quality factor: the TSO is penalized regarding the number of outages. Yet, they are often not responsible for the number of outages as some of the outages are caused due meteorological conditions or neighbouring TSOs. This quality factor should be reviewed in addition to coordinating well with neighbouring TSOs.



### **2.2.2. Regulatory practice related to innovation**

Innovative projects account for less than 10% of the financial volume for electricity projects. Innovative projects are understood as being demonstration projects and not R&D projects. The stakeholders note that the TSO has to guarantee security of supply and is not an innovation company. There are no clear innovation incentives in place. The TSO is not able to balance the grid by itself as it heavily relies on cross-border cooperation. For electricity, it is part of the German bidding zone and has delegated tasks to the German TSO. The TSO focuses more on interconnection with other neighbouring countries than innovation.

Regarding innovative projects, the stakeholders mentioned investments in phase shifters and underground cabling as innovative investments in electricity realized so far. Other investments, such as the introduction of dynamic capacity rating, high temperature lines, design of overhead line poles etc. are not (yet) done.

Examples of projects are a phase shifter employed at the border to Belgium, high temperature lines for the connection to Germany, new high voltage connections to Germany. Moreover, an analysis is conducted about which pole types to use in the future.

Whereas mostly infrastructure related projects have been done in the past, the NRA wants more intelligent and innovative solutions instead of pure infrastructure investments. Therefore, they defined particular projects with financial benefits if the projects are fulfilled. The total financial incentive set by the NRA is around 10-15 million Euro. These incentivised projects encompass data management projects, the establishment of a data hub on national levels and the development of smart grids. The DSO is already equipping all transformation stations with intelligent monitoring. Most of these projects, however, are related to DSO level.

Yet, it was remarked that investment should not only be innovative, but that its benefits to society should also be monitored. There should be more focus on output; the tariff-methodology should be more result-oriented. This means that, while ex ante cost recovery and approval are interesting for the TSO, incentives to deliver concrete results also need to be installed. Financial incentives should mirror consumer benefits from a project, which also need to be measured.

### **Adequacy of the NRF relating to its support for innovative investments**

The TSO would like to invest in batteries and storage; yet, they are not allowed to invest in these technologies. The TSO further has no incentives to do innovative projects or studies regarding Power to gas or storage. Furthermore, they are not allowed to own storage or power to gas facilities. Yet, some stakeholders indicated that compared to other market parties, the TSO would reduce complexity of possible storage and power-to-gas projects.

The regulator opened the possibility for additional one-time remuneration for different new technologies the TSO should implement. Most of these envisaged projects refer to smart grids and fall into the DSO domain. Moreover, the measures introduced in Luxembourg have only been partly helpful. These considerable stimuli are still there since they have been introduced for the regulatory period 2017-2020. Yet, the TSO and DSO do not seem very keen regarding the stimuli because the related projects are regarded as too ambitious and milestones have not been clearly set. An evaluation of the measures is going on but not yet concluded. The result of this evaluation will be how the measures could be improved for next period. So the reasons for the only partly success are not yet fully known.

The TSO is able to factor in 1% of R&D costs into tariffs. However, this does not encompass innovative investments as defined in this study.

Moreover, regarding innovative investments, the TSO is constrained by finding compromises with neighbouring countries. They have to deal with harmonization and might be forced to develop something that they are not in favour for.

There is also currently no investment plan for innovation. Some of the interviewees believe that this should be necessary and that the plan should have a long-term perspective. As of right now, innovative projects are being approved on a case-by-case basis.

### **2.2.3. Regulatory practice related to security of supply**

#### **Security of supply projects**

Around 80% of the projects are related to security of supply. Yet, the TSO does not have that many projects going on at one time. The TSO identified in a scenario 2040 study, that there is need for additional interconnection capacities.

Security of supply projects encompass additional capacities for import, capacity reinforcements for Germany, and smart grids for reduction of additional capacities.

#### **Adequacy of the NRF relating to its support for security of supply investments**

The national regulatory framework is considered adequate to support security of supply investments in general. High investments result in higher revenues when considering security of supply.

There has been an addition on WACC for security of supply projects and phase shifter transformers built at the interconnection to Belgium. Since last October, there are hence flows from Belgium to the German bidding zone through Luxembourg. In general, there are no rules preventing the development of interconnectors, but also no specific incentives to encourage the development of interconnectors.

### **2.2.4. Illustrative specific projects**

The following projects are considered successful security of supply projects. They illustrate how the regulatory framework works in practice to incentivise security of supply projects.

All projects were treated the same, except the second project "Phase shifter to Belgium", where an additional remuneration has been awarded for cross-border infrastructure and market coupling/integration projects. It is not yet clear whether there will be an additional incentive for the 400 kV connection with Germany.

Moreover, all projects profited from the application of rules for anticipatory investment and ex-ante approval of CAPEX, since all projects of more than 1 million Euro for electricity and more than 0.5 million Euros for gas respective require an ex-ante approval by the regulator.

#### **Luxembourg Ring**

##### ***Description and aim***

This is a completed project, which refers to high voltage ring around the capital city improving the N-1 situation in the South of the country and solved internal congestions through internal reinforcement. It increased dispatching possibilities and improved the security of supply of the country. With 80 million Euros in the period, 2012-2016 it was a costly infrastructure project.

##### ***Approval process***

This project has been approved in 2009. It has not been treated differently from other regulated investments. In general, the NRA did not approve projects. The TSO and the Ministry of Economy are responsible for security of supply, the NRA decides only about cost recovery. This project was decided back in 2009 when the tariff methodology has not yet been at the same level as today, so no individual approval for this project was needed from the NRA.

Regarding similar projects, there are no instances of not having approved costs. Sometimes projects needed to be modified to fit the NRA's requirements so that the costs could be approved. In one instance, the TSO wanted to recover the costs too early; the NRA wanted more justification on the project/CBA before approving the cost recovery. In such instances, the parties enter a discussions and a modified project is the result.

According to the stakeholders, there is no need to increase similar investments as necessary investments are done already.

#### **Phase shifter to Belgium**

##### ***Description and aim***

The project has been completed in 2013. The phase shifter was installed to protect the grid and it was supposed to reduce the price of the congestion rent for the TSO. It also improved security

of supply to Luxembourg and increased the potential for market integration, although it is not yet integrated in market coupling. Therefore, there is not yet commercial activity on the interconnector, but the physical trial phase is ongoing. After 12 months of trial phase it will be known how and when connection can enter the commercial phase and how it can be operated together with the Allegro project (interconnection to Germany). In the first regulatory period, there was a security of supply incentive (WACC incentive of 0.5%). The project costs were 10 million Euros.

