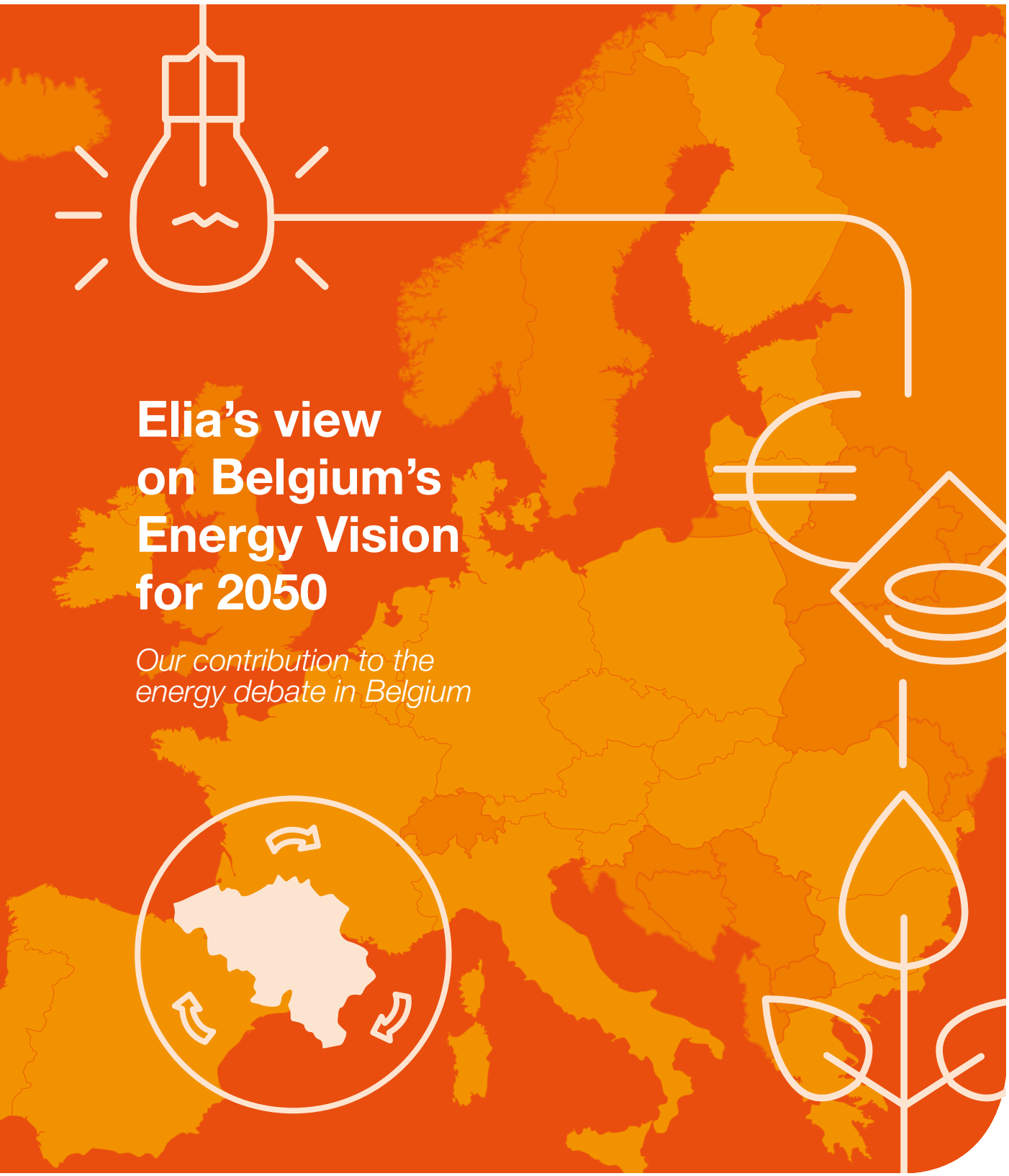

Elia's view on Belgium's Energy Vision for 2050

Our contribution to the energy debate in Belgium

June 2017

FOREWORD

Dear reader,

Belgium is about to take some important decisions about the future of its energy system. The so-called Energy Pact being drafted by the various regional and federal governments will set out the long-term future of a sector undergoing rapid and fundamental changes in a supranational context.

In this memo, as system operator of the Belgian high-voltage grid, Elia intends to make a fundamental contribution to society's discussion of this issue.

The need for clear, swift decisions to keep all options open.

The electricity grid is a key pillar of energy policy that drives both economic growth and our society's decarbonisation by integrating ever-increasing volumes of renewable energy.

