TASK FORCE SCENARIOS

Belgian Electricity Scenario Report

Final report

The final report takes into account the feedback from the public consultation

Content

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1 Introduction

1.1 Context

As final deliverable of the scenario co-creation process within the 'Task Force Scenarios', Elia now releases the final version of the scenario report. This Belgian scenario report serves as basis for the different studies Elia will perform in the near future.

The document is based on the draft scenario report, which was published for the "public consultation on the Belgian scenario framework and underlying data" held from 15/11/2021 until 12/12/2021. The final version incorporates the feedback received through this public consultation.

To facilitate the public consultation, questions were raised throughout the draft report which are removed in this final version. Elia has integrated the feedback leading to assumption changes within the main body of this document. All questions & feedback are however repeated in the public consultation answers report. This separate document that accompanies this final scenario report provides Elia's answer to all feedback received.

1.2 The Task Force Scenarios

In 2021, Elia has established the 'Task Force Scenarios' as a consultative body for the development of future scenarios used in power system analysis. The goal of the task force is the co-creation of storylines & scenarios for electrical demand and supply, both qualitatively & quantitatively for their use in studies performed by Elia.

Elia has created this Task Force seeing the numerous advantages in stakeholders bringing added value to the scenario creation process. Most important to Elia is the elevated involvement of stakeholders in this process. Stakeholders are actively called upon to provide evidence based data to feed the various discussions. In addition, stakeholders can become more involved in prioritization of scenario related research topics and can participate in long-term storyline creation that will be used in Elia studies.

The Task Force aims to increase scenario transparency by rationalizing the scenario creation process, discussing openly on the correct interpretation of parameters, visualizing assumptions in a consequent manner and communicating transparently on the level of agreement.

In order to improve coherence, the Task Force's quantified Belgian electricity scenario serves as a common scenario basis for a growing amount of annually performed studies.

By providing a forum for discussion, in which scenario specific topics (demand, demand side response, renewables…) are covered separately and in depth, stakeholders have the opportunity to delegate subject matter experts to the task force in an ad hoc manner. In organizing a call for evidence, a larger number of trustworthy sources, formerly unavailable to Elia, can be harnessed for the creation of scenarios, thereby increasing the overall data quality.

In centralizing scenario governance, this task force eliminates a part of the need for scenario discussions at individual study level, thus freeing up time for study specific discussions in the respective task forces. However, it is important to note that this task force does not replace any legal processes required in the framework of studies performed by Elia where such process is defined.

Finally, the Task force supports the Transmission System Operator (TSO) when it is required to submit scenario data for Belgium for European studies, to comply with EU regulations.

Elia has set up a website for this task force where more information and meeting minutes can be found: "https://www.elia.be/en/users-group/task-force-scenarios".

The goal in the future is to make this Task Force evolve in order to meet stakeholder's expectations and level of involvement they would like to have in such process. This report constitutes a first step towards the co-creation of scenarios.

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1.3 The scenario co-creation process

The annual scenario creation process is depicted in Figure 1.3.1. Currently we are at the sixth step of the process, i.e. the publication of the final scenario report.

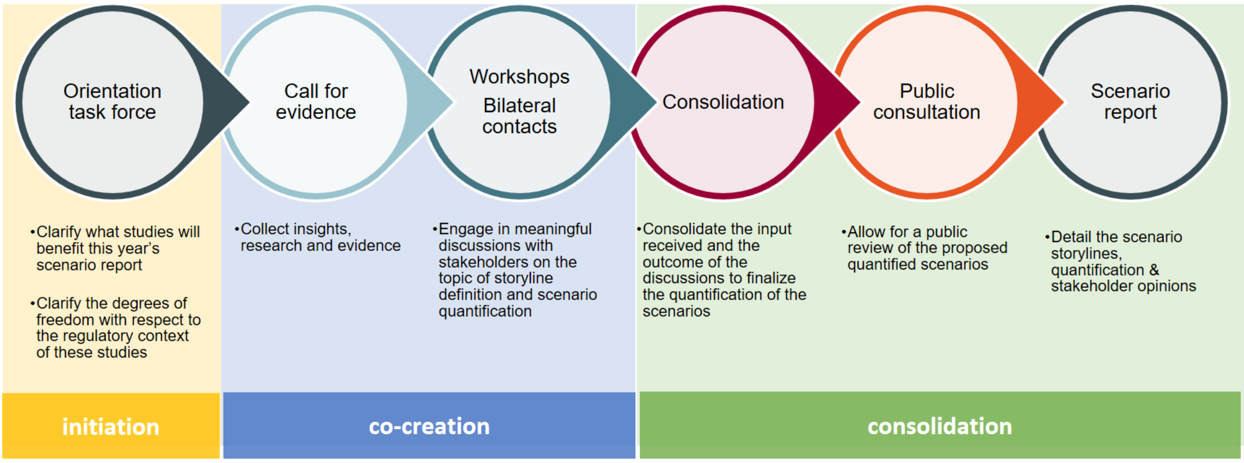

Figure 1.3.1 Recap of the annual scenario creation process

In Figure 1.3.2, a short recap is given of the external milestones in the first year of the Task Force.

End of March of 2021, a 'call for members' was launched. In this call for members, everyone was invited to become a part of the Task Force. Concurrently, the Terms of Reference were published for public consultation. After this, the Task Force was established with the stakeholders nominated through the call for members. In addition, as this was the first iteration of the annual scenario creation process, registrations were left open, so stakeholders could still join the Task Force during the rest of the year.

On 18/05/2021, Elia organized the kick-off meeting. Various topics (e.g. the Terms of Reference, an initial timeline for the rest of the year…) were discussed at this task force meeting. Furthermore, Elia proposed two topics for the 'call for evidence' and consequent workshops. Although stakeholders were free to propose other topics, the topics proposed by Elia were accepted by all parties.

Based on this, Elia launched a 'call for evidence' on two topics: "Scenario storylines" & "Flexibility in electricity consumption". Any evidence that was received in this 'call for evidence' public consultation was discussed further bilaterally with the relevant parties.

After this, two workshops were organized on the abovementioned topics. The draft minutes of these reports can be found on the Elia 'Task Force Scenarios' webpage[1]. These minutes will be formally approved in the next Task Force meeting.

Figure 1.3.2 Timeline of the 2021 process

On 15/11/2021 Elia published its draft scenario report for public consultation. This consultation ran until 12/12/2021. Multiple stakeholders provided feedback which has been integrated in this document. In addition, an answers document was prepared by Elia to address all questions directly.

This report, the final Belgian electricity scenario report, considers the output of all prior steps as described above.

1.4 The link with market studies

Market studies comprise studies where electricity market modelling is required (usually by the means of a unit commitment tool). Those can be roughly categorized in two large groups. On the one hand economic studies and prospective studies, on the other hand adequacy studies. A non-exhaustive list of examples of each group is given in the table below for both Elia & ENTSO-E studies.

	Elia	ENTSO-E
Economic & prospective studies	Federal Development Plan (FDP)	Ten Year Network Development Plan (TYNDP)
Adequacy studies	Adequacy & Flexibility study (AdFlex)	European Resource Adequacy Assessment (ERAA)

[1] Task Force Scenarios (elia.be)

	Capacity remuneration market volume calibration (CRM)	

Table 1.4.1 Examples of studies where electricity market modelling is required

Each of these groups has specific scenario needs:

- The former group considers a long-time horizon, with a window starting at 10 years from now, and looking 20 to 30 years ahead. For this group uncertainty is a given which is resolved by means of introducing multiple storylines that cover plausible future states (which are a combination of several drivers);
- The latter group considers a more short time horizon of roughly 10 years. Here, the most important thing is the preparation of a well-supported best-estimate on demand and generation, market rules & grid configuration. Such 'best-estimate' is usually complemented with several sensitivities on one or more parameters.

At present, most of Elia's and ENTSO-E's economic and prospective studies (FDP, TYNDP…) have a 2 or 4 year recurrence. In contrast, most of the adequacy studies (CRM volume calibration, ERAA, Adequacy & Flexibility…) have a 1 to 2 year recurrence. As a result of this duality, it was decided to organize a biennial process within the Task Force Scenarios. In this process, every odd-numbered year, the long-term hypotheses for Belgium are proposed and quantified in a scenario framework report.

In centralizing scenario governance, this task force eliminates a part of the need for scenario discussions at individual study level, thus freeing up time for study specific discussions in the respective task forces. However, it is important to note that this task force does not replace any legal processes required in the framework of studies performed by Elia where such process is defined. In Figure 1.4.1, a visual representation is given of the use of the scenario report. Please note that the list of studies is again not exhaustive.

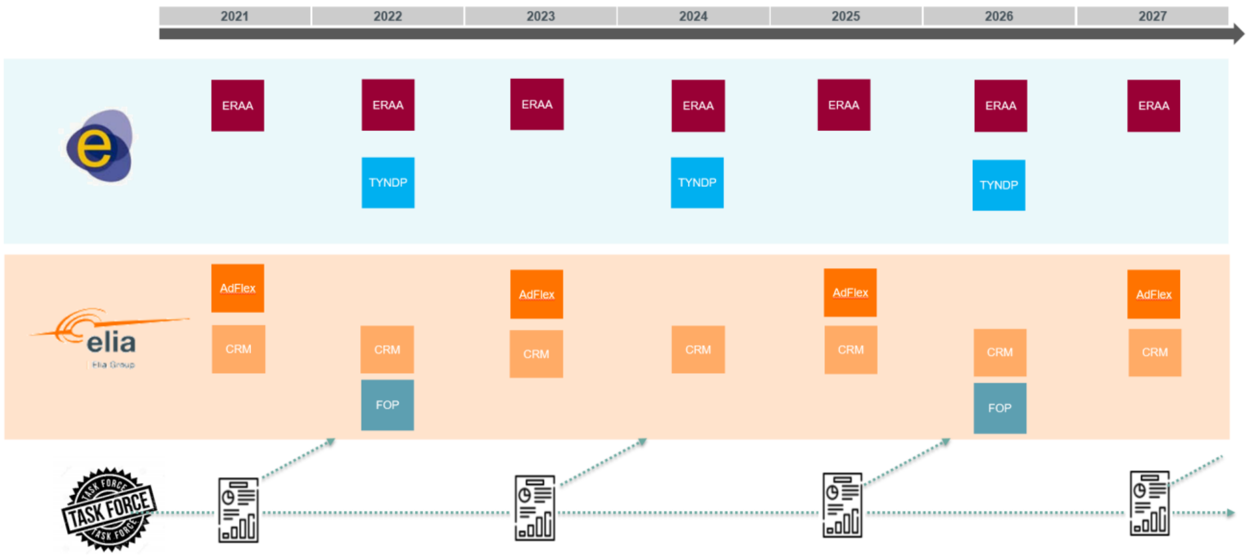

Figure 1.4.1 Visual representation of the use of the scenario report.

2 Scenarios

2.1 Long term vs. short term

As introduced in the previous chapter, **this scenario report focusses on the long-term perspective**. The short term scenario (up to 2030) was quantified and consulted upon last year. It was established in the framework of the ‘Adequacy and Flexibility study 2022-32’ and is rooted in the policy ambitions known at that time. The short term figures that are shown in this report are therefore based on that scenario. In addition, it is also the goal to take the latest policy proposals into account, such as the ‘Fit for 55’ package proposed by the European Commission (EC) by creating an additional scenario covering the year 2030. This will be further developed in section 2.3.4.

The long-term scenarios presented in this document intend to provide a diversified view on long-term energy supply and demand. These scenarios consider trends, policy ambitions and technological developments with a focus on the electricity system. While the storylines are defined on the total energy (not only electricity), their quantified translation is mainly done on the electricity supply and demand but also include the interfaces with other energy vectors which are needed to correctly model the electricity system.

When considering the many drivers of which scenarios are composed, and noting the vast degrees of uncertainty linked to any driver, it becomes apparent that one cannot consider all possible combinations.

Such a combinatorial approach would not be feasible both from an interpretation- as from computational point of view. The goal of the ‘long-term’ scenarios is therefore to combine several drivers and uncertainties together in a coherent way so as to define a set of relevant as well as possible storylines / scenarios. The amount of finally attained storylines & scenarios is usually limited to three or four. The same approach is followed in this report. In addition, one can define sensitivities on the scenarios where only 1 (or at most a few) parameter is changed while the rest is kept unchanged. Such an approach is mainly used to assess the impact of a certain driver.