#### ***Approval process***

The project has not been treated differently from other regulated investments. As the project before, the NRA has not approved it; only the costs have been approved using the tariff methodology. A SCBA has been performed, although it played no role in the approval process. The project has been approved by national authorities as proposed. In addition to possible regulatory barriers in the context of the approval of cross border investment itself, a second step is the regulatory process to approve the commercialisation principles of the new interconnector according the regulation CACM and FCA currently under implementation. As the different articles and provisions of the CACM and FCA regulation have not been approved yet (capacity calculation methodology, cost and congestion revenue sharing), the commercialisation process is challenging. Hence, the main challenge in the approval process is the question of how the commercialisation of additional available capacities should be approved by regulators at CWE (Central West Europe Region) level.

#### ***Financial mechanisms***

In that regulatory period, it was eligible for WACC premium for security of supply projects. The ex-ante approval of CAPEX is seen to have helped to realize this project.

Also for this type of projects, there is no need to increase similar investments as necessary investments are done already, according to the stakeholders.

### **High temperature lines for the connection to Germany**

#### ***Description and aim***

There is a need to increase the interconnection capacity with Germany in order to guarantee the future security of supply in Luxembourg, but investments in Germany are also needed. These investments were not done, which held up the project. The project encompassed dynamic line rating and high temperature lines. Ampacimon is the company developing innovative dynamic line rating systems, which are also applied by CREOS.

#### ***Approval process***

The regulator has not yet approved the project costs.

### **400 kV connection**

#### ***Description and aim***

The aim of the project is to increase the cross-border capacity towards Germany to address future security of supply issues in Luxembourg and allow additional transit flows towards Belgium.

#### ***Approval process***

The regulator has not yet approved the project costs.

#### ***Possible improvement to the (approval) process for such projects***

The stakeholders note that the total costs for the permitting and buying the land necessary for the project have not been accounted for in the total project costs. This means that these costs will become non-controllable OPEX. That means that the costs will be included in the TSO tariff of the next year, but the TSO will not get the incentive as the project itself (Depreciation and incentive are based on the regulated asset base as for the transformers, cables etc.). This might be a disincentive for the future.

## 2.3. Options for improvement

### 2.3.1. *Options to improve regulatory practice*

The above discussion shows that the NRF works reasonably well for security of supply and especially interconnection projects, which are important for Luxembourg. Yet, barriers have been highlighted by stakeholders with respect to the implementation of innovative projects (see above). Although the NRA does not approve the projects, it approves their costs. Changes to the tariff methodology could hence be considered if the objective is to increase the innovative efforts by the TSO.

#### (i) **Bonus system for meeting deadlines**

Despite incentives, such as ex-ante approval of CAPEX and monetary incentives to do certain types of innovative projects, the requirement to stay within budget, timeframe and the CAPEX/OPEX ratio from a photo year pose a barrier to risky investments in the eyes of interviewees. To avoid this negative effect, deadlines could be made more flexible or penalties for meeting those deadlines could be removed for defined risky or innovative projects. Note that this could have the effect of systematically delaying certain types of projects, if the measure is not targeted. Therefore, a bonus system for meeting deadlines could be introduced to provide an incentive to meet the deadlines also for risky and innovative projects, instead of the current penalties that apply.

#### (ii) **Favouring of OPEX-based solutions**

Luxembourg does not have a TOTEX regulation and the stakeholders were concerned about a bias in favour of CAPEX solutions. They also recognized the requirement to stick to a certain CAPEX-OPEX ratio from a photo year as being unnecessarily rigid. Without changing to a TOTEX-based system, specific incentives for OPEX-based solutions, which have been identified as advantageous or necessary, could be introduced. Such an approach has already been taken with regard to smart grid projects: monetary rewards have been introduced to stimulate these types of projects. Another possibility would be the introduction of a specific budget, e.g. for IT-technologies.

Note that there can also be disadvantages of specific incentives for OPEX-based solutions that need to be considered. If poorly designed it can introduce an 'OPEX-bias' and may result in inefficient investment decisions.

#### (iii) **Statutory requirement to consider alternatives**

A more general approach to foster OPEX-based solutions in the long-term, i.e. beyond a single regulatory period, would be the introduction of an obligation to consider OPEX-related innovative options in the network development plan. The TSO would then have to provide OPEX-based options as alternatives to (CAPEX) projects outlined in the network development plan. This approach necessitates that a framework is developed determining when OPEX-based solutions should be favoured over CAPEX-based solutions. This approach should be coupled with monetary incentives (like option (ii)) for the TSO to invest in OPEX solutions to counteract the CAPEX bias.

#### (iv) **Statutory reference to innovation**

The stakeholders interviewed criticized that there is no long-term perspective on innovative investment. The measures so far, such as the monetary rewards given for specific innovative projects, have been ad hoc and introduced as a consequence of the NRA assessing current and mid-term needs. A long-term strategic perspective can only be developed if the regulatory framework contains an explicit reference to innovation. This long-term strategic perspective could be shaped by governmental policies, statutory duties or could be included in the TYNDP.

#### (v) **Consultation on investment plans**

On the national plan and on a project level, stakeholder consultations could increase the likelihood that the output will ultimately be beneficial to the consumers, thereby moving towards a more output-focussed regulation. Stakeholder consultation can also be used to determine OPEX solutions to be favoured from option (iii) and help shape the long-term perspective on innovation of option (iv). Yet, the organisation of stakeholder consultations has disadvantages, such as the additional organisational burden on the party organising the consultation (the TSO or NRA) and potential delays in implementing an investment project. Hence, one needs to think carefully how often and for which purposes to consult stakeholders.

### **2.3.2. National law mechanism(s) for implementing options**

We consider that, with the exception of the following, the above-mentioned changes could be implemented using legal powers already available to the NRA or others under the existing NRF.

As regards option (iii) (statutory authorisation to consider alternatives), we understand that the legal mechanism for implementing this option would involve the issue of a regulation which would be carried out by presenting an initiative to the relevant minister (i.e. the Ministry of Economy which coordinates Luxembourg's energy policy). The minister would then submit the legislative initiative for the approval of the Council of Government before being reviewed by the Council of State and eventually by the professional committees concerned by the initiative at stake. When the initiative is agreed upon by all parties above, the Ministry of Economy will address the initiative for the signature successively to the prime minister, to the *Maréchalat de la Cour* and then to the Grand Duke. The regulation enters into force three days after having been published in the Official Memorial (the "**Luxembourg Regulatory Process**").