Clear and swift decisions need to be taken if we are to keep all our options open in the future. It can easily take between 5 and 10 years to construct new generating capacity and grid infrastructure. Such a period of time would take us up to the threshold of Belgium's planned phase-out of nuclear power in 2025.

Access to sustainable electricity at the best price through the Energy Roundabout.

Consequently, it is crucial that Belgium should occupy a strong position, respond intelligently to the challenges facing it and exploit any opportunities arising today. Thanks to Belgium's geographical location and well-developed electricity and gas grid, we play a central role in the European power system.

"Clear and swift decisions need to be taken if we are to keep all our options open in the future."

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So we have to optimally exploit our unique position as an 'Energy Roundabout'. Through interconnectors, additional investment, further digitisation, more innovation and suitable market platforms we can give our businesses and consumers constant access to a supranational market with the most sustainable electricity available at the lowest price.

Follow-up report in November to quantify various options.

This memo outlines our vision of the Belgian power system between now and 2050. In mid-November 2017 this will be followed by a comprehensive study in which we will quantify various options and help to seek answers to unresolved issues with which both policy-makers and the energy sector are struggling today. How quickly do we intend to complete the energy transition? How much will it cost and which energy mix will we be using? To what extent do we want to be dependent on foreign imports? Will our energy prices remain competitive? And so on.

As transmission system operator, Elia serves society. By writing this memo and carrying out the follow-up study, Elia intends to fully contribute ideas on how to solve the challenges that Belgium is facing in the energy transition.

Chris Peeters
CEO of Elia

"The electricity grid a key pillar of energy policy that drives both economic growth and our society's decarbonisation."

TABLE OF CONTENTS

1 INTRODUCTION

The energy system has matured over the past decades becoming an integral part, and a cornerstone of our economic activity. It has ensured an affordable and secure energy supply. In the future it will facilitate sustainable energy generation. The drivers for the development of the electricity system have evolved over the years from reliability and affordability to being driven by sustainability.

From being driven by reliability and affordability…

Looking back many decades ago, Belgium made a choice of an energy mix largely based on nuclear power and fossil fuel (mainly coal and gas), aimed at delivering reliable and affordable electricity. This enabled a energy-intensive industry and comfort at home. The grid was built and operated to transport and distribute highly controllable and foreseeable electricity. Interconnections were mainly used for reliability reasons (i.e. to import electricity in the case of a possible outage of the domestic power plant).

As the wider European context became more important, interconnections have been increasingly used to import cheaper electricity to complement the domestically generated power, as well as to export excess power to neighbouring countries.

…to being driven by sustainability (while maintaining affordability and reliability)

During the last couple of decades, climate concerns have prompted the adoption of European policies on sustainable energy production (e.g. 20-20-20 targets at European and national levels[1]). As a consequence, renewable generation - both at transmission and distribution level - has rapidly become an increasingly important part of Belgium's and Europe's energy mix. In line with the European commitment to further decarbonise our society by 2050 - as agreed during the COP21 climate conference in Paris - renewable generation and other decarbonising technologies will become ever more present.

Reliable **Affordable** **Sustainable**

[1] 20% cut in greenhouse gas emissions (from 1990 levels), 20% of EU energy from renewables, and 20% improvement in energy efficiency.

There are opportunities to be seized from a changing environment

Given that Belgium has no or low potential in primary fuels (such as coal, gas, oil, uranium, etc.), the transition towards more renewables represents an opportunity both in sustainability and in energy independency. But it also brings many challenges, in particular about how to maintain a competitive economy and social welfare in the next decades.

The magnitude and speed of the challenges affecting the energy system will only increase in the years to come. However, changes also mean that there is a chance to seize opportunities that arise with the right choices in terms of vision and steps to make it happen.

Our vision

As the Belgian Transmission System Operator for electricity, Elia aims to bring forward its point of view on the Energy Vision for 2050, in order to contribute to the current ongoing energy debate in Belgium.

We believe in a renewables-based and EU integrated electricity system where the full extent of our domestic potential is valorised and complemented - via interconnections - with affordable energy from the most efficient and sustainable resources abroad.

This will bring maximum benefits to the three pillars of the Energy Trilemma: reliability, affordability and sustainability.

2 KEY ELEMENTS OF THE EUROPEAN ENERGY TRANSITION

The current European climate and energy policies are aiming at creating a sustainable, affordable and reliable energy system. The three objectives of the so-called 'Energy Trilemma' should be pursued at all times and should be supported by national policies being consistent with and building on this European mission.

