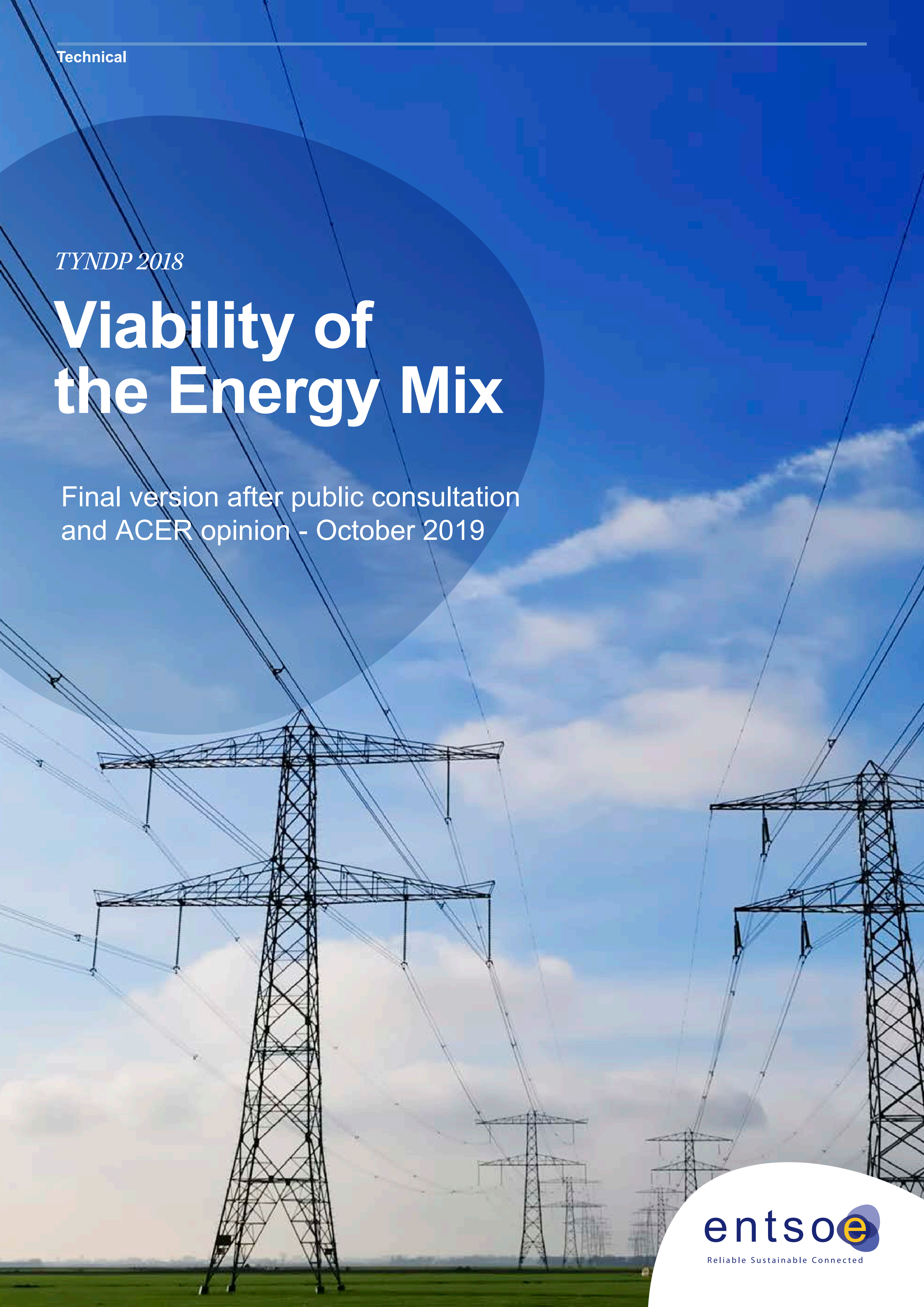
Technical

TYNDP 2018

Viability of the Energy Mix

Final version after public consultation and ACER opinion - October 2019



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Reliable Sustainable Connected

Contents

ENTSO-E Reports 2018

As an improvement to the TYNDP 2018 package, the Insight Reports have been categorised in order to help readers navigate through the document and focus on what readers might find of interest. The category of reports are:

— Executive Report – Contains the key insights of the whole TYNDP package through its two-year cycle.

— Regional Reports – Based on the four projects of common interest (PCI) regions, the reports focus on the regional challenges of the energy transition.

— Communication – These reports communicate how we have interacted with our stakeholders and improved the TYNDP package from 2016 to 2018.

— Technical – These reports give a deeper insight into the technical subjects, including how we use our data, and the technical challenges of energy transition.

We hope this guide is of benefit to all stakeholders.