Turning to option (iv) (statutory reference to innovation), we expect that this could be implemented by including such an explicit requirement in the Electricity Law which will fall under the duties of the TSO and the NRA. In order to insert this reference into the current legislation, one or several members of the Government must file a request (i.e. a bill of law) in front of the Chamber of Deputies. Comments of the Chamber of Deputies and of the Government on the bill of law will be sent across to the Council of State, which will opine on it. Once the Chamber of Deputies receives the review of the Council of State, it then decides on the merits the bill of law in public session. If retained, the bill of law will then be sent to one or more professional committees. The professional committees will analyse the bill of law and whether subsequent amendments are required.

The bill of law will then be placed on the agenda of a public sitting of the Chamber of Deputies and amendments may still be made if at least five members of the Chamber of Deputies so request. Once the final wording is agreed, a two steps vote will be in theory required to be cast. A first vote on a part of the bill of law or its full text when applicable followed by a second vote at least three months after the first one, unless the Chamber of Deputies and the Council of State have agreed to waive said second vote. The bill of law will be promulgated after its signature by the Ministry of Economy and the Grand Duke. Three days after its publication in the Official Memorial, the law will enter into force, unless otherwise provided (the "**Luxembourg Legislative Process**").

As regards option (v) (consultation on investment plans), the suggestion of incorporating a mandatory requirement in legislation for the TSO to explain what alternatives have been looked at when developing the TYNDP plan, could be implemented by amending the wording of article 11(4) of the Electricity Law through the Luxembourg Legislative Process above.

### **2.3.3. Impact assessment**

A negative side effect of option (i) could be the introduction of delays in the implementation of investment projects. The NRA remarked that projects were systematically delayed before the introduction of the penalty. However, if the measure is well-targeted and the introduction of a bonus system for meeting deadlines for innovative and risky projects could counteract a potential negative effect. The difficulty is how to define risky or innovative project to which these provisions can be applied. It will require some time, efforts and maybe cooperation between the NRA and the TSO to determine the characteristics of such projects.

Option (ii) also results in more work for the NRA and potentially the TSO: innovative and socially beneficial OPEX solutions to be favoured by the regulation need to be defined. Such projects would need to be redefined for each regulatory period, possible in cooperation with the TSO and maybe including a stakeholder consultation.

The long-term strategic perspective on innovation mentioned in option (iv) necessitates efforts and coordination between the TSO and the NRA regarding the design of this long-term perspective (e.g. the organisation of stakeholder consultations, determining the scope of the innovation needed, monitoring and evaluating of how the statutory duty is translated into the long-term perspective).

As mentioned in option (vi) and the other options above, stakeholder consultations can contribute to moving to a more output-focussed regulation. Yet, too many consultations will increase the organisational burden of the TSO and/or the NRA and possibly reduce the

willingness of stakeholders to participate in the consultation. Therefore, consultations as instrument need to be used wisely.

We have not encountered any specific examples of projects that have been cancelled due to the regulatory framework. For this reason, we do not expect that any of the suggested changes will result in considerable changes to investment levels. Yet, if the perceived risk of innovative projects is lowered and a long-term strategic perspective on innovation could be attained, the share of innovative projects is expected to increase. Options (v) is expected to have a similar effect. Moreover, if implemented well, option (ii) could result in a shift from primarily CAPEX investments to more OPEX investments.

### 3. GAS

#### 3.1. Legal analysis of the NRF in Luxembourg

##### 3.1.1. Overview of the regulatory framework of Luxembourg – legal rules

“Transmission” for the purposes of the Legal Framework in Luxembourg means the transmission of natural gas through a network consisting mainly of high-pressure pipelines other than an upstream pipeline network and other than that part of high-pressure pipelines used mainly for the distribution of natural gas at local level, for the purpose of supply to customers, but not including supply.

The law of 1<sup>st</sup> August 2007 related to the organisation of the gas market, as amended (the “**Gas Law**”) is the main piece of primary legislation governing the Legal Framework for gas in Luxembourg.

L’*Institut Luxembourgeois de Regulation* (“**ILR**”) <sup>39</sup>, an independent public institution having a legal personality<sup>40</sup>, is the independent regulator and the Government Commissioner of Energy (the “**Ministry**”) have duties and objective derived from the Gas Law.

As far as relevant to the transmission network development is concerned, the duties and objectives are as follows:

- ILR (i) promotes a competitive, secure and environmentally sustainable internal gas market within the EU, an effective market opening for all consumers and suppliers in the EU and ensures the appropriate conditions for gas networks to operate effectively and reliably, taking into account long-term objectives<sup>41</sup>; (ii) removes barriers to gas trade between Member States, including by establishing sufficient cross-border transmission capacity to meet demand and strengthen the integration of national markets, which should allow for a secure supply of gas within the whole EU<sup>42</sup>; (iii) ensures that network operators and network users receive sufficient incentives, both on a short and long term basis, to improve the network performance and promote the market integration<sup>43</sup>; (iv) monitors the investment plans of the transmission system operators and provide, in its annual report, an analysis of the investment plans of the transmission system operators in terms of their consistency including recommendations for their improvement<sup>44</sup> and (v) contributes, in cooperation with the Minister, to ensuring compliance with the rules governing the safety and reliability of the network and for assessing their past performance, and defining or approving the standards and requirements for the quality of service and supply<sup>45</sup>;
- The Ministry monitors the general estate of networks and interconnections as well as the security and quality of supply<sup>46</sup>. The said monitoring covers *inter alia* the balance between the supply and demand on the national market while taking into account cross-border trade, the level of expected demand and available reserves, the level of investment necessary for the current and future proper functioning of infrastructure as well as all aspects concerning the quality of gas<sup>47</sup>. The Ministry will set out the results of this monitoring in a report relating to the operational security of the network, the storage capacity levels and the long-term gas supply contracts concluded with companies established and registered in Luxembourg with a particular focus on the remaining duration of these contracts. Additionally, the purpose of this report is to provide the security of supply prospects over the following 15 years as well as any TSO(s) cross-border interconnection investment project over the 10 years the following the issue of the report.<sup>48</sup>

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<sup>39</sup> <https://web.ilr.lu/FR/ILR>.