2.1. Trends at European level

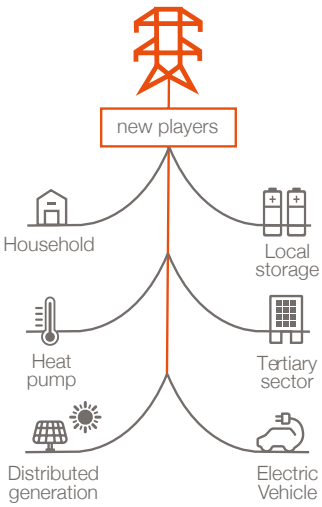
As a consequence of these EU objectives, the European energy system is undergoing a profound transformation linked to three major changes:

1. **the transition of a centralised electricity system mainly based on conventional energy sources (like nuclear, coal and gas) towards more decentralised generation with more renewables (mainly wind and solar) located far from consumption centres and even on lower voltage levels.**
2. **the increasing digitalisation and appearance of new players and more active consumers**
3. **the shift to an integrated EU market, with increased supranational cooperation.**

The consequences of the above mentioned changes are already occurring, as shown in recent trends and events at European and national level.

The development of intermittent generation

Decentralisation, digitalisation & new players



Increased supranational cooperation

TREND 1:
the transition of a centralised electricity system towards more decentralised generation

- **More renewables set to replace conventional capacity**

At the United Nations' climate conference COP21 in Paris (2015), Europe has committed to reducing its carbon emissions by at least 80% by 2050. Given the importance of the electricity sector concerning carbon emissions, the European Commission estimates that, in order to achieve the decarbonisation target, renewables will have to account for between 64% and 97% of electricity generation by 2050[2].

In line with this objective, several European countries plan to decrease their coal-fired power plants by 2030. We also see a gradual phase out of nuclear plants. The combination of both will lead to an estimated 20% reduction in conventional generation capacity in Northern Europe (FR, DE, NL, GB, BE).

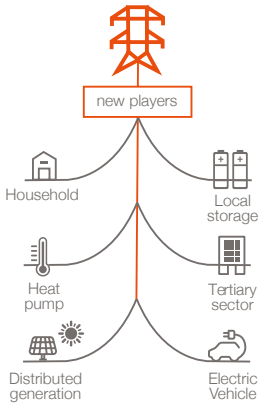
In parallel with this, there is a transition towards a renewables-based system, with increasing amounts of renewables steadily displacing conventional generation. This transition is facilitated by the reduction in total costs (investments, maintenance) of renewables which has been made possible by technological progress. Wind and solar are progressively emerging as the "winning" technologies to decarbonise the system.

- **Conventional fuels as flexible backup**

Storage (e.g. batteries) is increasingly contributing to the management of the daily variability of renewables and the balancing of the system, but is not yet mature (in the short to medium-term) to manage the weekly or seasonal variability.

Given the limited storage capacity and the intermittent nature of renewables, the contribution of conventional fuels to the energy mix still remains necessary for providing flexibility and keeping a role as a backup. This conventional generation will highly likely come from gas-fired power stations that allow a quick start/stop to adapt to the variable nature of renewables, while maintaining a limited CO_2 emission rate.

[2] European Commission, Energy Roadmap 2050



TREND 2:
the increasing digitalisation and appearance of new players and more active consumers

- **Towards a consumer-centric energy market**

Recent technological developments (e.g. in the field of digitalisation) enable the consumer to enhance its local generation/storage capacity and to optimise its consumption in near real-time. This innovation paves the way for a consumer-centric energy market, a sine qua non for achieving the transition at the lowest cost.

However, a self-sufficient consumer model is not yet feasible. It presents a higher cost than a mixed model (based on network and production/local storage) for a similar level of reliability. In addition, storage technology does not yet cover a winter season.

- **Towards an Internet of Energy**

Automation and digitisation of devices make it possible to transform formerly “passive” consumers into a network of intelligent generation and storage units. These units will soon communicate with each other in a digital way to adapt to the intermittent profile of renewable generation. This paves the way for an Internet of Energy (e.g. charging all electric vehicles in the event of sunshine or unloading in case of rain).

TREND 3:
the shift to an integrated EU market, with increased supranational cooperation.

• **Optimisation of investments and harmonisation of rules**

National networks and markets are gradually being integrated through interconnections. They are developed in a coordinated manner at European level in order to optimise investments and to harmonise the rules of an integrated market (e.g. characteristics of cross border products, rules for system balancing, etc.).

Clearly, the integration of renewables is driving the need for more grid infrastructure and for more coordination of the operation system – both at national and European level. For the European transmission grid alone, investments could amount to €100 – €400 billion in order to decarbonise our societies by 2050, while the benefit for the European economy, resulting from an optimal use of resources, would largely exceed these costs[3].