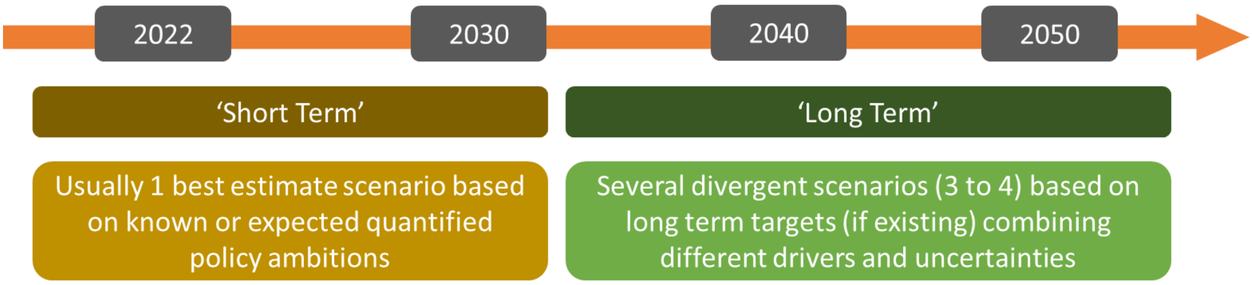

Figure 2.1.1 Differentiating short-term from long-term scenarios

The distinction between ‘short-term’ and ‘long-term’ can also be explained by the national & European policies planning and the level of uncertainties. Indeed, detailed or quantified ambitions are usually available for the short-term where uncertainties are either less present or can be tackled with sensitivities. In the ‘long-term’, a quantified breakdown of ambitions is not known and there are many uncertainties (each with major impact) which should be taken into account.

Given the goal to reflect different long-term pathways in order to assess (in the case of a TSO) the need of infrastructure, different scenarios are constructed combining several drivers and uncertainties. Although detailed quantification of the ‘solutions / options’ is usually missing for the ‘long-term’ horizon, European and national policy goals and strategies do exist. Those can therefore be taken into account when quantifying the scenarios.

2.2 The link with the European framework

A similar exercise is also happening at European level on a bi-annual basis. Here, ENTSO-E and ENTSO-G jointly aim to construct divergent scenarios, subject to public consultation by stakeholders and TSO's. These scenarios are used in the framework of gas and electricity infrastructure plans, e.g. the TYNDP. At the time of writing, the draft TYNDP2022 quantified scenario data was already submitted to public consultation[2] and changes to these data are being implemented by ENTSO-E/G based on stakeholder feedback.

As infrastructure planning is done partly using European market models, it is important to have European-wide scenario data. Hence, although the focus of this report is on Belgium, and TYNDP storylines might not reflect all possible pathways or focus on the main drivers affecting Belgium, it is still important to keep consistency with this European approach. In practice, this means data for other countries will be based on the TYNDP2022 scenarios. Additionally, for some countries (e.g. neighboring countries), the data could be further complemented with more up to date information from these countries' national scenario reports.

2.3 Storylines

2.3.1 EUROPEAN SCENARIO OVERVIEW

The TYNDP scenarios are quantified as from 2030 with one ‘Bottom Up’ scenario called **National Trends** and two ‘Top Down’ scenarios called **Distributed Energy** and **Global Ambition**. Prior to 2030, a **Best Estimate** scenario is used.

The **National Trends** scenario is in line with national energy and climate policies (NECPs, national long-term strategies, hydrogen strategies, etc.) derived from the European targets. The quantification of National Trends is done as of 2030 and up to 2040[3]. It is a bottom-up scenario, meaning the data are collected on a country basis by the TSOs. It is important to mention that the data collected for this scenario was collected prior to the ‘Fit for 55’ package proposal from the European Commission.

The **Distributed Energy** (DE) and **Global Ambition** (GA) scenarios are both COP 21[4] compliant top-down scenarios and achieve at least 55% of emissions reduction in 2030. Both scenarios were quantified on a

[2] https://consultations.entsoe.eu/system-development/entso-e-entsog-tyndp-2022-draft-scenarios-report-c/

[3] The expansion model for National Trends for the 2040 time horizon is not run at the draft stage of the TYNDP scenario report. TYNDP2022 scenario results for National Trends 2040 will only be included in the final TYNDP scenario report.

[4] 21st Conference of the Parties: https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement

country basis until 2040 and on EU-27 level for 2050[5]. These storylines were established through extensive stakeholder engagement and public consultations.

Distributed Energy is driven by a willingness of the society to achieve energy autonomy based on widely available indigenous renewable energy sources. It translates into both a way-of-life evolution and a strong decentralised drive towards decarbonisation through local initiatives by citizens, communities and businesses, supported by authorities. This leads to a maximization of renewable energy production in Europe and a strong decrease of European energy imports.

Global Ambition on the other hand is driven by a global move towards the Paris Agreement targets. It translates into the development of a wide range of renewable and low-carbon technologies (many being centralised) and the use of global energy trade as a tool to accelerate decarbonisation. Economies of scale lead to significant cost reductions in emerging technologies such as offshore wind, but also imports of decarbonised energy from competitive sources are considered as a viable option.

Figure 2.3.1 provides a visual overview of the TYNDP2022 scenarios.

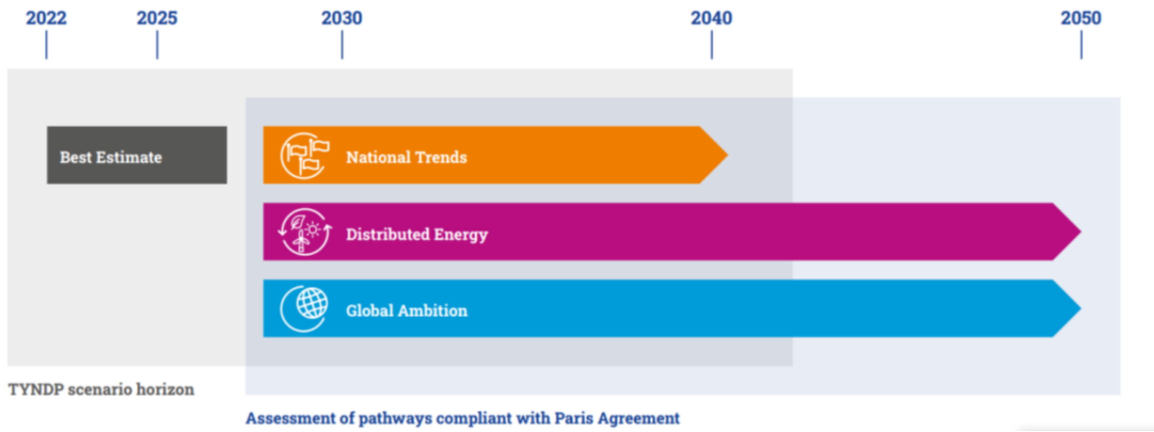

Figure 2.3.1 Overview of the TYNDP2022 scenarios

The main drivers used within TYNDP to characterize the Distributed Energy and Global Ambition top down storylines are:

- ‘Green transition’;

[5] TYNDP 2022 Draft scenario report, October 2021, p12

- ‘Driving force of energy transition’;
- ‘Energy intensity’;
- ‘Technologies’.

Those drivers were further developed in the TYNDP scenario report[6]. On 17th September 2021 during the first Task Force workshop of 2021 a more detailed presentation on the drivers and their respective categorical quantification was given.

2.3.2 MODIFICATIONS REQUIRED DUE TO STATE-OF-THE-ART MODELLING

As explained previously, consistency with the TYNDP scenario framework is required. However, additions and improvements to that framework will be considered to comply with the ‘state-of-the-art’ modelling used in Elia adequacy studies. Indeed, during the past years Elia has greatly improved several market modelling aspects based on stakeholder feedback but also to comply with newly adopted regulations on the matter. Several of those aspects are also planned to be introduced at ENTSO-E level but are either in ‘proof-of-concept’ stage or not yet taken into account. Ensuring consistency between studies and using state of the art techniques is key to correctly modelling the electricity market and its expected developments.

Elia’s state of the art market modelling introduces major improvements which go beyond the current modelling of ENTSO-E and ENTSO-G in the framework of the TYNDP studies. Examples of such improvements are:

- A forward looking climate database will be used consisting of 200 equiprobable climate years developed by Météo France. Current modelling at ENTSO-E and ENTSO-G uses an historical climate database and only simulates 3 years for the TYNDP. More information on the forward looking database can be found in here[7];

- A flow based modelling of the electricity grid is planned to be used. The current TYNDP modelling uses the ‘Net Transfer Capacity’ (NTC) approach for most of its deliverables (except for the so called Identification of System Needs (IoSN)). Given that the current approach used by the market in Central West Europe (CWE) is already flow based and that it is planned to extend this approach

[6] https://2022.entsos-tyndp-scenarios.eu/

[7] 20201029_Public consultation on the methodology the basis data and scenarios used (elia.be)

to most of Europe (at least the Core region), it is key to correctly model the possible market exchanges between the market areas. More information on the methodology developed by Elia for its adequacy studies can be found in the 'Adequacy and Flexibility study 2022-32' report in section 3.5 and Appendix B.

- Improved economic viability assessments and expected market design (e.g. CEP rules) will be taken into account. Several expected market design elements are planned to be introduced in the coming years and need to be taken into account in the modelling in order to correctly assess the market behavior.
- Updated global assumptions. The TYNDP scenarios are based on data collected several months ago and might not reflect the most 'up-to-date' expected evolution of some assumptions. This is the case for carbon and fuel prices where a new report from the International Energy Agency (IEA) (World Energy Outlook 2021) is available since October 2021. The proposal is therefore to use updated information when available and when it fits the scenario storyline. It was also the purpose of the consultation where input from stakeholders was requested to use the most up-to-date information available. Several national or European studies mentioned by stakeholders will also be integrated (e.g. updated assumptions for a given country).

These improvements can imply that some scenario quantification results obtained within the approach followed at TYNDP level require adaptations.

2.3.3 FEEDBACK FROM STAKEHOLDERS

As mentioned before, prior to drafting the scenario framework, Elia has organized a 'call for evidence'[8] in June-July 2021 on two topics: "*Scenario storylines*" & "*Flexibility in electricity consumption*". This consultation was followed by two workshops on these same topics.

In 'Task Force Scenarios – **Workshop #1** on **Storylines**' on 17th September 2021 the TYNDP top-down storylines (DE & GA) were presented to the TF Scenarios. In this workshop, the goal was not to find an optimal scenario nor to assess the most plausible one, but to assess the pathways provided by TYNDP and evaluate whether they capture the desired spectrum for Belgium, or whether a Belgian-specific variant

[8] https://www.elia.be/en/public-consultation/20210531-public-consultation-call-for-evidence-2021-as-part-of-the-task-force-scenarios

storyline or sensitivity was desired. Additionally the workshop aimed at having an in depth discussion on the drivers which are of great importance for Belgium.

Stakeholder input has proved very valuable in many ways. General questions raised by stakeholders have already been addressed in the previous sections of this scenario report to provide a more full-fledged overview. Examples are:

- How do storylines & sensitivities differ?
- What studies rely on best estimate scenarios vs. pathway scenarios?
- How are the efforts of the scenario task force linked to Elia studies?

An interesting discussion and point of controversy amongst stakeholders was the importance of cost and cost assumptions in a scenario framework & the viability assessment of new technologies. Some stakeholders were firm advocates that cost should be the primary driver for new investments and that scenario cost calculation and even optimization should be done. This in turn would mean that 'technology potential' has little added value. By contrast, other stakeholders believed that the uncertainty on cost is too high in the long term and that policy & societal acceptance should be the primary drivers for storylines, with cost being merely a consequence of these drivers. These stakeholders see 'technology potential' as a means of estimating the feasibility of a scenario.

As a result of a brainstorming exercise held in this workshop, the following elements were identified as having major impact for Belgium:

- Energy demand of buildings & the renovation rate;
- Electrification of transport;
- Electrification of commercial transportation (trucks & shipping);
- Electrification of industry (chemicals, steel…);
- Disruptive technology developments;
- Globalization vs. self-sufficient economies;
- Available (decarbonized) imports;
- Societal acceptance of new technologies.

In addition, multiple task force members argued that:

- ‘Fit for 55’ ambitions were not represented in the ENTSO-E scenario package;
- Both top-down scenarios are extreme. A middle ground, more 'business as usual' trajectory is missing in the scenario framework towards the long term;

- It is unclear how fast different trajectories meet the climate targets.