<sup>40</sup> Article 1 of the law of 30 May 2015 regarding the organization of ILR.

<sup>41</sup> Article 51 (1) letter (a) of the Gas Law.

<sup>42</sup> Article 51 (1) letter (c) of the Gas Law.

<sup>43</sup> Article 51 (1) letter (f) of the Gas Law.

<sup>44</sup> Article 51 (5) letter (h) of the Gas Law.

<sup>45</sup> Article 51 (5) letter (i) of the Gas Law.

<sup>46</sup> Article 16 (1) of the Gas Law.

<sup>47</sup> Article 16 (2) of the Gas Law.

<sup>48</sup> Article 16 (4) letter (f) and (g) of the Gas Law.

ILR does not have specific duties relating to security of supply – instead, the Ministry is solely responsible i.e. the Ministry monitors the balance between supply and demand, the existing and planned production capacities, the necessary investments and the safe operation of the networks<sup>49</sup>.

### **3.1.2. Specific legal rights and duties**

#### **Role of TSO**

Transmission system operation (the **SO**) and transmission ownership (the **TO**) role belong to the same entity. Indeed, Luxembourg has one transmission system operator (the **TSO**) (for gas transmission), namely Creos Luxembourg SA. Additionally, Luxembourg has an industrial grid operator, Balansys SA, which operates the interconnection with the Belgian transmission grid<sup>50</sup>.

The main objective of the TSO<sup>51</sup> is to ensure the management and operation of the transmission and distribution gas network, including its maintenance and the development of networks. To this end, the TSO may carry out any investment necessary to ensure the security of energy distribution / delivery and may build or maintain a viable infrastructure and / or infrastructure with an optimal operation and performance and procure, either directly or indirectly all authorizations and concessions in connection with the previous item the direct and indirect obtaining of all authorizations and concessions concerning the provision and development of the network.

The Gas Law sets out various obligations for the TSO(s) which are specific to security of supply, including (but not limited to):

- Obligation for the TSO to establish the technical safety criteria and the technical requirements laying down the minimum technical design, construction, operating or operational requirements for the connection of production plants, networks, and gas installation works of consumers directly connected interconnection circuits and direct lines. Where necessary, the TSO shall consult the TSOs of the neighbouring countries<sup>52</sup>; in case of issues, the TSO needs to inform the other TSOs concerned, the Ministry as well as the ILR;
- The TSO (and where appropriate in conjunction with other concerned TSOs) shall: (i) guarantee the long-term capacity of the network to meet reasonable demands for gas transmission capacity, operate, maintain and to develop, under economically acceptable conditions, safe, reliable and efficient networks; (ii) contribute to security of supply through adequate transmission capacity, network reliability and network operating security; (iii) manage the flow of energy on the network taking into account exchanges with other interconnected networks; and (iv) draw-up, by consulting the Ministry and ILR, a safeguarding code and a reconstitution code<sup>53</sup>;
- The TSO is required to measure and document the quality of the gas, as well as the continuity of supply, which is assessed in particular by the degree of unavailability, the quantity of gas not supplied, the average duration and the probability of interruption<sup>54</sup>.

#### **Undertaking of investments**

The TSO is required to carry out any investments projects in order to comply with the legal obligations as described above. The projects meant to strengthen the interconnections of gas transmission networks with those of neighbouring countries (as described below Section 3.1.3) and aim to increase the security of supply in Luxembourg and contribute to the integration of markets in these areas.

#### **Role of NRA regarding investment projects undertaken by the TSO**

The TSO published the 2016 - 2025 Regional Investment Plan for natural gas. This investment plan contains no cross-border investment project. It focuses on national developments and the modernization of equipment to ensure the perfect working condition of infrastructure in order to

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<sup>49</sup> <https://assets.ilr.lu/energie/Documents/ILRLU-1685561960-448.pdf>.

<sup>50</sup> <http://www.creos-net.lu/fournisseurs/gaz-naturel/marche-gazier-integre-belux.html>.

<sup>51</sup> [http://www.te.public.lu/fr/participations/societes\\_droit\\_prive/non\\_cotees\\_en\\_bourse/creos.html](http://www.te.public.lu/fr/participations/societes_droit_prive/non_cotees_en_bourse/creos.html).

<sup>52</sup> Article 13 (1) of the Gas Law.

<sup>53</sup> Article 14 (2) of the Gas Law.

<sup>54</sup> Article 15 (2) of the Gas Law.



guarantee the continuity and quality of gas supply, while respecting and ensuring the protection of people and the environment<sup>55</sup>.

The TSO started a network development study aiming to investigate an optimal long-term network strategy for the Luxembourg grid. During 2013, Creos and GRTgas launched a binding market survey for additional capacity of 9 GWh/d and 40GWh/d from France to Luxembourg. This project was however abandoned since Luxembourg confirmed its wish to secure its gas supply<sup>56</sup> directly with Belgium, as below.

Triggered by Luxembourg security of supply considerations, Creos Luxembourg and Fluxys Belgium launched the first integration of gas markets between two EU Member States in October 2015 (the so-called Interconnector BeLux). This merger between the TSOs, their respective regulators, ILR and the *Commission de Régulation de l'Electricité et du Gaz (CREG)* in Belgium is in line with the European Union's desire to build an internal gas market without borders where gas flows can move freely between all countries<sup>57</sup>.

### **Institutional or procedural constraints on the performance of these roles**

For the new regulatory period 2016 - 2025 (as detailed in Section 3.1.3 below), the TSO has identified two important restrictions (i) the first concerns the return on capital invested; given the drop of the interest rates in the past years, ILR lowered rates on investments comparing to the prior regulatory period and consequently the investments capabilities of TSO will be lowered; the costs accepted by ILR will have a direct impact on the future development results of the TSO, because ILR is encouraging to the decreasing of costs and (ii) the new rules set out by ILR are more restrictive and rigorous regarding the control of the TSO's activities, irrespective if these rules refer to the maintenance, outage or investments. Said rules will impose TSO to provide more information and documentation.

#### **3.1.3. Mechanism for financing of investment projects**

In the absence of competition in the Luxembourg energy networks, ILR should protect consumers by acting as a proxy for normal competitive forces. The tariff method regulation, as established by ILR for the regulatory period between years 2016 - 2025, sets out the principles applicable to all network operators for determining their network costs and translating them into a tariff structure. The principle features used are the calculation of depreciation according to the straight-line method and on the basis of investments made and valued at their historical acquisition value, as well as the calculation of the return on capital.