• **Increasing security of supply**

As wind and solar generation is dependent on weather conditions, interconnections increase the security of supply for all EU countries. Therefore, pooling renewable and conventional resources via interconnections is cheaper than creating storage for which technologies are not yet economically viable. Moreover, as the potential of wind and sun is unevenly distributed, EU market integration allows member states with limited renewable capacity at the moment to yet to meet their CO_2 emissions reduction targets.

• **Converging of energy prices**

Interconnectors also enhance price convergence by building on synergies in the production mix of European countries. They facilitate the dispatch of the most efficient production resources at European level, based on a European 'merit order'.

[3] eHighway2050 project results: http://www.e-highway2050.eu/fileadmin/documents/e_highway2050_booklet.pdf

2.2. Events at Belgian level:

Currently debates are taking place at federal and regional levels, with the aim of defining Belgium's long-term energy vision, with a focus on the future energy mix and market design. This is of particular importance given the decision to phase out nuclear generation by 2025, and Belgium's commitment to the COP21 Paris Agreement.

In April 2016 Elia delivered a study on the adequacy and flexibility needs of the Belgian electricity system, which was performed at the request of the Federal Minister of Energy, Marie-Christine Marghem, and developed in cooperation with the Cabinet of the Minister and the Belgian Energy Administration of the Federal Public Service (FPS) Economy. The study covered the period from 2017 to 2027 and an addendum was delivered in September 2016.

In preparation for the energy debate, various studies by different stakeholders have been published at the end of 2016 and in early 2017. Most of them are looking at the energy system by 2030, with only a few performing analysis up to 2050[4].

Given the profound and rapid changes happening in the energy system, Elia is willing to contribute to the debate on the Belgium Energy Vision.

[4] For instance BBL, Greenpeace, IEW, WWF Belgium: "Our Energy Future 2016", Energy Ville "Energy Transition in Belgium - Choices and costs", Bureau du Plan, Nucleair Forum, DNV GL "Vision on an open and resilient energy system"

3

THE ENERGY VISION FOR BELGIUM: ELIA'S POINT OF VIEW

The electricity system is a key pillar of economic growth, social welfare and it is vital for the decarbonisation of our society. As it easily takes 8 to 10 years to construct new infrastructure, clear and quick decisions are needed in order to keep all options open for the future.

Here we present our view on the Belgian Energy Vision for 2050 and its key elements. Our Energy Vision needs to be considered over the longer-term, and translate into a roadmap with the intermediate steps to make it happen.

3.1. Achieving Belgium's ambitions by building on its strengths

Europe has committed to the decarbonisation of its society, with a target of an 80% reduction in greenhouse gas emissions (with respect to 1990 levels) by 2050 as stated in the COP21 Paris Agreement. On the path towards 2050, Belgium is set to phase out its nuclear generation by 2025 which accounts for about one third of Belgium's total installed capacity today and for half of the produced electricity.

Encouraged by climate policy, technology and economic drivers, energy efficiency will dramatically improve. On the other hand, electricity consumption will increase as electricity substitutes other energy sources (e.g. oil) in different economic sectors. In this sense, electrification of highly energy-demanding sectors such as heat and cooling (via heat pumps, combined-heat and power, etc.) and transportation (through electric vehicles), will play an important role in our path towards decarbonisation.

While achieving the above ambition, Belgium should stay a competitive country at the centre of Europe - with a reliable energy supply - in order to create a stable environment for industry and citizens alike. To build the path allowing Belgium to achieve its ambitions, it is important to take into account its strengths and challenges.

Strengths

- Located at the centre of Europe, Belgium is at the crossroads of important renewable generation hubs - major wind hubs in the North and solar hubs in the South – and close to the main load centres.

- In this central position, Belgium is surrounded by large countries (such as Germany, France and the UK) with different strategies from the energy point of view, which gives Belgium access to the best of their choices.

- As part of its energy strategy, Belgium has built and maintained a robust and interconnected energy infrastructure (electricity and gas), as well as a leading position in market design and integration. This constitutes the biggest strength on which Belgium should leverage.