A second workshop '**Workshop #2** on **Flexibility** in electricity consumption' was held on 24th September 2021. The goal of this workshop was to discuss the options for flexibility in consumption and their relevance for the Belgian electric energy system. Stakeholders voiced the following insights and opinions on the topic:

- Hydrogen will be required for hard-to-abate sectors. Producing hydrogen from electricity using electrolyzers is very flexible and could thus contribute to flexibility in consumption e.g. by reacting to real-time market pricing. Hydrogen projects are currently limited to low capacity plants but projects of several magnitudes larger are already in the pipeline[9] in Europe. However, stakeholders are cautious regarding the domestic potential and believe Belgium will have to rely on hydrogen import.

- All stakeholders firmly believe in the electrification of household energy consumption urged by national policy. This translates to the deployment of e.g. heat pumps but might also require home batteries. Evidence that this is the direction Belgium is taking can already be seen today in construction codes for new built homes & renovation.

- Concerning electrified private transportation, stakeholders believe Belgium has a unique position, having a large share of company owned vehicles which are renewed more quickly than privately owned vehicles. This could lead to faster rate of EV penetration than elsewhere. The EV penetration will be strongly linked to the deployment of a 'fast charger' network to alleviate range anxiety.

- Stakeholders have identified two important barriers for short term flexibility contribution of these newly electrified assets (heat pumps, EVs…). A first identified barrier is infrastructure (both grid and data infrastructure). A second barrier relates to the societal acceptance of the transfer of price risk to the consumer.

[9] New Large-Scale Offshore Wind-to-Hydrogen Project Emerges in Denmark: https://www.offshorewind.biz/2021/09/03/new-large-scale-offshore-wind-to-hydrogen-project-emerges-in-denmark/

- Some stakeholders believe these barriers could be alleviated by moving from the individual perspective to the development of energy communities to mitigate investment risk. These communities, through jointly investing in energy assets, can make energy products more accessible to the end-user, at a higher rate of efficiency.

- Other stakeholders think these barriers may be too hard to overcome wholly and flexibility should be first and foremost developed at the producer side.

- In general, stakeholders believe these barriers, while still strongly present today, and even still by 2030 but should be resolved by 2040. Up to date infrastructure (grid and data) and transparent policy should lead to wide-scale integration of flexible vehicle charging and even 'vehicle to grid', optimal use of home batteries, demand shifting of heat pumps…

Finally, based on this feedback, Elia constructed a draft scenario report, which was published for the "public consultation on the Belgian scenario framework and underlying data" held from 15/11/2021 until 12/12/2021. During this consultation Elia received feedback on many of its proposals. In this final scenario report this feedback was taken into account:

- Some hypotheses were seen as too progressive by certain stakeholders, and too conservative by others. In this case, Elia has generally decided to hold on to its initial proposal.
- Some hypotheses received only feedback in one direction with sound argumentation, which led Elia to revise the hypotheses to better match the feedback received.
- Some feedback, although useful for future scenario exercises, was a too fundamental change to incorporate in the present report given the available time.

Changes in assumptions are reflected in this final scenario report, whereas Elia's answers to all feedback received can be found in Elia's consultation report.

2.3.4 SCENARIO FRAMEWORK

Building on the arguments listed in sections 2.3.2 and 2.3.3 it quickly becomes apparent that the current TYNDP scenario framework is insufficient in covering all Belgian scenario needs.

To cover the modifications required for state-of-the-art modelling, scenarios need to be updated. In order to provide a clear distinction between TYNDP and updated Elia framework, a rebranding was done of these scenarios. This section elaborates on Elia's proposal for most relevant storylines and scenarios for Belgium whereas section 2.4 goes into more detail on how these scenarios are constructed.

As depicted in Figure 2.3.2 the Belgian scenario framework consists of 5 scenarios and one sensitivity.

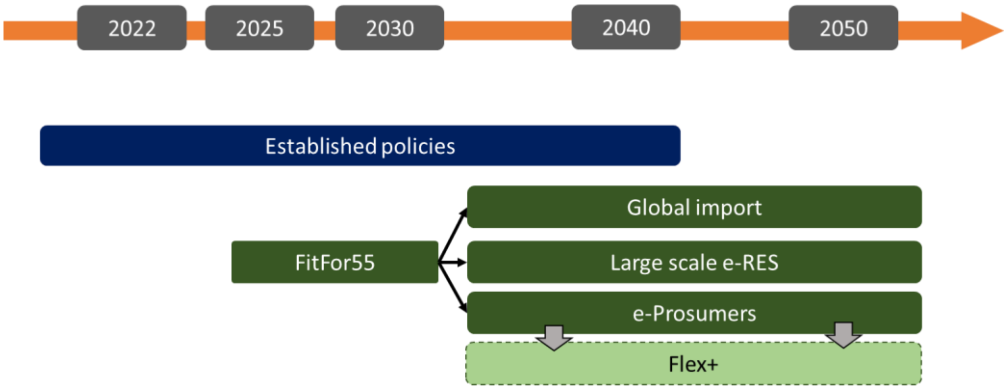

Figure 2.3.2 Overview of the Elia scenario framework

<u>For the period up to 2030:</u>

This time horizon is composed of 2 scenarios:

- **Established policies:** This scenario follows the national trend storyline. It is reflecting expected and known national policies as set in the National Energy and Climate Plans of each country. Any updates between the time of data collection of the TYNDP National Trends scenario (which was held several months ago) but before the implementation of 'Fit for 55' policy will be integrated in this scenario. Such approach was already followed in the framework of the Elia's Adequacy and Flexibility study published in June 2021.

- **FitFor55:** The European Commission has published its 'Fit for 55' package which includes a large amount of policy proposals and measures. In addition, the EU recovery plans were introduced which include many national measures that could have an impact on the future energy demand and supply in Europe. This package is still a proposal by the EC and has yet to be approved and translated into national climate plans. This scenario starts from the established policies baseline, but then goes on by integrating the more ambitious European 'Fit for 55' climate goals affecting the electricity demand and supply (e.g. in order to align with the RES objectives of the 'Fit for 55' EC package). The so-called 'MIX' scenario developed by the EC as a possible pathway to reach the 'Fit for 55' objective[10] is to be used as reference. By integrating this scenario, Elia is trying to meet stakeholder requests as voiced during the workshops. In additional to the FitFor55, several recent national announcements will also be integrated into this scenario such as the German governmental agreement, Dutch coalition agreement, Irish plans but also long term studies such as suggested during the public consultation (RTE 2050 study[11], the most recent 'Monitoring leveringzekerheid' of TenneT[12], Future Energy Scenarios of National Grid[13]…)

For the period after 2030:

This time horizon is composed of 4 scenarios. The first being a direct continuation of the 'established policies 2030' scenario. The other 3 as forks of the 2030 FitFor55 scenario. These three scenarios reflect the many uncertainties that could be combined in the longer term.

- **Established policies:** stakeholders requested a more 'business-as-usual' pathway in which societal acceptance might be less of a challenge compared to the two top-down TYNDP scenarios but also where the national concrete plans and ambitions are kept to the level known today. Hence, Elia, upon receiving the 2040 National Trends scenarios from ENTSO-E will adapt this scenario to be compliant with its modelling approach. In addition, the year 2035, which is unavailable in the TYNDP scenario framework, will also be quantified by Elia based on the 2030 and 2040 scenario data.

- **Global import:** this scenario follows the Global Ambition storyline from the TYNDP scenario framework as described in section 2.3.1. The focus is on centralized solutions to facilitate the energy transition. Making the bridge to stakeholder feedback, one could expect more producer-side flexibility in this scenario. With respect to the workshop discussion on European energy self-sufficiency, this scenario fully commits to importing large amounts of decarbonized energy from

[10] https://ec.europa.eu/energy/data-analysis/energy-modelling/policy-scenarios-delivering-european-green-deal_en

[11] Futurs énergétiques 2050 : les scénarios de mix de production à l'étude permettant d'atteindre la neutralité carbone à l'horizon 2050 | RTE (rte-france.com)

[12] Rapport Monitoring Leveringszekerheid - TenneT

[13] Future Energy Scenarios | National Grid ESO

outside of the EU. In addition, following the TYNDP storyline on which it is based (Global Ambition), this scenario is more intensive in terms of final demand than the other ones.

- **e-Prosumers:** this scenario follows the Distributed Energy storyline from the TYNDP scenario framework as described in section 2.3.1. Electrification of mobility and decentral energy solutions are thoroughly explored, combined with more efficiency in the final demand. The same goes for consumer side flexibility. With respect to the workshop discussion on European energy self-sufficiency, this scenario aims to make Europe more energy independent from other countries by maximizing RES supply and electrification.

- **Large scale e-RES:** this completely new scenario tries to find a middle ground between both previous scenarios which are either very centralized or decentralized, without forsaking the long-term climate goals. As such it combines both centralized RES generation (mainly offshore) with decentral solutions but at the same time introduces higher electrification rate than the TYNDP 'Global Ambition' scenario, thus integrating stakeholder feedback on the importance of electrification for Belgium.

Lastly, a sensitivity is also added to the framework:

- **Flex+**: is a sensitivity which is constructed based on the 'e-Prosumers' scenario where the flexibility of the electricity consumption is deployed to an extreme, yet reasonable level.

These post 2030 proposals can be mainly differentiated along 4 axes (but non exhaustive):

1. The **level of energy imports of EU.** This considers all energy carriers and is assessed on European level;
2. The **level of electrification** of the demand which relates mainly to the pace of electrifying heating, transport and industry;
3. The **level of flexibility of the electricity demand** which consists in the amount of flexible electricity consumption and storage devices in the system;
4. The **decentralization of the electricity generation** which is characterized by which type of technologies are mainly deployed in the system but also by their level of concentration (large scale generation versus small-scale generation spread over a certain territory).

Figure 2.3.3 gives the high-level qualitative description of the 3 scenarios and sensitivity for the post 2030 horizons.

<table>
<tr><th></th><th>EU energy imports</th><th>Electrification</th><th>Demand flex</th><th>Decentralization</th></tr>
<tr><td>Global import</td><td>High</td><td>Low</td><td>Low</td><td>Low</td></tr>
<tr><td>Large scale e-RES</td><td>Moderate</td><td>Moderate</td><td>Moderate</td><td>Moderate</td></tr>
<tr><td>e-Prosumers</td><td rowspan="2">Low</td><td rowspan="2">High</td><td>High</td><td rowspan="2">High</td></tr>
<tr><td>Flex+</td><td>Very high</td></tr>
</table>

Figure 2.3.3 High-level description of scenarios

2.4 From Storylines to Scenarios

For each storyline (see section 2.3.4) and target year in which it is applicable, a scenario is built. This section presents a high-level overview on how each of these scenarios are constructed.

The '**Established policies'** scenario is quantified for the years 2030, 2035 and 2040 and is based on the Best Estimate and National Trends scenarios from the TYNDP. This is complemented with information known prior to the 'Fit For 55' package which was introduced during summer 2021. For an overview of the data underlying this scenario for Europe, one can consult the TYNDP National Trends scenario (see 'The ENTSO-E visualisation platform'[14] for further details) but also the latest 'Adequacy and Flexibility study 2022-32'. Starting from those data, improvements in market modelling methodology as explained in section 2.3.2 are introduced:

- Improvements in the market modelling (forward looking climate database, flow based market coupling…) are taken into account;
- Fuel and CO_2 prices are updated based on the latest World Energy Outlook;
- All countries with a market wide CRM meet their known reliability standard. This is performed with an economic viability assessment of generation.

[14] https://2022.entsos-tyndp-scenarios.eu/

The ''**FitFor55**' scenario is quantified for 2030 and starts from the National Trends scenario. This scenario takes into account the previous National Energy and Climate Plans (NECPs) that were based on the REDII directive with the main objective of reaching at least 32% renewable energy share by 2030. In July 2021, a revision was proposed by the EC which led to a renewed objective of 38%-40% renewable share by 2030[15]. The aggregated national contributions and policies put forward in the final NECPs, achieves 33.2% renewable energy share in 2030, and thus underachieves the renewed ambition. Therefore, in order to make the National Trends scenarios 'Fit For 55' compliant, the following steps are taken:

- The recently adopted or announced national ambitions are taken into account (e.g. Germany, Ireland, the Netherlands…);
- The RES capacities are upgraded in order to meet the ranges set in terms of RES-E share which is in the range 64-67%;
- The electrification is updated in order to meet the proposed ranges of RES-Heating & Cooling share (39-42%) and RES-Transport share (22-26%);
- The absolute amount of electrical flexibility consumption options are upgraded in order to take into account a higher penetration of electric heating and mobility consumption;
- In addition, the steps applied for the 'Established policies' scenario are also taken into account here;
- An overall check is performed in order to ensure that the scenario complies with the targets set in the 'Fit For 55' package on an EU-level.