ILR has improved the financial incentives for the network operators by clarifying the accounting for the activities that are not part of the regulated scope, optimizing the procedure of significant investment projects and setting up additional remuneration in the event of implementation of specific projects with high added value for the consumers, as further described.

Regulation E16 / 13 / ILR takes into account the partial decoupling between the actual and maximum allowed income and an individual assessment of significant investment projects. From 2016, the latter includes the investments which are exceeding one million euros and which are out of the ordinary framework of day-to-day management as well as investments valued at less than EUR 1 million but having a cross-border impact.

Regulation E16 / 13 / ILR inserted new incentives, such as (i) an incentive awarded for the development of individual projects in line with project planning while retaining the necessary flexibility for the occurrence of unforeseeable events; and (ii) a financial benefit for the network operator and users in the event of good financial management of the project. Moreover, the said Regulation sets out additional financial rewards to be allowed to the TSO for carrying out individual investments.

The TSO's costs regarding research and development may be included in the network tariff up to a maximum of 1% of the maximum allowed income unless ILR consents in advance to the TSO exceeding that threshold.

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<sup>55</sup> ILR rapport published on 6 February 2018 regarding investments on gas transmission page 68.

<sup>56</sup> Regulations (EU) No 994/2010 of the European Parliament and of Council of 20 October 2010 concerning measures to safeguard security of gas supply.

<sup>57</sup> [http://www.creos-net.lu/fileadmin/dokumente/NEWS/pdf/2015/CP\\_2015\\_10\\_01\\_fluxys\\_creos\\_fr\\_DEF.pdf](http://www.creos-net.lu/fileadmin/dokumente/NEWS/pdf/2015/CP_2015_10_01_fluxys_creos_fr_DEF.pdf).

#### **3.1.4. Regulatory rules with respect to innovation**

##### **Specific duties of the NRA aimed at encouraging innovation**

When establishing the methods for determining transmission system usage fees, IRL with due consideration given to the general energy policy guidelines indicated by the Ministry, takes into account the need to encourage and stimulate investment in order for transmission and distribution system operators to develop their networks to meet foreseeable market demand<sup>58</sup>. Price calculation methods aim at supporting related research activities, improving economic efficiency and optimizing service quality.

Given that the TSO's costs regarding research and development are specifically mentioned, we tend to believe that the ILR's regulatory intention was to give priority to investing in innovative network infrastructure. The 2016 - 2025 Regional Investment Plan for natural gas of the TSO (as detailed in Section 3.1.3 above) underlines the investments in "the modernization of equipment to ensure the perfect working condition of infrastructure" instead of the refurbishment investments in the existing gas network.

##### **Features of financing mechanisms designed to incentivise investment in innovation and result in a balance between innovation and effectiveness**

The TSO's costs regarding research and development may be included in the network tariff up to a maximum of 1% of the maximum allowed income unless ILR consents in advance to the TSO exceeding that threshold.

When establishing the methods for determining transmission system usage fees, IRL with due consideration given to the general energy policy guidelines indicated by the Ministry, takes into account the need to encourage and stimulate investment in order for transmission and distribution system operators to develop their networks to meet foreseeable market demand<sup>59</sup>. Price calculation methods aim at supporting related research activities, improving economic efficiency and optimizing service quality.

#### **3.1.5. Regulatory rules with respect to security of supply**

##### **Specific duties of the TSO aiming at safeguarding security of supply**

In order to support the economic development of Luxembourg and to cope with the permanent growth of the population, regular investments in the networks (including gas transmission) are essential to maintain a level of security and quality of supply<sup>60</sup>. TSOs are given incentives to invest in interconnected infrastructure between Member States in order to increase competition in gas supply and improve security of supply<sup>61</sup>.

As a rule the development of the national gas grid is based upon the 10 year investment plans (as per article 16 (4) letter (g) of the Gas Law) therefore the TSO should anticipate all changes in production and consumption.

Duties, including those applicable to security of supply are more fully described at in Sections 3.1.1 and 3.1.2 above.

### **3.2. Regulatory practice**

#### **3.2.1. Overview over regulatory practice in Luxembourg**

##### **Information about the general regulatory framework in Luxembourg**

The NRA sets the tariff methodologies and they have an obligation to include adequate financial incentives, such as a general capital expenditure incentive. The tariff calculation methodology for the regulatory period 2017-2020 has been set in April 2016. There are two separate

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<sup>58</sup> Article 29 (1) of the Gas Law.

<sup>59</sup> Article 29 (1) of the Gas Law.

<sup>60</sup> Item 1, ILR rapport published on 6 February 2018 regarding investments on gas transmission <https://assets.ilr.lu/energie/Documents/ILRLU-1685561960-494.pdf>.

<sup>61</sup> Article 28 (1) of the Gas Law.

methodologies for electricity and gas, but there is no differentiation between the TSO and DSO business.

Regarding project financing: for the DSO, the NRA monitors the procedures of how investment takes place. If the NRA agrees on the process, the DSO can recover the actual costs. The TSO's projects, on the other hand, fall under special assessment, i.e. individual investment projects are assessed. The condition that projects under 1 million Euro are not assessed, only applies to the DSO.

The regulatory framework includes a general capital expenditure incentive. Yet, the TSO has to ex-ante demonstrate that costs are efficient and that the project has a positive CBA. Then the NRA can validate the projects, judging the estimated costs and time planning. After approval, the project enters into the TSO's allowed revenue. The project is reviewed ex-post again; investment costs are compared with the ex-ante defined costs. The difference is shared between TSO and consumer. The shares are 30:70 (TSO: consumer) for both losses and benefits. The TSO is hence incentivized to realize its projects more cost efficiently than ex-ante expected. Additionally, there is an efficiency factor for OPEX.

### Main regulatory barriers

There is only an incentive regulation to reduce OPEX and the TSO gains only if it reduces OPEX costs faster than expected. A reduction in CAPEX investments (i.e. by investments in OPEX reducing CAPEX needs) results in a loss of revenue for the TSO.