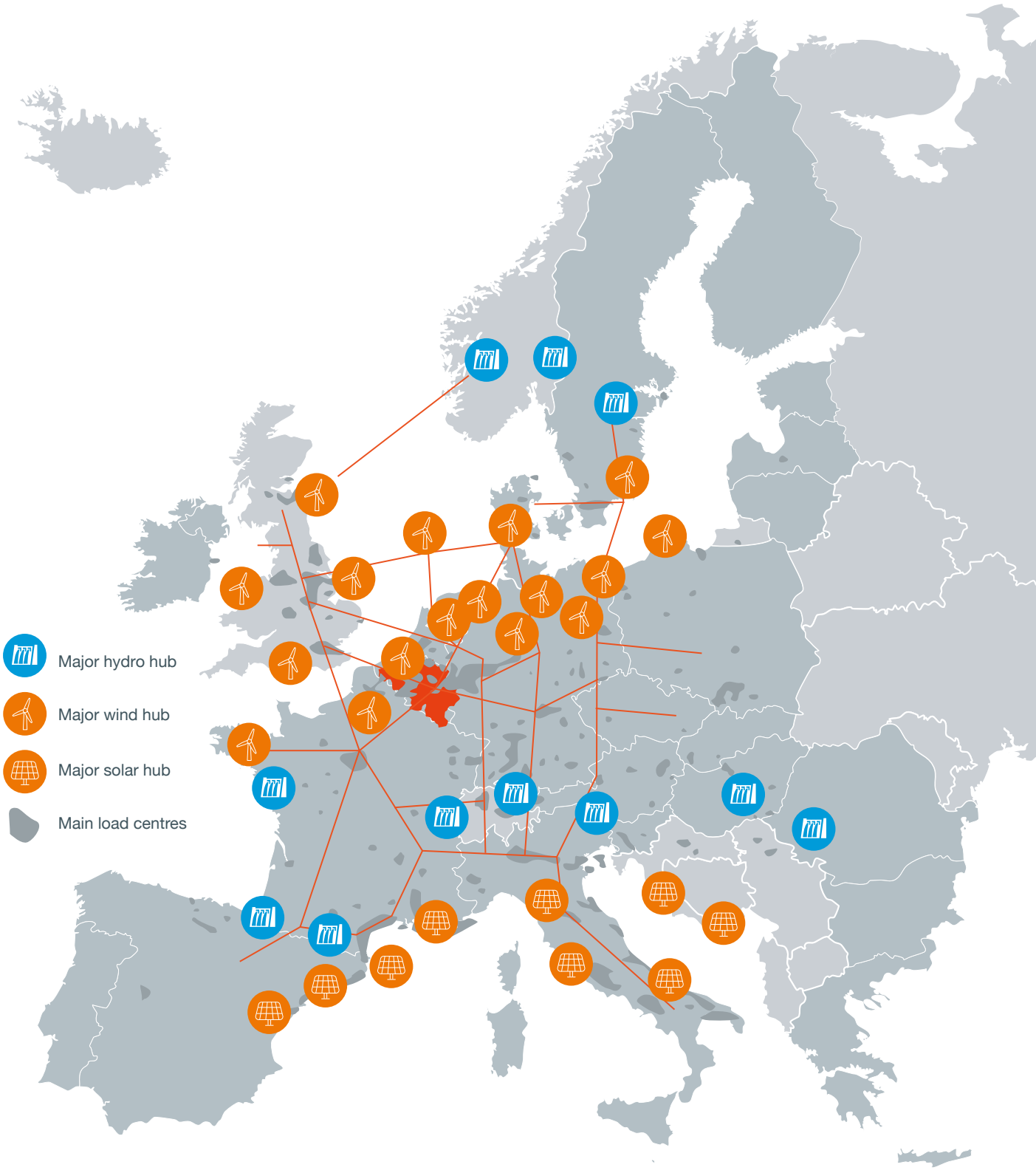
Challenges

- Given Belgium's small territory, only a part of Belgium's demand could be met by domestic renewable capacity. It is therefore not possible to rely only on domestic renewable generation to achieve a full decarbonisation.

- In the current market design, with higher amounts of renewables in the system, concerns have been raised about the profitability of conventional units.

- Maintaining security of supply becomes increasingly challenging given that less than a decade from now nuclear power will be phased out in Belgium.

Thanks to our geographical location and well-developed electricity and gas infrastructure, our country is at the centre of the European energy system.



3.2. Belgium in 2050: an Energy Roundabout for Europe

Taking into account our strengths and challenges, Belgium has to leverage on existing and upcoming energy infrastructure and its central EU position, to benefit from the European renewable potential and the diversified energy mix of our neighbouring countries.

In an energy world that is becoming more renewable and decentralised, with increasing levels of digitalisation and with consumers becoming increasingly active, Belgium could become an Energy Roundabout for Europe[5] not only to decarbonise society but also to keep a competitive economy and preserve our comfortable way of life.

The evolution towards an Energy Roundabout would contribute to solving the Energy Trilemma for the generations to come, by providing:

1. **A sustainable energy system enabling a decarbonised society,** thanks to a renewable-based system where the full extent of our domestic potential is exploited, and where it is complemented with renewables sourced from abroad via interconnections.