The steps for the construction of the **FitFor55** scenario are represented in Figure 2.4.1

Figure 2.4.1: Creation of the FitFor55 scenario

[15] https://ec.europa.eu/info/sites/default/files/amendment-renewable-energy-directive-2030-climate-target-with-annexes_en.pdf

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As from 2030, three additional scenarios and one sensitivity are constructed. These all go through the same process:

- The recently adopted or announced national ambitions are taken into account (e.g. Germany, Ireland, the Netherlands…);
- Improvements in the market modelling (forward looking climate database, flow based…) are taken into account;
- Fuel and CO_2 prices are updated based on the latest World Energy Outlook;
- An economic viability assessment is performed on electricity generation which also ensures that each country stays within its reliability standard.

The process for the creation of the scenarios "Established Policies", "Global Import" and "e-Prosumers" is represented in Figure 2.4.2.

Figure 2.4.2: Creation of the Established policies, Global import and E-prosumers scenarios for post-2030 horizons

Some particular steps would be applied for the "Large scale e-RES" scenario" and the "Flex+" sensitivity.

- The "**Large scale e-RES**" scenario starts from the "Global Import" scenario, increase the electrification and finally move the renewables within Europe to reduce its dependence on imports (e.g. by maximizing the RES load factors).
- The latter, "**Flex+"** scenario, starts from the "e-Prosumer" scenario and increase the flexibility options of the electricity demand.

After these procedures, a new economic viability assessment is performed to ensure countries remain within their reliability standards but which could also remove capacity if deemed not economically viable. The additional steps to create these two scenarios are represented in Figure 2.4.3.

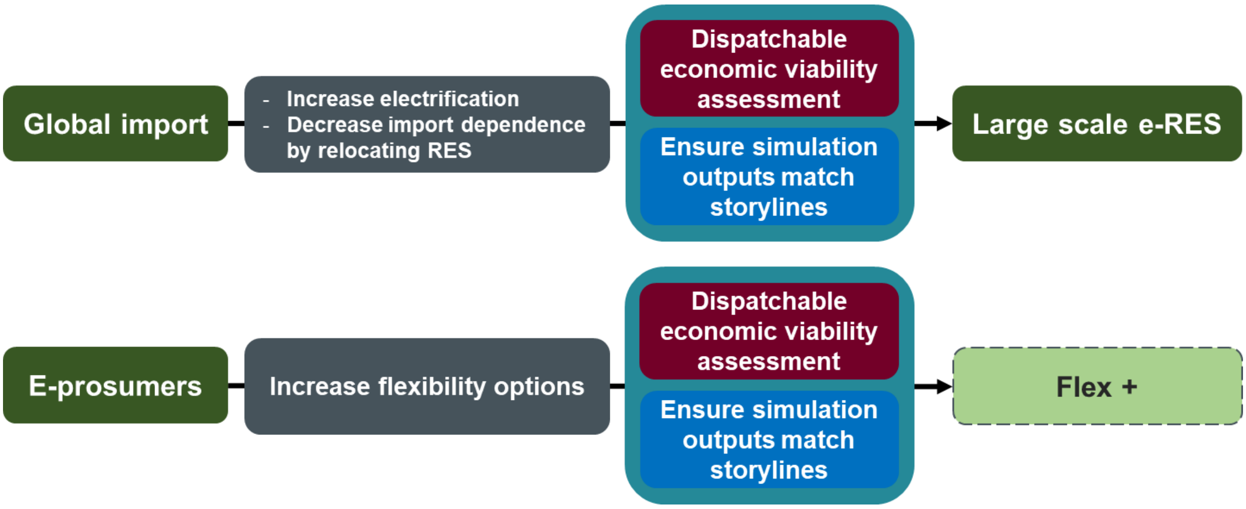


Figure 2.4.3: Creation of the Large scale e-RES and Flex+ scenarios

The scenario quantification follows the process explained above for each of the scenarios. Some parts of the scenarios will be thus initially quantified 'directly' within the range of their trajectories to be considered as relevant for Belgium. These trajectories are presented below and consider the following parts of the scenarios: Photovoltaic (PV), Wind Offshore, Wind Onshore, Electricity Demand, Demand flexibility, Storage and Electrolyzers. More details on these assumptions can be found in the next sections. Similarly, for some global parameters such as 'Fuel and emission costs' (see section 2.5.9) the trajectories are considered inputs to the scenario creation process. Additionally, some parts of the scenarios will be fully quantified only when its construction is completed. An example of this is the final level of dispatchable generation (see also section 2.5.10) which will be set following an economic viability assessment.

2.5 Trajectories on

2.5.1 PV

The evolution of PV capacity is mainly challenged by the large surface needed leading to geographically distributed production and the evacuation (or storage) of the excess of energy when penetration increases. In Belgium, most of photovoltaic panels are installed on rooftops (at residential and tertiary level). The installed capacity in Belgium in 2020 was around 4.8 GW and is foreseen to increase in the coming decade following the different ambitions set by Belgian federal and regional authorities as translated in the National Energy Climate Plan (published in December 2020) and European authorities with the 'Fit For 55' package (published in July 2021) accelerating the ambition set by member states in the NECP. The evolution of PV capacities in Belgium is based on the following assumptions:

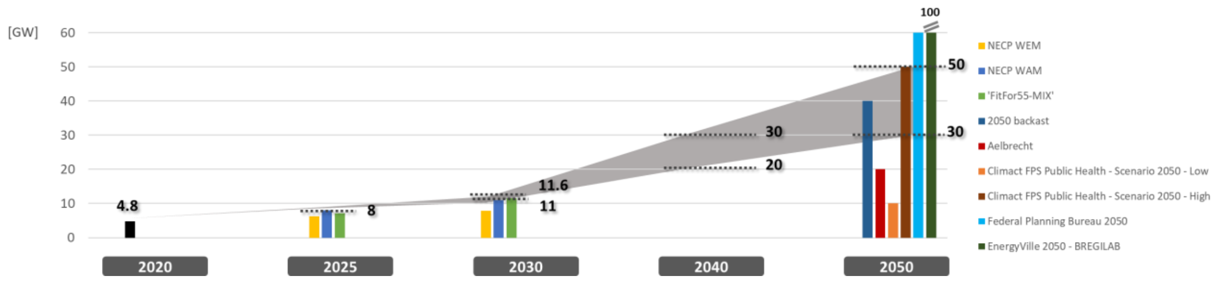
- **For 2025 and 2030**: the main assumptions are mainly based on the targets set by the Belgian regional and federal authorities in the National Energy and Climate Plan following the most ambitious scenarios called 'With Additional Measures' scenario (WAM), which foresee respectively 8 GW and 11 GW for 2025 and 2030. For 2030, the scenario FF55 will assume a slightly higher penetration of solar capacity with 11.6 GW as estimated by the European Commission in the 'Fit For 55' impact assessment of the EC (EC-MIX scenario);

- **On the long term**, the available theoretical potential for solar panels in Belgium is around 100 GWp following the "BEGRILAB" project from EnergyVille[16]**.** As described in this last study, this value is retained as the maximum technical potential, but reaching such amounts would require massive curtailments or large amounts of local storage capacities and/or local grid upgrades to evacuate or store the produced energy surplus. Following FPS Public Health study[17] performed by Climact, the level that is usually retained for Belgium by 2050 is ~50 GW (following their most optimistic evolution).

The graph below provides an overview of the min-max evolution for solar capacity in Belgium based on external studies and known / expected ambitions.

[16] https://www.energyville.be/en/press/expert-talk-high-penetration-wind-and-sun-possible-minimal-costs-grid-reinforcement

[17] 2050 (climat.be)



NECP	*https://www.nationalenergyclimateplan.be/en/what-is-the-necp-*
'FitFor55-MIX'	*https://ec.europa.eu/commission/presscorner/detail/en/IP_21_3541*
2050 backast	*https://www.plan.be/publications/publication-1191-fr-towards_100_renewable_energy_in_belgium_by_2050*
Aelbrecht	*Ugent 2018, EnergyPact Scenarios; Adequacy and System costs*
Climact FPS Public Health	*https://climat.be/doc/climate-neutral-belgium-by-2050-report.pdf*
Federal Planning Bureau 2050	*https://www.plan.be/uploaded/documents/202110180556490.WP_2108_12501.pdf*
EnergyVille 2050	*Expert Talk: High penetration of wind and sun possible with minimal costs for grid reinforcement | EnergyVille*

Figure 2.5.1 Range for solar capacity in Belgium

2.5.2 WIND OFFSHORE

The evolution of offshore wind capacity in Belgium is mainly defined by the Belgian Exclusive Economic Zone (EEZ) available space in the North Sea, the navigation routes, the protected areas and the distance to shore where wind turbines could be installed. Belgium has already more than 2 GW of offshore capacity. The federal government agreement foresees to double the installed offshore capacity by 2030. The Minister's Council has also recently increased the ambition for offshore wind development even further based on new area identified for potential wind farms as illustrated in the graph below.

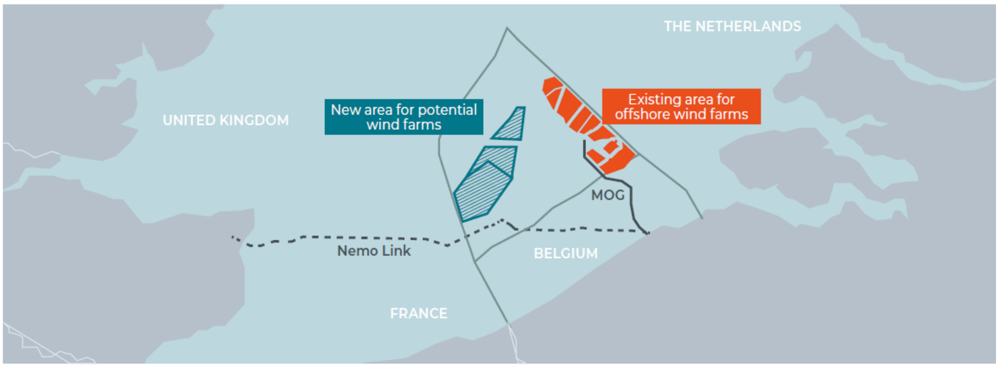
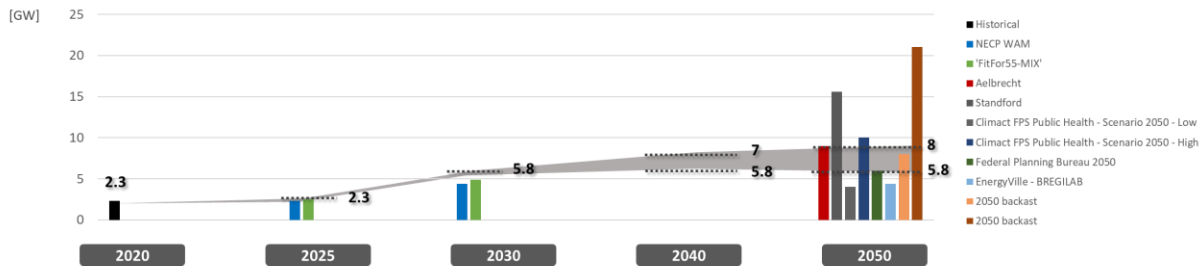


Figure 2.5.2 Overview of current and planned offshore development in the Belgian EEZ

Given the limited space available and the foreseen wind development in the Belgian EEZ, the available space to install additional wind turbine becomes very limited. In previous Elia studies looking beyond 2030, it was assumed that up to 8 GW of offshore capacity could be installed in the Belgian EEZ. This does not take into account wind farms that would be installed in other countries' EEZ and directly connected to Belgium. Other studies, foresee up to 10 GW of offshore connection[18] by assuming a hybrid connection configuration (meaning that wind would also be located in other EEZ than the Belgian one). Another option to increase the installed capacity could be to repower the existing wind farms with larger turbines but it is yet unclear if this would lead to much higher installed capacities. On this basis, the level of offshore capacity for Belgium by 2050 is foreseen to be between 5.8 GW (current ambition for 2030) and 8 GW.