Regarding the main regulatory barriers in Annex 3:

1. **Higher TSO CAPEX, lower OPEX:** this barrier is seen as quite important;
2. **Higher Capex, but benefits to wider society;** According to the interviewees this should be no problem if the regulator is convinced by the arguments and the regulator accepts the project. Yet, there is no requirement to submit a SCBA yet. Maybe this might come later for larger projects. The interviewees hope that then, in the future, projects which are commercially not viable could be approved if additional benefits for the society can be proven;
3. **Investments in security of supply without commercial benefits:** the TSO convinced the NRA that, to adhere to the N-1 criterion, the best way is not to be obliged to do commercially non-profitable projects, but to choose another solution than investment in infrastructure: e.g. higher gas pressure. In electricity, there are not many market benefits: Luxembourg is together with Germany in the same bidding zone, so no there are no price differences between Germany and Luxembourg. The building of inter-connectors is hence not justified by large benefits, but justified by security of supply, such projects are usually approved. So this is not seen as a barrier;
4. **Lower TOTEX, but shift in CAPEX/OPEX ratio:** although Luxembourg does not have a TOTEX regulation, there is a disincentive to invest in OPEX solutions. The TSO is penalized for deviating from CAPEX. OPEX ratio (see below).

Moreover, the stakeholders name three other barriers/elements, which are important when investment projects are done:

- costs;
- delays;
- CAPEX/OPEX ratio (which is established in each "photo" year, the next one being 2019 and relevant until 2024).

It is important to stay within costs, budget, timeframe, and not to deviate from the CAPEX/OPEX ratio; otherwise, there will be penalties. This uncertainty prevents investments in innovative demonstration projects, for instance.

The stakeholders also indicate that a main barrier is that that there is not enough cooperation with other countries.

### 3.2.2. Regulatory practice related to innovation

#### Innovative projects

Innovative projects do not even account for 10% for both electricity and gas. Innovative projects are understood as being demonstration projects and not R&D projects. The stakeholders note that the TSO has to guarantee security of supply and is not an innovation

company. Moreover, they note that, at least on the gas side, not to make too many costs is important.

The TSO is not able to balance the grid by itself as it heavily relies on cross-border cooperation. For gas, it cooperates with Belgium through a market merger that resulted in a single entry/exit zone. The TSO focuses more on interconnection with other neighbouring countries than innovation.

For gas, the market integration with Belgium has been innovative, despite the fact that there are no incentives for it. The interviewees named power to gas and storage interesting developments, but noted that there are no incentives to do these projects.

### **Adequacy of the NRF relating to its support for innovative investments**

Regarding gas, there are no incentives for market integration, no incentives for storage projects and power to gas. The TSO would like to invest in batteries and storage; yet, they are not allowed to invest in these technologies. The TSO further has no incentives to do innovative projects or studies regarding Power to gas or storage. Furthermore, they are not allowed to own storage or power to gas facilities. Yet, the TSO is of the opinion that they should be able to own and invest in this equipment: compared to other market parties, the TSO would reduce complexity of possible storage and PtG projects.

Moreover, regarding innovative investments, the TSO is constrained by finding compromises with neighbouring countries. They have to deal with harmonization and might be forced to develop something that they are not in favour for.

There is also currently no investment plan for innovation. The interviewees believe that this should be necessary and that the plan should have a long-term perspective. As of right now, innovative projects are being approved on a case-by-case basis.

The interviewees mentioned that there are difficulties with provisions in the NRF relating to R&D: The TSOs would like to invest in R&D projects, but the conditions are too strict; the restriction is that a research institute has to be part of the project. The TSO wants to subsume also internal demonstration projects under costs for R&D studies. The line is blurry what a research project is and what a TSO-internal demonstration project is.

### **3.2.3. Regulatory practice related to security of supply**

#### **Security of supply projects**

Around 80% of the projects are related to security of supply.

Security of supply projects encompass additional capacities for import, capacity reinforcements for Germany, and smart grids for reduction of additional capacities.

### **Adequacy of the NRF relating to its support for security of supply investments**

The NRF is considered adequate to support security of supply investments in general. High investments result in higher revenues when considering security of supply.

### **3.2.4. Illustrative specific projects**

The project below is considered a successful security of supply project; however, it can also be considered innovative. Thus the project illustrates how the current regulatory framework can incentivise innovative and security of supply investments.

#### **BeLux gas market integration**

The BeLux gas market integration is a completed project. It has been a zero cost project, since no new infrastructure has been built. The objective was to do something at zero cost for consumers, bringing more competition and more security of supply. The project has delivered on these goals. Luxembourg consumers and retailers have now better access to the gas market and are in a better competition situation. Through market integration, CREOS secured better physical pressure arrangement, which can deal better with supply scenarios and scenarios coming from security of supply scenarios of EU. As no physical infrastructure was added, all benefits resulted from the renegotiated Framework.

### **Approval process**

The NRA requested a feasibility study regarding the possibility of a market merger to resolve the issues outlined above. In previous analyses, the market merger was best solution to deal with the problem, as it was a contractual congestion problem at an interconnection point. The feasibility study showed only benefits, as there were no investment costs, only operational costs. Yet, there were many regulatory barriers, as the regulatory framework did not cover this type of investment. There were many negotiations. The law in Belgium had to be amended.

The regulation should be improved to include a regulatory framework for approval of OPEX projects.

Since then, the NRA has been receiving similar projects for approval and it expects more and more projects to come with similar goals. The approval of this kind of projects is on a case-by-case basis.

### **Financial mechanisms**

This project did not require a large investment. The investment came in the form of the people involved and some IT developments. There were no major monetary investments.

## **3.3. Options for improvement**

### **3.3.1. Options to improve regulatory practice**

The above discussion shows that the NRF works reasonably well for security of supply and especially interconnection projects, which are important for Luxembourg. Yet, there are barriers for the implementation of innovative projects. Although the NRA does not approve the projects, it approves their costs. Changes to the tariff methodology could hence be considered if the objective is to increase the innovative efforts by the TSO.

#### **(i) Bonus system for meeting deadlines**

Despite incentives, such as ex-ante approval of CAPEX and monetary incentives to do certain types of innovative projects, the requirement to stay within budget, timeframe and the CAPEX/OPEX ratio from a photo year deters risky investments in the eyes of stakeholders. To avoid this negative effect, deadlines could be made more flexible or penalties for meeting those deadlines could be removed for defined risky or innovative projects. Note that this could have the effect of systematically delayed projects. Therefore, a bonus system for meeting deadlines could be introduced to provide an incentive to meet the deadlines also for risky and innovative projects.