2. **An affordable energy system enabling a competitive economy,** by building upon the complementarity of the generation mix of European countries. Thanks to its well interconnected infrastructure, Belgium can access energy from the most efficient resources located domestically and abroad. Digitalisation and an enhanced market design will help exploit the full value of the system.

3. **A reliable energy system facilitating economic activity and maintaining comfort in daily life,** thanks to an energy mix (renewables, imported energy via interconnections, demand response and storage, and backup plants) that can meet demand at all times.

[5] The idea of an Energy Roundabout is also put forward in several studies, such as in DNV GL's "Vision on an open and resilient energy system"

1. Providing a sustainable energy system

• **Using the full potential of domestic renewables**

Belgium's potential for domestic renewables will mainly be onshore and offshore wind, and solar photovoltaics; while biomass, geothermal and hydro energy could contribute in lower volumes to decarbonisation. Biomass, due to its "storable" and controllable character, remains highly valuable as long as the organic fuel used is sustainable.

However, even by exploiting the full potential of domestic renewable generation, the achievable decarbonisation will be limited by geography to a level below the potential of Western Europe as a whole.

• **Leveraging on the energy-mix of our neighbouring countries**

Belgium therefore needs to leverage on the climate and energy policy choices made by Europe and our neighbouring countries in terms of renewables. Indeed, many countries in Europe have a renewable potential that will allow their generation to exceed their own demand. These countries will also have an energy mix where the share of conventional generation will decrease.

Excess generation – increasingly renewable – in those European countries can then be imported to complement our domestic generation.

2. Providing an affordable energy system

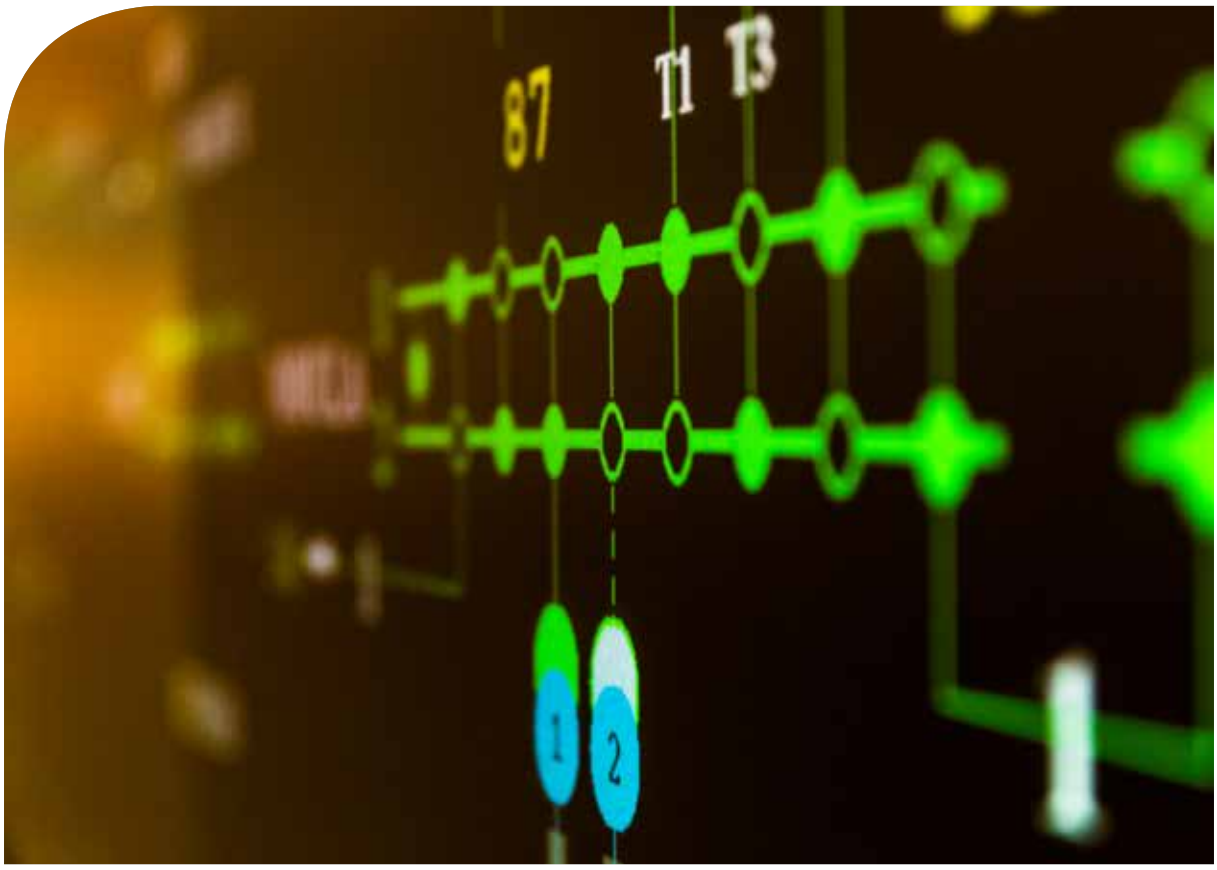
• **Facilitating the dispatch of the most efficient resources**