The graph below provides an overview of the min-max evolution for wind offshore capacity in Belgium based on external studies and known/expected ambitions.



NECP	*https://www.nationalenergyclimateplan.be/en/what-is-the-necp-*
'FitFor55-MIX'	*https://ec.europa.eu/commission/presscorner/detail/en/IP_21_3541*
2050 backast	*https://www.plan.be/publications/publication-1191-fr-towards_100_renewable_energy_in_belgium_by_2050*
Aelbrecht	*Ugent 2018, EnergyPact Scenarios; Adequacy and System costs*
Climact FPS Public Health	*https://climat.be/doc/climate-neutral-belgium-by-2050-report.pdf*
Federal Planning Bureau 2050	*https://www.plan.be/uploaded/documents/202110180556490.WP_2108_12501.pdf*
EnergyVille 2050	*Expert Talk: High penetration of wind and sun possible with minimal costs for grid reinforcement | EnergyVille*

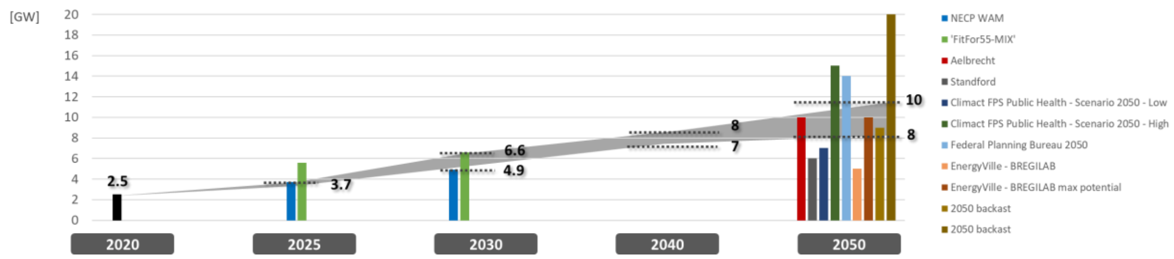
Figure 2.5.3 Evolution for offshore capacity

[18] FPS Public Health, https://climat.be/doc/climate-neutral-belgium-by-2050-report.pdf

2.5.3 WIND ONSHORE

The evolution of onshore wind farm penetration on the long term will be mainly limited by available space, land use, and public acceptance. Moreover, Belgium is one the European countries with the highest population density (>370 inhabitants per km² for Belgium vs. for instance >105 inhabitants per km² for France) limiting in this way the available area to install such technology. Based on other external national studies, the onshore capacity that could be installed by 2050 is between 8-10 GW[19] and theoretically up to 14-15 GW[20]

The graph below provides an overview of the min-max evolution for wind onshore capacity in Belgium based on external studies.



NECP	*https://www.nationalenergyclimateplan.be/en/what-is-the-necp-*
'FitFor55-MIX'	*https://ec.europa.eu/commission/presscorner/detail/en/IP_21_3541*
2050 backast	*https://www.plan.be/publications/publication-1191-fr-towards_100_renewable_energy_in_belgium_by_2050*
Aelbrecht	*Ugent 2018, EnergyPact Scenarios; Adequacy and System costs*
Climact FPS Public Health	*https://climat.be/doc/climate-neutral-belgium-by-2050-report.pdf*
Federal Planning Bureau 2050	*https://www.plan.be/uploaded/documents/202110180556490.WP_2108_12501.pdf*
EnergyVille 2050	*Expert Talk: High penetration of wind and sun possible with minimal costs for grid reinforcement | EnergyVille*

Figure 2.5.4 Evolution for onshore capacity

[19] Energy Ville: https://www.energyville.be/en/press/expert-talk-high-penetration-wind-and-sun-possible-minimal-costs-grid-reinforcement

[20] Federal Planning Bureau: https://www.plan.be/uploaded/documents/202110180556490.WP_2108_12501.pdf and FPS Public Health: https://climat.be/doc/climate-neutral-belgium-by-2050-report.pdf

2.5.4 OTHER OFFSHORE RES TECHNOLOGIES

Other offshore renewable energy source technologies such as floating solar panels or tidal energy currently under research and development stage can play a major role at the European scale to increase the RES potential on long term. This is also the ambition of the EC where an ambition of 40 GW is set by 2050 for 'ocean energy'. Based on the public consultation feedback, it was suggested by the stakeholders to integrate such offshore new technologies for Belgium in the trajectories. The development of such new offshore technologies in Belgium is today quite limited due to the potential/maturity of such technologies and the limited area available in the country compared to other countries. Very limited studies mention such technologies or potentials for Belgium and the trajectories for the following new offshore technologies are based on some ranges found in the literature. For floating solar panel and tidal energy, a maximum for both 100 MW as from 2040 is retained for Belgium.

2.5.5 UNDERLYING ASSUMPTIONS OF ELECTRICITY DEMAND

In this section a set of trajectories are presented related to final electricity demand. The main trajectories are given for total electricity demand, electric vehicles, heat pumps and parameters related to energy efficiency and economic activity.

For the period until 2030, the values used in the 'AdFlex 2021' (which were based on the economic forecast by the Federal Planning Bureau and taking into account the Belgian NECP WAM ambitions with regards to electrification) are planned to be used as 'Established Policies' scenario. It is important to note that the update of the economic assumptions was performed by Climact and presented to the Elia User's Group on 28/09/2021[21] and is to be used for the 'Established Policies' scenario. This tool developed by Climact is updated yearly and allows to construct a factual scenario for electricity consumption based on transparent assumptions over societal and technological evolutions and open-source modelling. As such, the total electricity demand of the 'CENTRAL' scenario in the 'Adequacy and Flexibility study 2022-32' was elaborated on growth rates based on the economic projections from the Federal Planning Bureau and with additional electrification based on the National Energy and Climate Plan. These values are based on projections made in June 2020, and an updated projection which takes into account the latest economic projections has been

[21] 20210928 Meeting (elia.be)

made in September 2021, for which the results are shown underneath. For the full methodology of the Climact projections we refer to Elia website[22].

In addition, the trajectory is presented including the increased ambition with regards to the so called 'Fit-For55' objective to reach 55% CO_2 emissions reduction by 2030[23]. The values are based on the 'MIX' scenario developed by the EC using the PRIMES model. It has to be noted that this scenario is a proposal by the EC, and has yet to be approved and translated into national climate plans. In concrete for this scenario, the aim is that the scenario aligns with the objectives in terms of renewable energy in heating, cooling and transport as specified in the revised RED II directive[24].

For the period 2030-2050, a range of trajectories is presented within which the final demand scenarios will be bounded. These ranges are based on the assessment of external long-term studies. The values of the TYNDP2022 scenarios fall within the range.
Finally, it has to be noted that this section only looks at direct electrification of the demand, *i.e.* indirect electrification (for example for the creation of green molecules) is not considered here and is an output of the simulation process based on the assumptions taken for electrolyzer capacities. Assumptions on proposals for electrolyzers capacities can be found in section 2.5.8.

Main drivers of demand intensity

When looking towards 2050, the final electricity demand will depend on a wide set of parameters such as:

- **Demographic** aspects such as the growth of the population and corresponding building stock and transport fleet;
- **Macro-economic indicators** such as the added value growth in the industrial and tertiary sector and growth in average disposable income;
- **Energy efficiency and circularity**, including the renovation rate & level in the residential & tertiary sector, the application of process optimization and circularity in the industrial sector and finally the evolution in efficiency of technologies used for lighting, heating, transport and industrial processes;

[22] https://www.elia.be/-/media/project/elia/elia-site/public-consultations/2020/20200603_total-electricity-demand-forecasting_en.pdf

[23] https://ec.europa.eu/energy/data-analysis/energy-modelling/policy-scenarios-delivering-european-green-deal_en

[24] Commission presents Renewable Energy Directive revision | European Commission (europa.eu)

- **Behavioral changes** of the end-consumer in terms of transportation needs and modes, heating needs and general consumption patterns;
- **Fuel switching behavior** away from fossil fuels towards zero or low carbon fuels such as electricity, bio-energy, excess heat and green molecules such as hydrogen(-derivatives) produced from renewable electricity.

The most important parameters related to the first four points mentioned above are highlighted in Table 2.5.1. A range is given with the possible 'low' and 'high' value. The low value for *population*, *household* and *GDP* growth is based on the EU Reference scenario (2020)[25]. The high value corresponds to the latest estimations of the Federal Plan Bureau (2021)[26] [27].

Looking at demand drivers in buildings, the current *renovation rate* is around 0.8% when looking at registered renovations in StatBel[28] and has increased slightly in recent years. However, a much more rapid increase is needed in order to decrease heating demand towards 2030 and 2050. The FF55-MIX scenario foresees a rapid increase in renovation rate for Belgium towards 2030, reaching 2.8% by 2030. This would mean for the current rate to more than triple which is a huge challenge. Therefore a range between 1.4% (almost double the current rate) and 2.5% is retained. This leads to a decrease in heating demand in the range of 40%-67%. Trajectories for electrification are shown separately underneath.

For transport, the total *person-km* (*i.e.* the km's traveled for passenger transport by any possible means) 'low' value is retained at the value of 2015 (150Gpkm) which would indicate that behavioral levers compensate population growth resulting in less transport per capita. On the higher end, the forecast of the Federal Plan Bureau (FPB) of 2040 is extrapolated towards 2050[29]. For the *modal shift*, in the 'high' trajectory the business as usual scenario of the FPB will be used. For the low end, a more optimistic modal shift is based

[25] EU Reference scenario 2020: https://ec.europa.eu/energy/data-analysis/energy-modelling/eu-reference-scenario-2020_en

[26] https://www.plan.be/uploaded/documents/201901240958590.FOR_POP1870_11813_F.pdf

[27] Microsoft Word - Rapport_feb2021_12364_N.docx (plan.be)

[28] Building permits | Statbel (fgov.be)

[29] https://www.plan.be/uploaded/documents/201901311348570.FOR_TRANSPORT1540_11854_N.pdf

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on information found in the NECP[30]. Note that the value of EU Reference scenario falls exactly within this range (159 Gpkm). For freight transport the same logic is used for the higher end value (extrapolation of Federal Plan Bureau). The lower end is fixed at the value found in the EU Reference scenario and includes a more optimistic modal shift from road to rail. Trajectories for electrification are shown separately underneath.

Industrial energy demand is dependent on production output, overall energy efficiency gains and substitution of energy vectors. Sectoral activity can be used as a proxy for production output. *Energy efficiency* for the industrial sector is defined as the needed final energy for a certain production output. The hypotheses for this driver are the gains between 2020 and 2050. The range is based on external European sources that define an energy efficiency potential by sector, such as the ADEME[31], the French agency for energy transition and the DGEC, Direction Générale de l'Energie et du Climat in France[32], and the energy efficiency study for the European Commission by ICF consulting[33].

Finally, electricity demand will be dependent on the amount of *electrification*. Examples include: industrial heat pumps, microwaves, infrared heaters, induction and resistance heaters in the metal sector, electric boilers and crackers in the chemical sector, electric arc furnaces in the steel industry and electric kilns in the cement. Today, the electrification rate in industry is around 31%. In the 'low' trajectory the focus for decarbonisation is on green molecules such as bio-methane, biomass, hydrogen, liquid e-fuels and e-gas which lead to a moderate offtake in electrification to 35%. In the 'high' trajectory all electrification technologies listed above are considered commercially available at scale and fully deployed leading to an electrification rate of 70%.

[30] https://www.nationaalenergieklimaatplan.be/admin/storage/nekp/nekp-finaal-plan.pdf.

[31] ADEME : https://www.ademe.fr/efficacite-energetique-lindustrie

[32] DGEC : https://www.ecologie.gouv.fr/sites/default/files/Synth%C3%A8se_provisoire_des_hypoth%C3%A8ses_et_r%C3%A9sultats pour les exercices 2018-2019.pdf.

[33] ICF for EC: https://ec.europa.eu/energy/sites/ener/files/documents/151201%20DG%20ENER%20Industrial%20EE%20study%20-%20final%20report_clean_stc.pdf.