Main Report

Regional Reports

- North-South Interconnections East
- North-South Interconnections West
- Northern Seas Offshore Grid
- Nordic & Baltics

Communication

- Stakeholder Engagement
- Improvements to TYNDP 2018

Technical

- Data and Expertise
- Technologies for
- Transmission
- Viability of the Energy Mix
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Section 1

Challenges of switching to renewable energies

The transformation of the energy generation mix is accelerating. A central question for Transmission System Operators (TSOs) is: How can the proportion of renewable energy generation with extensive energy exchange continuously increase to higher percentages while maintaining secure system operation?[1]

To achieve the climate targets set by the EU, changes in the energy system – switching from conventional production to renewable energy sources (RES) – are clearly gathering momentum.

A growing number of renewable energy plants, including smaller ones at distribution levels, are feeding into the networks of European countries. The dispersed infeed from RES also depends on the weather and is therefore subject to considerable fluctuations. In order to make the best possible use of these resources, an intensive and highly variable exchange of energy, within the individual country and across borders throughout Europe is necessary.

Compared to the past, this situation encompasses a much higher diversity of energy exchange patterns and generation mix, which can also lead to important system stability challenges highlighted hereafter.

[1] The TYNDP 18 "European Power System 2040 – System Needs Analysis" provides in its Technical Appendix an exhaustive analysis of the dynamic and operational challenges of the future power system as a basis to derive the necessary measures to tackle the challenges in a timely manner. This analysis includes the identification of clear trends regarding the integration of RES through power electronics and its impacts and foreseen mitigating measures and research needs related with reduced system inertia, flexibility and voltage control.

Section 2

Changes in the generation mix

Large conventional power plants are directly connected to the grid. In normal operation and in the event of a fault, their generators react immediately and automatically to disturbances in the network and can thus assume a stabilising function for frequency, voltage and synchronism that has some differences with respect to RES generation.

— **Frequency** variations are an image of the slight imbalance between electricity generation and consumption: when the generation is lower than the consumption, the frequency decreases and vice-versa. In order to keep the balance of power when the load or generation is changing rapidly or even largely (e.g. loss of a generating unit) the system relies on the fast response of generators.
  — Conventional generators can provide an instantaneous power response due to the energy stored in the rotating parts. This capability is referred as the inertia.
  — The large majority of decentralised renewable energy systems are different as they are connected to the grid via power electronics, whose behaviour is determined by control algorithms. Today, they do not provide inertial capability or they provide it with a delay, which cannot fully emulate the response from conventional generators.

— **Voltage** is an indicator of the quality of the power transmission via the grid: when the voltage is uniform and correctly set across the grid (within pre-defined limited ranges), the power losses are low. On the contrary, when the voltage is very low the losses can be so high that the grid is no longer able to transfer power, which can lead to a blackout.
  — Traditionally, conventional power plants have supported the voltage. In the course of the energy transition, the displacement of these plants combined with highly variable generation patterns will have to be compensated by other means to ensure a uniform voltage across the network.
  — The renewable decentralized generating units are capable of providing voltage support when the suitable capabilities are implemented (and when they are required by the grid codes).

— **Synchronism** is the ability of all rotating machines directly connected to the grid to rotate at the same speed. When a sudden change occurs in the system, some machines may speed up or oscillate with respect to the others and may not resynchronize and disconnect leading to a further aggravation of the problem.
  — Conventional machines have controls that help their re-synchronization and the synchronization of other machines.
  — With renewable generation, the power electronics can interact in a positive or a negative way depending on the control algorithms implemented.

In the future, if further expansion of renewable energies is to succeed, renewable energy plants will have to react immediately and collectively in an adequate scale to fluctuations in the grid and thus assume the stabilising function usually held by conventional generators. This way the system will remain stable even if the proportion of renewable energy exceeds high values. The TSOs, as those responsible for system stability, have a special role in meeting these challenges:
it is necessary to keep defining grid connection requirements in cooperation with the producers, so that future renewable energy plants meet the requirements concerning system security[2].

[2] Commission Regulation (EU) 2016/631, (EU) 2016/1388 and (EU) 2016/1447, establishing network codes on requirements for grid connection of generators, demand connection and requirements for grid connection of high-voltage direct current system and direct current-connected power park modules, are successfully reaching the completion of the national implementation phase. These codes will evolve according to RES penetration and system needs.