#### **(ii) Favouring of OPEX-based solutions**

Luxembourg does not have a TOTEX regulation and the stakeholders were concerned about a bias in favour of CAPEX solutions. They also recognized the requirement to stick to a certain CAPEX-OPEX share from a photo year as being unnecessarily rigid. Without changing to a TOTEX regulation, specific incentives for OPEX-based solutions, which have been identified as advantageous or necessary, could be introduced. Such an approach has already been taken with regard to smart grid projects: monetary rewards have been introduced to stimulate these types of projects. Another possibility would be the introduction of a specific budget, e.g. for IT-technology.

Note that there can also be disadvantages of specific incentives for OPEX-based solutions that need to be considered. If poorly designed it can introduce an 'OPEX-bias' and may result in inefficient investment decisions.

#### **(iii) Statutory requirement to consider alternatives**

A more general approach to foster OPEX-based solutions in the long-term, i.e. above beyond a single regulatory period, would be the introduction of an obligation to consider OPEX-related innovative options in the network development plan. The TSO would then have to provide OPEX-based options as alternatives to (CAPEX) projects outlined in the network development plan. This approach necessitates that a framework is developed determining when OEPX-based solutions should be favoured over CAPEX-based solutions. This approach should be coupled with monetary incentives (like option (ii)) for the TSO to invest in OPEX solutions to counteract the CAPEX bias.

**(iv) Statutory reference to innovation**

The stakeholders criticized that there is no long-term perspective on innovative investment. The measures so far, such as the monetary rewards given for specific innovative projects, have been ad hoc and introduced as a consequence of the NRA assessing current and mid-term needs. A long-term strategic perspective can only be developed if the regulatory framework contains an explicit reference to innovation. This long-term strategic perspective could be shaped by governmental policies, statutory duties or could be included in the TYNDP.

**(v) Consultation on investment plans**

On both the TYNDP/national plan and on project level, stakeholder consultations could increase the likelihood that the output will ultimately be beneficial to the consumers, thereby moving towards a more output-focussed regulation. Stakeholder consultation can also be used to determine OPEX solutions to be favoured from option (iii) and help shaping the long-term perspective on innovation of option (iv). Yet, the organisation of stakeholder consultations has disadvantages, such as the additional organisational burden on the party organising the consultation (the TSO or NRA) and a potential delays in implementing an investment project. Hence, one needs to think carefully how often and for which purposes one wants to consult stakeholders.

**3.3.2. National law mechanism(s) for implementing options**

We consider that, with the exception of the following, the above mentioned changes could be implemented using legal powers already available to the NRA or others under the existing NRF.

As regards option (iii) (statutory authorisation to consider alternatives), we understand that the legal mechanism for implementing this option would involve the issuance of a regulation which would be implemented through the Luxembourg Regulatory Process (as outlined at Section 2.3.2 above).

Turning to option (iv) (statutory reference to innovation), we expect that this could be implemented by including such an explicit requirement for innovation in the Gas Law by implementing duties on the TSO and the NRA. The insertion of this reference within the current legislation would require following the Luxembourg Legislative Process (as outlined in Section 2.3.2 above).

As regards option (v) (consultation on investment plans), the suggestion of incorporating a mandatory requirement in legislation for the TSO to explain what alternatives have been looked at when developing the TYNDP plan, could be implemented by amending the wording of article 17(1) of the Gas Law through the Luxembourg Legislative Process (as outlined in Section 2.3.2 above).

**3.3.3. Impact assessment**

A negative side effect of option (i) could be the introduction of delays in the implementation of investment projects. The NRA remarked that projects were systematically delayed before the introduction of the penalty. However, the restriction to only innovative and risky projects and the introduction of a bonus system for meeting deadlines for innovative and risky projects could counteract a potential negative effect. The difficulty is how to define risky or innovative project to which these provisions can be applied. It will require some time, efforts and maybe cooperation between the NRA and the TSO to determine the characteristics of such projects.

Option (ii) also results in more work for the NRA and potentially the TSO: innovative and socially beneficial OPEX solutions to be favoured by the regulation need to be defined. Such projects would need to be redefined for each regulatory period, possible in cooperation with the TSO and maybe including a stakeholder consultation.

The long-term strategic perspective on innovation mentioned in option (iv) necessitates efforts and coordination between the TSO and the NRA regarding the design of this long-term perspective (e.g. the organisation of stakeholder consultations, determining the scope of the innovation needed, monitoring and evaluating of how the statutory duty is translated into the long-term perspective).

As mentioned in option (vi) and the other options above, stakeholder consultations can contribute to moving to a more output-focussed regulation. Yet, too many consultations will increase the organisational burden of the TSO and/or the NRA and possibly reduce the

willingness of stakeholders to participate in the consultation. Therefore, consultations as instrument need to be used wisely.

We have not encountered any specific examples of projects that have been cancelled due to the regulatory framework. For this reason, we do not expect that any of the suggested changes will result in considerable changes to investment levels. Yet, if the perceived risk of innovative projects is lowered and a long-term strategic perspective on innovation could be attained, the share of innovative projects is expected to increase. Options (v) is expected to have a similar effect. Moreover, if implemented well, option (ii) could result in a shift from primarily CAPEX investments to more OPEX investments.





## ANNEX I: TYPOLOGICAL INVESTMENTS – ELECTRICITY

Generally, the term typological investment relates to technical solutions that TSOs can adopt to provide the transmission capacities needed to cover the transmission demand of grid users. Thus, a typological investment is meant to be a type of solution that can be implemented, in principle, by any TSO in situations in which these solutions are appropriate to provide the desired benefit. Hence, typological investments are not specific to a concrete location or a particular TSO. In the following, we have listed a selection of typological investments for the electricity transmission sector, that are differentiated in 7 categories that can be considered innovative as compared to conventional solutions. For each of these categories we have provided a number of examples of solutions, based on our existing knowledge, a literature review and interviews. The list might not be completely comprehensive, but should give an idea of our understanding of the different types of typological investments, we are interested in.