Values towards 2050	Low	High
Demographics		
Population (Mil.)	11.9	12.6
Household (Mil.)	5.2	5.6
Macro-economic		
GDP annual growth (%)	1.4%	1.6%
Buildings		
Average renovation rate (%)	1,4%	2,5%
Heating demand savings / dwelling 2020-2050 (Residential)	-40%	-67%
Heating demand savings / m^2 2020-2050 (Tertiary)	-40%	-60%
New build heating demand (kWh/m^2)	15	
Transport		
Passenger transport (Gpkm) *car/public road/rail/bike&foot*	150 *65%/10%/15%/10%*	170 *83%/4%/9%/4%*
Freight transport (Gtkm) *Road/rail/inland navigation*	93 *73%/15%/12%*	113 *76%/12%/12%*
Industry		
Energy savings per unit of production output 2020-2050 (%)	-20%	-30%
Electrification Rate - 2050 (%) Excl. Feedstock	35%	70%

Table 2.5.1 Main energy demand parameters

Electrification of the transport sector

In 2020, the amount of electric vehicles was limited, with 24 000 fully electric and 155 000 hybrid vehicles having a market share of 1.7% (counting hybrid as ½ equivalent EV). Figure 2.5.5 summarizes the expected evolution of electric passenger cars penetration until 2050. Under the ‘Fit For 55’ package, a reformed, and binding target is proposed; The revised RED II directive leads to an improved target of 22-26% for the share of RES in transport fuels for 2030, as compared to 21% in the EC REF scenario. The MIX scenario, sees an increase of electrification in road transport to 3% versus 2.6% in the REF scenario for Belgium.[34] In practice, the EV share based on the previous NECP is therefore increased to align with this objective. This increased ambition, leads to a slightly higher share of around 27% for electric vehicles in passenger cars in 2030. Looking towards 2050, to achieve carbon neutrality it is necessary to phase-out the usage of gasoline and diesel based drivetrains in road transport and shift this towards either electricity,

[34] Vehicle stock | Statbel (fgov.be): https://statbel.fgov.be/en/themes/mobility/traffic/vehicle-stock

hydrogen fuel cells, bio-fuels or synthetic fuels. For the passenger car segment, electrification is the most efficient method to decarbonize lightweight road transport, therefore it is projected to battery-electric vehicles will reach a share of 70% to 100% by 2050. Such path is also the one followed in recent communications from regional and federal authorities where policies are expected to be put in place to electrify the current vehicle fleet or to ban certain types of vehicles in certain zones.

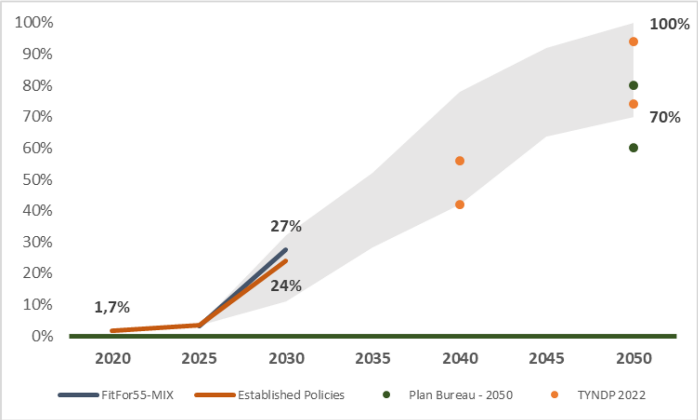

Figure 2.5.5 Share of electric vehicles in passenger cars (%)

For electric busses, the share in 2020 reached around 3%[35] . This segment shows large electrification potential, mainly because a large part of the fleet is managed by a small number of players such as public bus companies which have clear decarbonization objectives. In this way it is estimated that the share of battery-electric busses can be as high as 95% and as low as 50% in 2050.

[35] Vehicle stock | Statbel (fgov.be), with hybrid counted as ½ equivalent EV

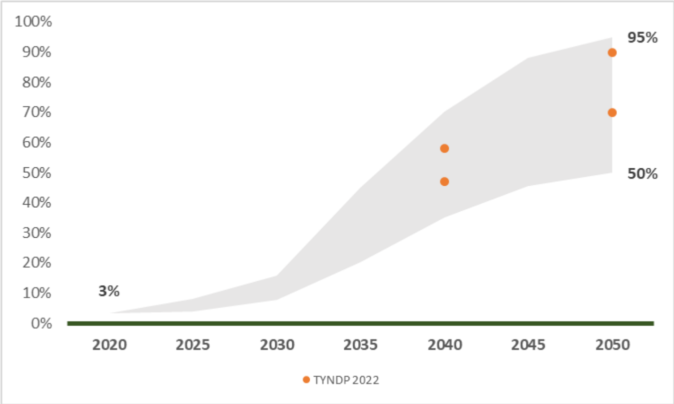

Figure 2.5.6 share of electric vehicles in busses & coaches (%)

Electrification in the road freight segment (*i.e.* vans, light and heavy trucks) is almost non-existent and expected to remain low in the medium term. Towards 2050, this segment could see a potentially high offtake in battery-electric share with the arrival of ever more performant and cost-effective battery packs. In the extreme, market share of EVs in this segment could be as high as 90%[36], however taking into account stock inertia a value of 80% is retained for 2050. In the lower end, other technologies such as hydrogen fuel cells or ICE with e-fuels or bio-fuels are considered dominant and the electric share is at 30%.

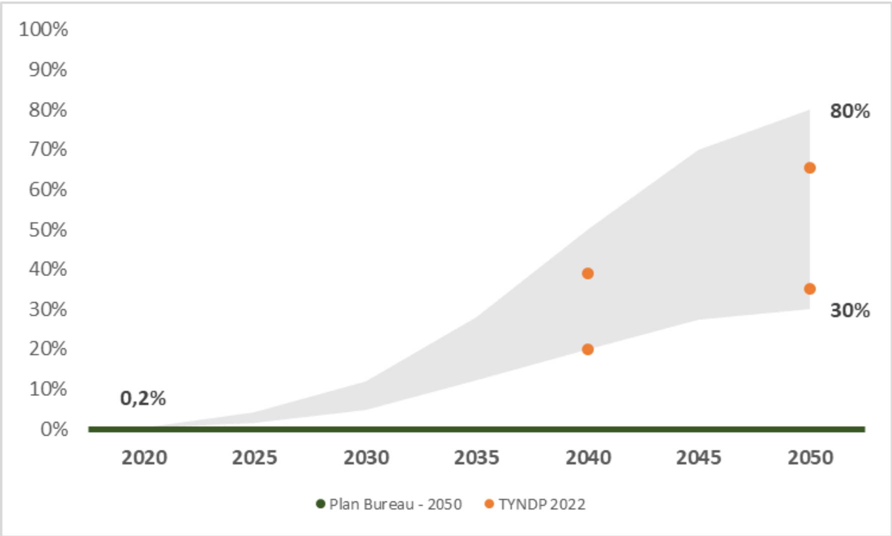

Figure 2.5.7 Share of electric vehicles in road freight (%)

[36] EVO Report 2021 | BloombergNEF | Bloomberg Finance LP (bnef.com): https://about.bnef.com/electric-vehicle-outlook/

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Electrification of heating

Heat pumps are the most efficient method to decarbonize space heating thanks to their high COP, however, the uptake of heat pumps in Belgium is currently low and is expected to remain rather low towards 2030. The revised RED II directive under the 'Fit For 55' package leads to an increased target of 39%-42% for the share of RES in heating and cooling, as compared to 33% in the EC REF scenario. This increased ambition, leads to a slightly stronger electrification of heat at 8.6% market share for heat pumps in 2030. Electrification of heating remains low in these projections as compared to the values of the DE & GA scenarios of TYNDP 2022, which reach 23% and 9% market share by 2030.

Towards 2050, the maximum potential for electric heat pumps could be as high as 90%. This will require however a strong push in renovations, both in rate and level. On the other end, green and synthetic molecule based boilers or are also applicable in less insulated dwellings, in this lower case scenario a share of 40% is retained.

In the scenario with the highest degree of centralization and lowest degree of electrification, **Global Import**, it is assumed that decarbonized molecules such as bio-gas, hydrogen & e-gasses are deployed at scale. This means that traditional (condensing) boilers are assumed to remain in use, but that the existing gas infrastructure is re-purposed to transport those fuels. In densely populated areas around industrial clusters, thermal power plants and cogeneration units (running eventually on CO_2-neutral gasses) provide heat through district heating systems, with a larger relative share as compared to the decentral scenarios. Electric heat pumps are installed where most economically viable and/or where gas infrastructure is not available, in the least insulated dwellings these are hybrid types with molecule-based back-up, corresponding to the lower-end of the trajectory.

In the scenario with high decentralization and high electrification, **E-prosumers** and **Flex+**, the main focus is on large-scale electrification at the end-consumer side in the form of electric heat pumps (mostly all-electric), corresponding to the higher end of the trajectory. Molecule-based heating technologies are largely phased-out and only remain in thermal power plants and cogeneration units which supply residual heat through district heating networks to end-consumers. In the more centralized (but high degree of electrification) **large scale e-RES** scenario, district heating systems with large centralized heat pumps and cogeneration units as back-up are also assumed widely installed in favor of more decentrally located heat pumps.

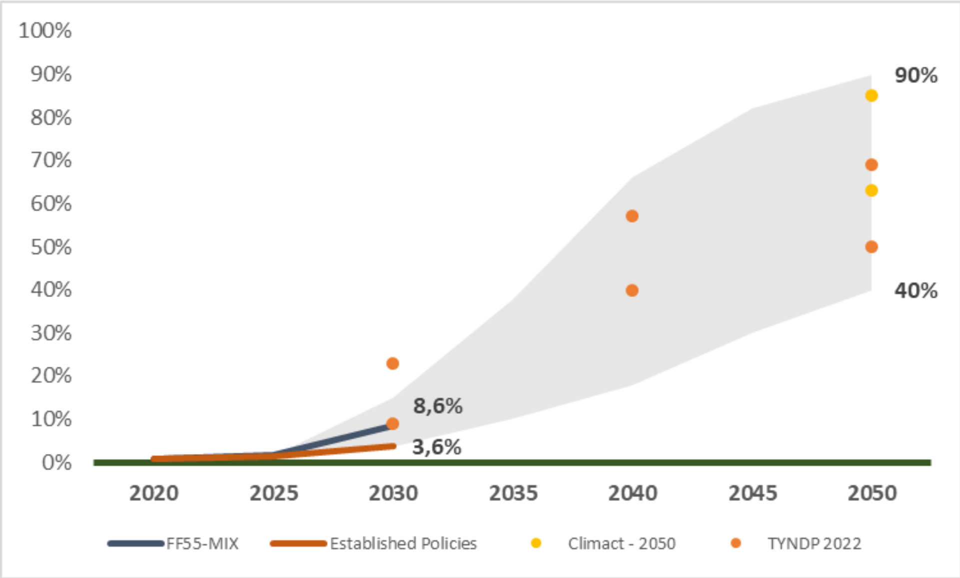

Figure 2.5.8 Share of electric heat pumps in heating demand (%)

Total Electricity Consumption

Looking at the period 2019-2030, in all trajectories an increase is expected versus 2019 (85.5 TWh). The increased forecast updated in September 2021 by Climact is mainly explained by a more favourable evolution of the economic activity post COVID-19 than was foreseen in 2020 when the previous one was done. The **FitFor55** MIX scenario sees a significant increase in electricity demand towards 2030 (106.6 TWh) which is mainly caused by an increased electricity demand in industry (+12 TWh), in buildings (+7 TWh) and transport (+2 TWh). The increase in the FF55-MIX scenario is stronger than what was foreseen in the 'Adequacy and Flexibility study 2022-32' and the latest Climact forecast.

For the trajectories towards 2050, the lower and upper bounds of final direct electricity demand are largely dependent on the degree of electrification which will take place within the different sectors.

In a trajectory reaching up to 170 TWh of direct electricity demand, this implies that electric heat pumps deliver the majority of heat in buildings. All lightweight, and to some extent heavy freight transport, are assumed electric. In industry, most low temperature heat as well as a major share of medium to high temperature heat is considered to be electrified. Furthermore, new breakthrough technologies would also allow the application of electricity-based processes in specific industrial processes. Green molecules are only applied in the most heavy freight transport segment, as non-energetic feedstock and in specific industrial processes.