Section 3

Long-range transport of energy

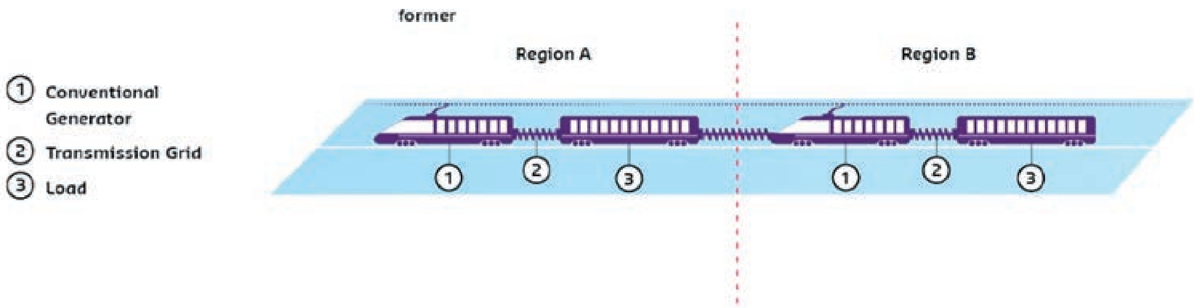
The energy generation from renewable sources and its exchange throughout Europe are leading to a more extensive energy transport. In order to adapt the transmission grid accordingly, it needs to be strengthened and expanded.

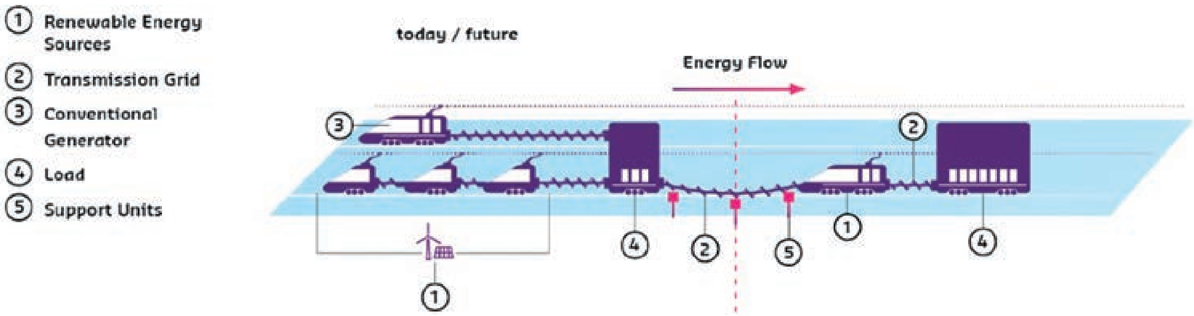
Beyond the grid reinforcement need, other technical challenges also arise.

The more energy has to be transported over long distances, the more voltage regulating means are needed. Together with generators capabilities, elements such as inductors, phase shifters or reactive power compensation systems are needed to regulate and support the voltage.

Due to the large distance between regions with high production and regions with high load, disturbances can also affect several regions or countries. In the event of a grid disturbance leading to a so-called system split, i.e. the separation of the transmission grid into several regions, a power surplus would arise in exporting regions and a power deficit would arise in importing ones. To mitigate these extreme situations from the most serious disruptions, the system defence plans[3] (and when necessary system restoration plans[4]) must define appropriate measures.

Figure 3.1 Energy Systems: traditional and today/future dynamics, info-graphic





Conventional power plants used to generate energy where it was needed – comparable to a locomotive coupled almost directly to the railway carriage. The locations of the smaller renewable energy plants, on the other hand, depend on renewable source conditions. They are built in regions with strong winds or sunshine, where the energy demand is often relatively low. For this reason, extensive networks – shown here as elongated springs – are necessary to transport the excess electricity to the consumption centres. For energy to be transmitted, the springs must not sag too much. To avoid the sagging in an elongated spring, voltage-supporting units must be used. If a crack occurs in the spring, a so-called system split can be created, which abruptly decouples several regions from one another.

[3] According to the Commission Regulation (EU) 2017/1485 establishing a guideline on electricity transmission system operation: system defence plan means the technical and organisational measures to be undertaken to prevent the propagation or deterioration of a disturbance in the transmission system, in order to avoid a wide area state disturbance and blackout state.
[3] According to the Commission Regulation (EU) 2017/2196 establishing a network code on electricity emergency and restoration: restoration plan means all technical and organisational measures necessary for the restoration of the system back to normal state.

Section 4

Viability of the energy mix

Network investment solutions and the Connection Network Codes requirements are, from a technical perspective, key and complementary aspects to ensure the necessary technical capabilities from to grid users. Given the goal of a system with increasing shares of RES, Research & Development will be also an essential factor to ensure solutions able to bridge the gap between conventional and RES generation capabilities (e.g. the inertia capability).

Because the proportion of electricity from renewable energy sources must continue to achieve decarbonisation goals, TSOs are committed to lead a successful energy transition, contributing with their comprehensive understanding of the various interrelationships, experience in system development and operation coordination between TSOs, DSOs, manufacturers, stakeholders and research centres.

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