Category	Examples of solutions
New transmission lines based on innovative technology or change of technology of existing lines	<ul style="list-style-type: none"> <li>• New HVDC lines (→allow to control the power flow; less expansive for long distance transport; undergrounding less complex);</li> <li>• Replacement of HVAC by HVDC lines (→less complex and less expensive; more compact design);</li> <li>• Underground cables or GIL (→ more expensive than OHL but can help improving public acceptance and accelerate the authorisation process);</li> <li>• Design of overhead line poles (→can help improving public acceptance and accelerate the authorisation process);</li> <li>• Replacement of conventional overhead line conductors by high-temperature conductors (→more expensive than conventional ones but can allow to provide additional capacity at a lower cost level and more quickly than by building completely new lines).</li> </ul>
Introduction of dynamic capacity rating with the aim of utilising existing transmission lines or transformers at higher levels	Spectrum of technological options ranging from a differentiation of rating levels according to fixed time intervals (e.g. seasonal or time-of-day) down to online monitoring of equipment temperature and adaptation of capacity rating in real-time operation.
Installation of power flow control components in order to better adapt power flow patterns to capacities and topology of the existing grid.	<ul style="list-style-type: none"> <li>• Phase-shifting transformers;</li> <li>• Semiconductor-based FACTS elements (including HVDC converters).</li> </ul>
Investment into components contributing to ancillary services provision (reactive power / voltage control, short-circuit power, momentary power reserves and black-start capability)	<ul style="list-style-type: none"> <li>• Purely phase-shifting generators (→offer operational flexibility and can serve to improve cost efficiency);</li> <li>• FACTS elements (→ see above).</li> </ul>
New or extended power system control and automation technology with the aim to lower the risk of disturbances threatening security of supply	<ul style="list-style-type: none"> <li>• Improvements in observability and controllability based on conventional sensor and actor devices;</li> <li>• Wide-area measurement systems (aiming at synchronously measuring power phasor angles at the grid nodes to improve observability);</li> <li>• Real-time dynamic security assessment tools (aiming at observing stability phenomena beyond static voltage/current measurements).</li> </ul>

Category	Examples of solutions
Partial automation of system operation processes aiming at better utilisation of existing grid capacities	Automatic switching of network devices (in connection with adaptive protection schemes) or of generation-side or demand-side flexibilities in case of grid component outages in order to reduce the demand for (n-1) capacity reserves.
Improvement of approaches to curative congestion management providing the possibility to operate systems closer to their technical limits and/or to improve security of supply	<ul style="list-style-type: none"><li>• Generation-side flexibilities (especially renewables);</li><li>• Demand-side flexibilities (DSM/DR);</li><li>• Storage components; and</li><li>• Technologies coupling the electricity sector with other sectors (gas, heat, traffic).</li></ul>

## ANNEX II: TYPOLOGICAL INVESTMENTS – GAS

Typological investments are meant to be those type of investments whose aim is to promote innovation in the gas transmission systems while ensuring or enhancing the level of security of supply of a region. Hence, by definition, they can be implemented independent of a specific TSO and location.

In the following table, we offer a resume of the typological investments for the gas transmission system we have deemed as innovative compared to “conventional” solutions.

The investments are broken down into four categories each accompanied by examples that emphasise their importance and impact on the gas system.

Category	Examples of solutions
Increased need for flexibility for market development and security of supply.	<ul style="list-style-type: none"><li>• (Power-to-gas) Usage of excess pipeline capacity as “energy” storage of excess wind or solar energy by utilizing electrolysis (an efficient utilization of the excess of electricity produced by non-programmable sources of energy);</li><li>• Increase withdrawal and injection capacity in storages by incentivising investments supporting flexibility (support of gas market liquidity and security of supply level);</li><li>• Allowance of higher pressure in selected pipeline/routes (increase of flexibility of the supply side).</li></ul>
Incentivise and facilitate upgrade of biogas to the transmission system.	<ul style="list-style-type: none"><li>• Investments in upgrade of biogas to transmission system (support of gas market liquidity and security of supply).</li></ul>
Digitalisation of operations, through e.g. drone inspections and artificial intelligence (AI), resulting in a safer and cost-efficient operation.	<ul style="list-style-type: none"><li>• Drone inspections and AI in combination with modern SCADA systems can serve as input to reliability based operation and maintenance (lower maintenance cost and reduction of unforeseen/unplanned shutdowns).</li></ul>
In order to support security of supply and add liquidity to the gas market, there is a need to build interconnectors in Europe.	<ul style="list-style-type: none"><li>• More reverse flow systems could be considered to increase flexibility in the supply routes (reduction of dependency and power of trading of the large gas suppliers);</li><li>• Enhancement of available gas supply in situation of supply crisis;</li><li>• possibility of arbitrage a price convergence between markets to support the development of the internal market.</li></ul>



### ANNEX III: POTENTIAL REGULATORY BARRIERS FOR PROJECTS

Regardless of the character of a project (e.g. projects enhancing security of supply or applying innovative technologies, which this questionnaire is focussing on) there might be potential regulatory barriers for implementing projects in general but maybe also barriers for special kind of projects. To give you an impression what kind of barriers we have in mind, we have listed some examples of such barriers in the following. It should be noted that there might be different or even more or less barriers in the regulatory framework of your country.

Type	Description/Explanation
Higher TSO CAPEX but lower expected OPEX within the TSO	the investment upfront is more costly, but has a potential of lowering the operational costs in the future. However, because of its innovative and more risky character the lower OPEX is not guaranteed. If not allowed to put the costs in case of a failure in the tariffs, TSO would not invest in innovative solution.
Higher TSO CAPEX, but benefits go to the wider society, instead of the TSO	This is a situation where higher investment, including in new technologies, is needed on the part of a TSO but benefits in terms of RES integration, RES curtailment or CO2 avoidance benefit other players in the society, while the TSO is only faced with the cost increase. Projects in regulatory frameworks, which do not distribute adequately the benefits to the TSO that bears the costs and takes the risk, are less likely to happen. This could also apply to cross-border investments involving several TSOs.
Investments in smart grid elements /technology aimed at replacing planned grid investments	Investments in smart grids and other smart elements that actually reduce the need of physical construction of lines for example due to a better interactive/intelligent grid management of balancing tools (battery storage) may provide a reduction in the regulated asset base, however with a slight increase of tariffs, might not be realised.
Investments in security of supply – projects without commercial benefits	Projects that ensure security of supply will in some cases never bring enough commercial benefits such as a pipeline would be going to be used only in case of emergency. If the security of supply (e.g. diversification of the sources for gas) is not put into tariffs, a TSO is most likely not willing to invest.
Lower TSO TOTEX but shift in the CAPEX/OPEX ratio	In some member states CAPEX and OPEX are treated differently in the regulatory regimes. Depending on the incentives set by doing so, technical solutions/projects with higher CAPEX might be preferred by the TSOs even if they result in higher total costs.

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