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In the lower end trajectory, reaching direct electricity demand of 110 TWh, the pathway focuses on a relatively high share of molecule-based energy supply, especially "green molecules" that comprise hydrogen and its derivatives (e-gases and liquid e-fuels) but also (liquid) biofuels and bio-methane. In this scenario a large share of heating is assumed to be based on (e-)gas boilers and hydrogen fuel cells. In transport, hydrogen fuel cells and e-fuels are taken as the main energy vector used for heavy freight. Passenger and lightweight transport are still considered to be (almost entirely) electrified. In industry, e-gas and bio-gas is given an important role to play for high temperature heat whereas hydrogen, e-fuels and bio-fuels are applied in specific industrial processes and as non-energetic feedstock.

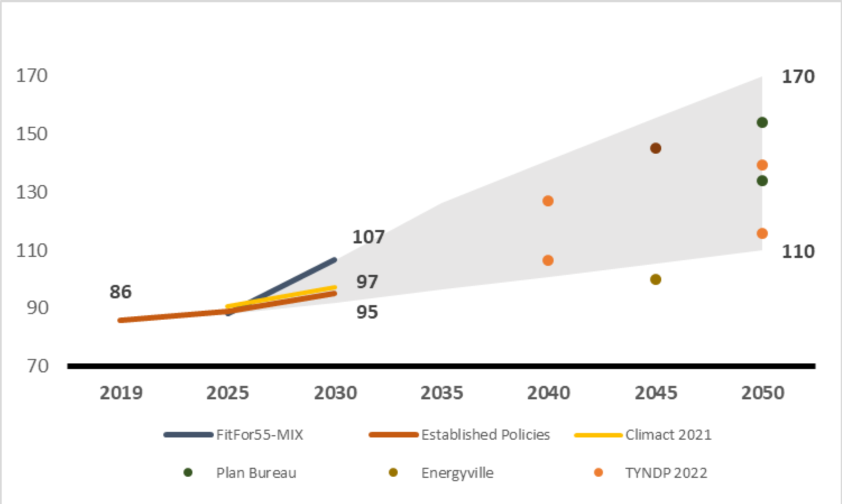

Figure 2.5.9 Annual direct electricity demand possible ranges (TWh)

The main sources consulted for the trajectories in demand are listed in the table underneath:

NECP	*https://www.nationalenergyclimateplan.be/en/what-is-the-necp-*
EC Fit For 55	*https://ec.europa.eu/commission/presscorner/detail/en/IP_21_3541*
Climact - 2021	*https://www.elia.be/-/media/project/elia/elia-site/public-consultations/2020/20200603_total-electricity-demand-forecasting_en.pdf*
Climact FPS Public Health	*https://climat.be/doc/climate-neutral-belgium-by-2050-report.pdf*
TYNDP 2022	*https://2022.entsos-tyndp-scenarios.eu*
Federal Planning Bureau	*https://www.plan.be/uploaded/documents/202010210453210.WP_2004_FUELFORFUTURE_12221.pdf*
EnergyVille	*https://www.energyville.be/belgian-long-term-electricity-system-scenarios*

Table 2.5.2 Sources for demand trajectories

2.5.6 ELECTRICITY DEMAND FLEXIBILITY

Electricity demand flexibility consists of three main categories:

- Demand-side response shedding from industry and appliances;

- Demand-side response shifting from heating and cooling;
- Flexibility from mobility (V1G and V2G).

For 2030, demand-side response shedding and shifting capacities follows the Belgian Energy Pact 2030 targets. The flexibility from mobility is based on the number of electric vehicles foreseen in the different scenarios. For later years, the targets are defined with the following assumptions:

- Demand-side response **shedding** is associated to the share of electricity consumption from industry and appliances that can be shed;
- Demand-side response **shifting** is associated to the share of heat pumps and air conditioning that can be shifted during the day;
- Flexibility from mobility is associated to the number of electric vehicles available and the share assumed to be flexible. **V1G** are modelled the same way as in 'Adequacy and Flexibility study 2022-32' and **V2G** are modelled by adding additional batteries (see 2.5.7.1).

Each of the following categories are associated to a different time horizon. V1G and DSM shifting are mainly associated to intraday variations of the residual demand while V2G and DSM shedding can also solve some weekly variations. This is summarized on Figure 2.5.10.

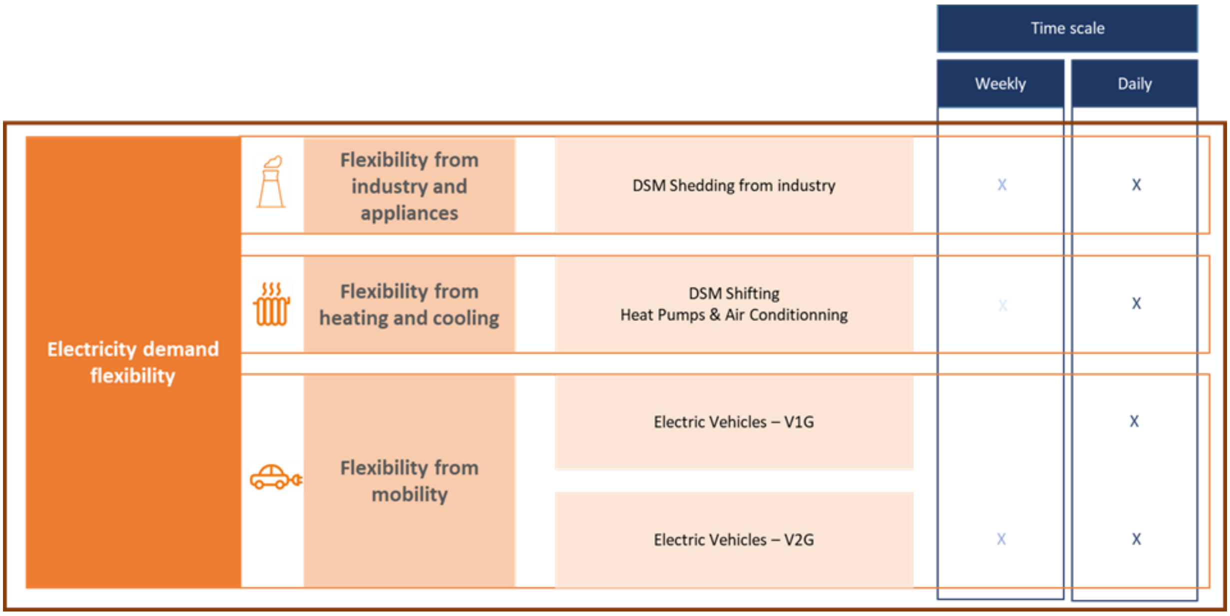

Figure 2.5.10 Overview of electricity demand flexibility considered and associated time horizon

2.5.6.1 FLEXIBILITY FROM INDUSTRY AND APPLIANCES

Regarding flexibility from industry and appliances, the trajectory started with the Energy Pact 2030 targets, as also mentioned in the 'Adequacy and Flexibility study 2022-32' considering 2407 MW of demand-side response shedding, which includes the volume providing ancillary services today.
Regarding the flexibility from industry and appliances from both residential and tertiary after 2030, as there is a lack of sources available, it is assumed that the target fixed in the Energy Pact for DSM shedding in 2030 can be associated to the total demand minus the demand from electric vehicles, heat pumps and air conditioning, as those are dealt with in an ad hoc section.
For the scenarios 'Global import', 'Large-scale e-RES', 'e-Prosumers' and 'Flex+', the same ratio is then kept between the DSM installed capacity and the total demand minus the demand from electric vehicles, heat pumps and air conditioning. The different targets fixed in this section are based on the sectoral growth and electrification rate assumed for industry and appliances in the residential and tertiary sectors. The main assumptions for consumption used to provide the proposal of demand-side shedding volume are presented in section 2.5.5.
By applying this methodology, we make sure that we start from the current ambitions but that we also take into account the potential from additional electrification.

2.5.6.2 FLEXIBILITY FROM HEATING AND COOLING

Regarding flexibility from heating and cooling, the trajectory starts with the Energy Pact 2030 targets, as also mentioned in the 'Adequacy and Flexibility study 2022-32', considering 1500 MWh by day during winter period of demand-side response shifting. The 'Fit For 55' scenario takes into account additional flexibility potential based on the increased numbers of heat pumps considered in this scenario, reaching a value of 1800 MWh by day. After 2030, the target is to be based on the flexibility of the heating and cooling demand. The different targets fixed in this section are based on the sectoral growth and electrification rate assumed for the associated sectors. The main assumptions for consumption used to provide the proposal of demand-side shifting volume are presented in section 2.5.5.

For the different scenarios, the percentages of the consumption from heating and cooling as defined in Table 3 are to be used. It takes into account intermediate values in 2040 to smooth the trajectories towards 2050, in order to integrate the feedback received during the public consultation.

<table>
<tr><th>Scenarios</th><th>2030</th><th>2035</th><th>2040</th><th>2050</th></tr>
<tr><td>Expected Policies</td><td rowspan="5">1800 MWh
(Fit For 55)</td><td rowspan="5">Linear
Interpolation</td><td>20%</td><td>-</td></tr>
<tr><td>Global Import</td><td>20%</td><td>35%</td></tr>
<tr><td>Large-scale e-RES</td><td>30%</td><td>50%</td></tr>
<tr><td>e-Prosumers</td><td>45%</td><td>65%</td></tr>
<tr><td>Flex +</td><td>60%</td><td>80%</td></tr>
</table>

Table 3: Assumptions for DSM shifting

It should be noted that the electricity consumption of heat pumps and air conditioning shows a strong seasonality. Therefore, the amount of demand-side shifting will take into account a monthly variation accordingly.
Furthermore, it should be noted that flexibility from heating and cooling can be associated mainly to intraday flexibility but that it can also solve part of the weekly variations.

2.5.6.3 FLEXIBILITY FROM MOBILITY

Flexibility from mobility is related to the charging profiles of electric vehicles and can be categorized into three groups: “natural” charging (meaning that the profile overlaps with the evening electricity consumption peak), ‘optimized’ charging (V1G) and Vehicle-to-Grid (V2G). This section mainly focus on V1G. V2G will be presented in section 2.5.7.1, as it will be modelled similarly to batteries.

For V1G, the trajectory started with the number of electric vehicles foreseen in the WAM (With Additional Measures) 2030 target from the final NECP. After 2030, the target is based on the trajectories foreseen for electric vehicles (see section 2.5.5) and the share assumed to be flexible. The methodology to model electric vehicles is to be the same as in ‘Adequacy and Flexibility study 2022-32’. In 2030, 50% of the electric vehicles optimizes their charging while the other 50% follows a ‘natural’ charging. This share increases until 2040 to respectively 60%, 70%, 80% and 90% for the ‘Global import’, ‘Large-scale e-RES’, ‘e-Prosumers’ and ‘Flex+’ (Figure 2.5.11), assuming that the percentages won’t probably reach 100%. These high shares in 2040 are chosen in order to align with the feedback received from stakeholders on the potential for EV penetration in Belgium due to the large share of company owned vehicles which are renewed more quickly. Between 2040 and 2050, even if the absolute number of electric vehicles increases, the share is assumed to remain constant.

Regarding trucks and busses, it is assumed that 15% of the vehicles follows the V1G profile.