The grid is key for integrating high amounts of renewables into both centralised and decentralised systems. Belgium should build upon its existing energy infrastructure (electricity and gas), by maintaining and further developing a strong and reliable grid ("Target Grid") – both onshore and offshore – as well as interconnections with our neighbouring countries.

Such interconnections facilitate the dispatch of the most efficient generation resources at European level, based on a European "merit order". They hereby improve the market position of the more efficient power plants, thus allowing these plants to find demand abroad at times when there is excess generation.
This will allow us to have energy (commodity) prices as low as those of our "competing" neighbours.

• **Exploiting the system's value via digitalisation and enhanced market design**

Digitalisation and "smarter grid" market design will unleash huge amounts of flexibility from all levels of the system – both at distribution and transmission level – and from all users – industrial, commercial and residential. This will put the active consumer or "prosumer" in a central role in the system, by creating a new ecosystem of applications and services thanks to new business models. Exploiting the flexibility from decentralised energy resources – flexible demand, decentralised renewables and distributed storage - to help manage the system will constitute a win-win for both the prosumer and society.



3. Providing a reliable energy system

• **Managing the variability of renewables**

Interconnectors enable the exploitation of the geographical spread of renewables as well as helping managing their temporal variabilities (the daily, and even weekly and seasonal cycles of renewables). A new wave of interconnector developments will then be driven by the integration of renewables at the lowest cost.

Furthermore, short-term storage (e.g. batteries) and demand response are and will continue to help the system in terms of flexibility. They help balance the system and manage the daily variability of renewables (e.g. day-night cycles of solar photovoltaics). However, achieving full decarbonisation in the longer run (close or beyond 2050) could require long-term storage technologies (e.g. power to gas, power to heat), which are not mature enough today.

• **Complementing renewables together with natural gas**

Gas-fired plants will play an important role for decades to come after the nuclear exit to ensure reliability (and contribute to sustainability in the short-term by replacing coal and lignite plants). As more renewables are being integrated, the share of gas-fired plants in the energy mix will gradually diminish towards 2050.

However, and despite the lower running hours, gas plants will remain crucial as backup. In this respect - as concluded by a number of studies[6] – a combination of more interconnection capacity in Europe, together with backup capacity close to load centres seems to be the cost-optimal way to enable decarbonisation in a highly renewable energy system.

Natural gas is therefore set to become the “transition fuel”, taking over other conventional fuels such as nuclear and coal in the European energy mix. Moreover, the combined gas and electricity roundabout will give a prominent place for Belgian gas plants in the European context, with high interconnection levels improving the market position of the more efficient plants. Despite the need for gas plants, the question on how to provide the appropriate signals for new investments remains.

[6] For instance: Agora Energiewende (2013): 12 Insights on Germany’s Energiewende; eHighway2050 Project results (2015): Europe’s future secure and reliable electricity infrastructure

3.3. The main requirements to realise the Energy Vision

In order to be achievable in Belgium, the Energy Vision should be pursued under the following conditions:

- **Keep a leading position in markets and digitalisation**

Belgium has so far been a pioneer in market design and market integration in Europe. Maintaining such a leading position is crucial. An updated market design ("software") will exploit the full value of the system assets ("hardware") at all levels (centralised and decentralised). Further market integration - both for energy and for balancing - will contribute to the affordability of electricity prices, and together with digitalisation will facilitate the active role of the consumer or prosumer in the electricity system.

- **Facilitate new investments along the entire value chain**

Building the future energy system will require timely investments in the energy sector at all levels of the value chain. Such new investments involves building more domestic renewables and efficient (backup) gas plants, more transmission (including interconnections) and distribution infrastructure to help integrate renewables and new demand, as well as technologies and appliances enabling the active participation of electric and decentralised assets such as electrical vehicles, heat pumps, storage, etc. A stable and supportive legal and regulatory framework will be required to facilitate such investments.

- **Innovate and look for opportunities**

Belgium must also be innovative and look to exploit the opportunities and synergies between the energy sector and other industrial activities. This may allow us to take a leading position in the development and integration of some technologies and services that will enable a full decarbonisation of the electricity sector.

- **Enhance coordination at all levels**

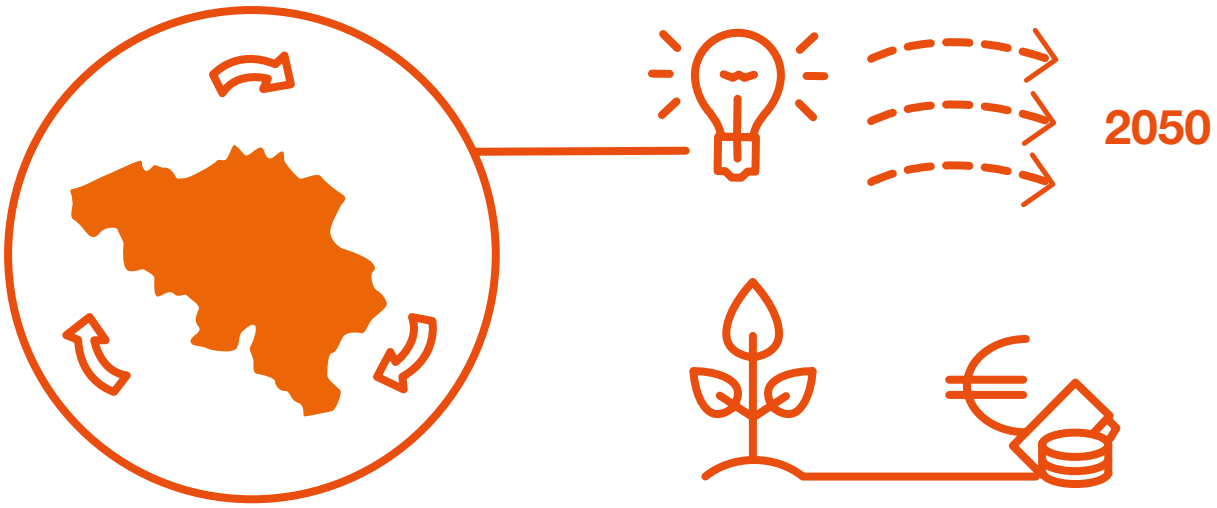
The appropriate means for ensuring security of supply (i.e. ensuring capacity meets peak demand in MW) will need to be complemented with enhanced coordination in the operation of the energy system at all levels. This will be needed both at national level through to more coordination between transmission and distribution system operators, as well as at pan-European level by increased coordination between transmission system operators.

3.4. How to get there?

There is not a single path to achieve the Energy Vision for 2050. Nevertheless, in the transition period from today to 2050 maintaining reliability is a must.

Different paths exist depending on:

- The pace to reach the sustainability target (e.g. do we perform more renewable investments to decarbonise faster?)
- The affordability of the transition (e.g. what is the cost of the different energy mix options and the resulting energy prices?)



Elia is willing not only to contribute to creating the Energy Vision for 2050, but also to the roadmap to get there, and subsequently to build the "Target Grid" (onshore & offshore) that will enable it.

4

NEXT STEPS: OBJECTIVISE OUR VIEW

Based on our vision for 2050, we will assess the intermediate timeframes of 2030 and 2040 ("backcasting"), making the link with the Elia study delivered in 2016 (assessment up to 2027).

For 2050, scenarios become too speculative in terms of the maturity and possible technologies that can allow high levels of decarbonisation to be achieved. As such, we will not quantify the scenarios in 2050. Although there are many uncertainties on the path from 2040 to 2050, we believe that there will be enough elements to support decision-making in the short term in order to achieve the intermediate stage up to 2040.

The assessment at the intermediate timeframes of 2030 and 2040 will be done under the framework of the Energy Trilemma of affordability, sustainability and reliability, to allow comparison of results. Concrete recommendations will be proposed – backed by quantifications - on the positioning and role of the Belgian electricity system in Europe and the energy mix, as well as possible transition paths to achieve the vision.

Through the study – expected to be delivered by mid-November 2017 - we expect to bring forward answers – where possible - to some outstanding questions which will help policy makers by enabling them to take informed decisions:

- **Will Belgium be competitive when compared to its neighbours in terms of wholesale energy prices?**
- **How much capacity (conventional plants, demand response, storage) will be needed in Belgium to guarantee adequacy?**
- **Are new investments (in capacity to guarantee adequacy) profitable under the current market design?**
- **How can interconnections be valued in the system?**
- **How can storage be valued in the system?**
- **etc.**

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