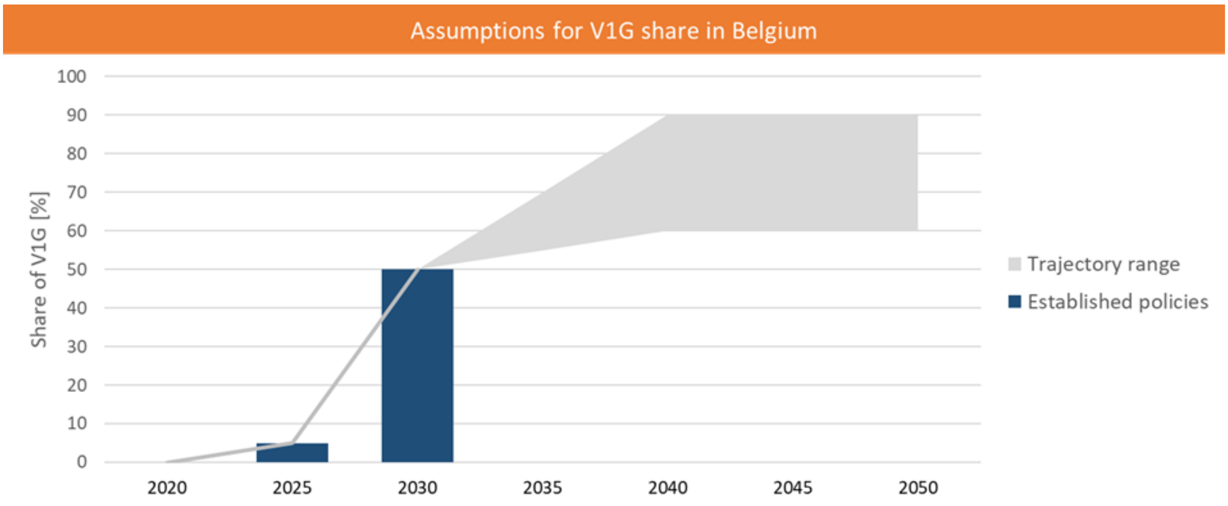

Figure 2.5.11 Share of V1G in Belgium

2.5.7 STORAGE

Storage technologies consist in two main categories. The first one is based on the different battery categories available (large-scale batteries, residential batteries and V2G). The second category is dedicated to closed-loop pump storage.
Storage is used to solve daily and weekly variations of the residual load, as summarized on Figure 2.5.12.

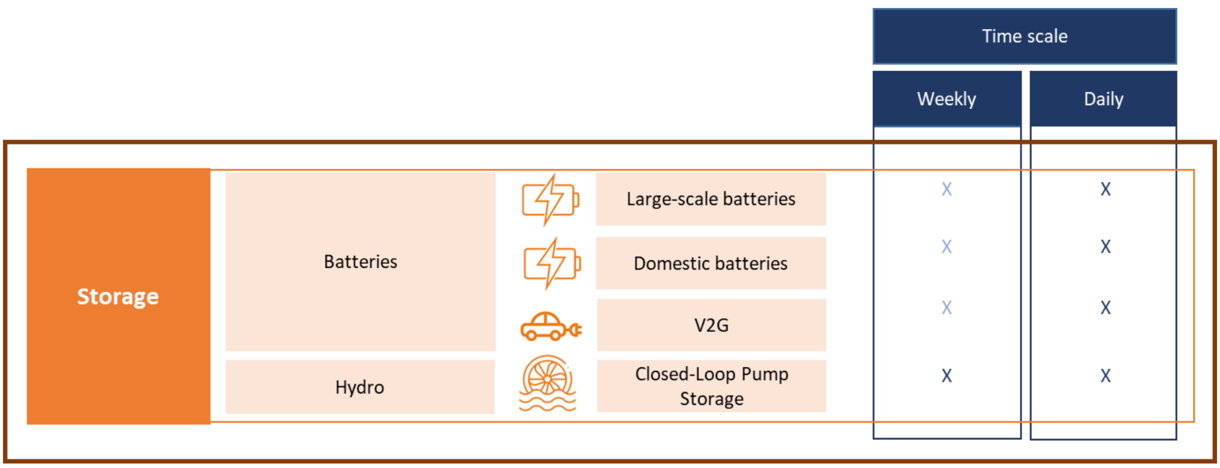

Figure 2.5.12 Overview of storage technologies considered and associated time horizon

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2.5.7.1 BATTERIES

Several types of batteries are considered and can be grouped together in 3 categories:

- **Large-scale batteries** (> 100kW);
- **Small-scale batteries** (< 100kW), that can be considered as residential batteries;
- Electric vehicles operating in "Vehicle-to-Grid" (**V2G**) mode where (a part of) the car battery can be used as storage.

Regarding batteries, the trajectory started with the Energy Pact 2030 targets, as also mentioned in the Adequacy & Flexibility study (Elia, 2021), considering 1600 MW of installed capacity of batteries. For later year, different trajectories are chosen, in line with the assumptions of the different scenarios considered. A slight decrease of the installed capacities after 2030 is integrated based on feedback received during the public consultation.

Large-scale batteries

Large-scale batteries consists in big projects with an installed capacity higher than 100kW. The trajectory is based on the TYNDP2022 data. For the Flex+ scenario, the value considered is to be doubled.

Small-scale batteries

Small-scale batteries is assumed to be associated with residential batteries or small-scale installation projects from industry or tertiary sectors. It is assumed that solar installations are associated in some cases to batteries in order to level out the solar generation, which allows to manage electricity consumption behind the meter. After 2030, the amount of residential batteries is assumed to increase and is correlated to the solar installed capacity. It is assumed that a share of the solar installed capacity is associated with the same installed capacity of batteries. This share is to be respectively equal to 5%, 5%, 10% and 15% in 2050 for the Global Import, Large-scale e-RES, e-Prosumers scenarios and Flex+ scenario (Table 4). The total small-scale batteries installed capacity is also related to the solar generation foreseen in the associated scenario (see section 2.5.1).

V2G

V2G is associated with the trajectories foreseen for electric vehicles (see section 2.5.5). It is assumed that a part of the electric vehicles battery can be used as storage, as introduced in section 2.5.6.3. This share is respectively equal to 5%, 10%, 15% and 20% in 2050 for the Global Import, Large-scale e-RES, e-Prosumers scenarios and Flex+ scenario (Table 4).

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Scenarios	V2G [%]	Residential batteries [%]
Expected Policies	5	5
Global Import	5	5
Large-scale e-RES	10	5
e-Prosumers	15	10
Flex +	20	15

Table 4: Percentages considered for V2G and residential batteries

Synthesis

Based on the assumptions mentioned above, Figure 2.5.13 presents the potential installed capacity for the different scenarios considering the associated level of flexibility and the electrification rate.

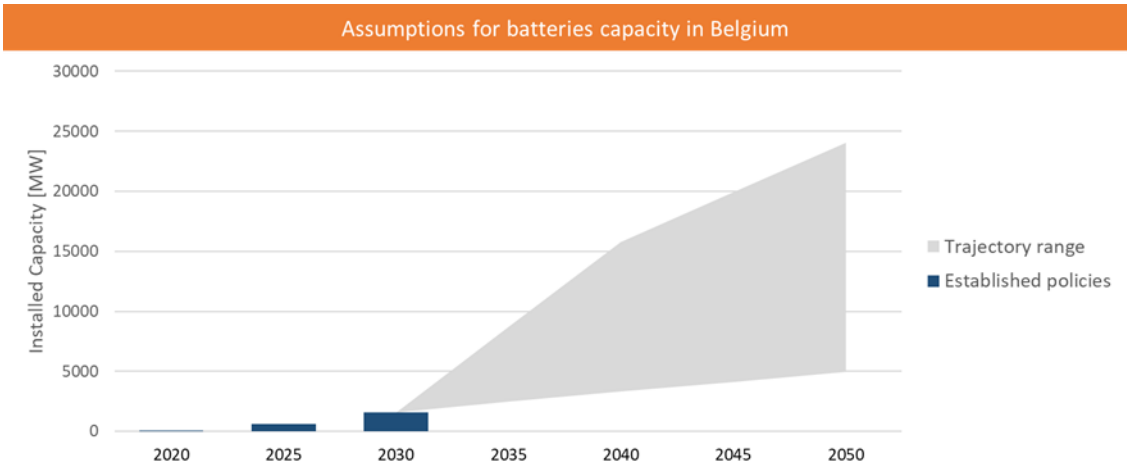

Figure 2.5.13 Overview of potential trajectories foreseen for batteries capacity in Belgium

2.5.7.2 CLOSED-LOOP PUMP STORAGE

The trajectory for closed-loop pump storage is based on installed capacity (1305 MW) and reservoir volume (6150 MWh) foreseen for Coo and Platte-Taille in 2030. The available volume is considered constant for the whole period regarding the limited potential available in Belgium.

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2.5.8 ELECTROLYZERS

Regarding electrolyzers capacities, the trajectory is based initially from the 'Adequacy & Flexibility 2022 – 2032 study' considering 510 MW available in 2030 which was based on known projects and their expected commissioning dates. The federal Energy Minister has recently announced the H2 federal strategy where there are no quantified objectives after 2025 but where it is acknowledge that there is little potential for electrolyzers in Belgium due to the limited RES potential compared to the demand. The focus would be relying on imports and positioning the country as an importing and transit hub.

Given this announcement, different trajectories will lead to a final electrolyzer's volume of minimum 1 GW and maximum 2.4 GW in 2050. In 2040, it would be comprised between 750 MW and 1500 MW. This is illustrated on Figure 2.5.14.

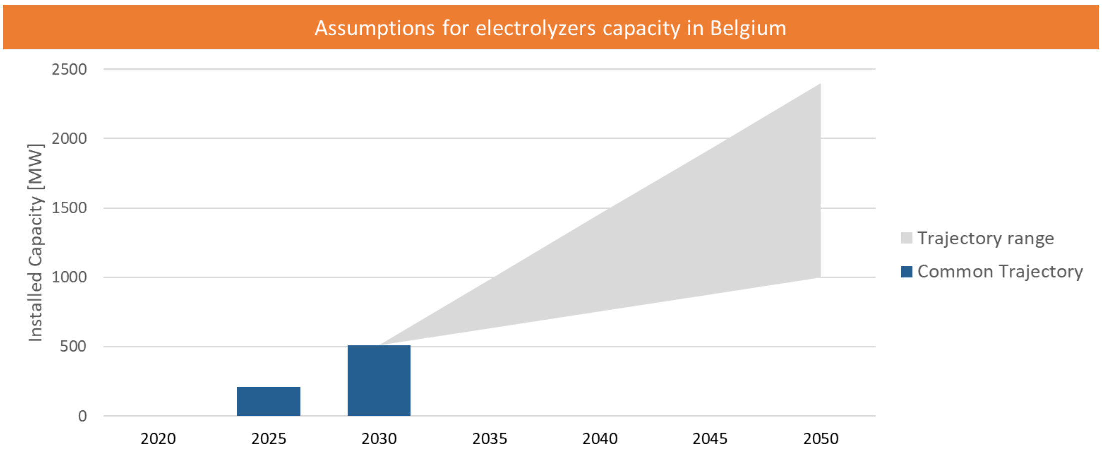

Figure 2.5.14 Overview of potential trajectories foreseen for electrolyzers installed capacities in Belgium

2.5.9 FUEL AND EMISSION COSTS

In order to perform economic dispatch simulations assumptions on future fuel and emission costs are needed. For this report, these assumptions are based on the most recent "World Energy Outlook" (WEO) published on October 2021 by the International Energy Agency[37]. The "stated policies" scenario from the WEO incorporates the currently known policies that are in place as well as those that governments around

[37] https://www.iea.org/reports/world-energy-outlook-2021

the world have announced. For this reason, it is to be used in the 'Established policies' scenario. On the other hand, in the "Announced Pledges" scenario the IEA assumes that all climate commitments made by governments, even those for which no specific policies have been announced yet, will be met on time and in full. These price assumptions will be used for all other scenarios.

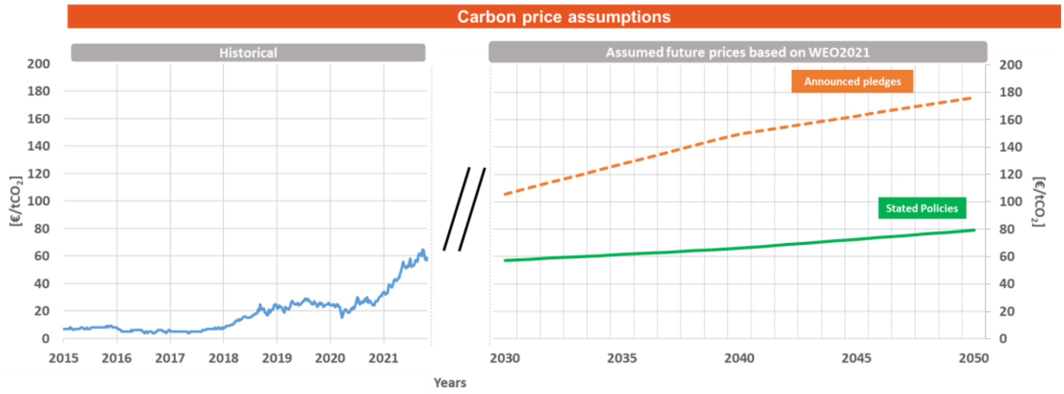

Figure 2.5.15 Historical carbon prices (ETS) and future ETS carbon prices based on WEO2021 trajectories.

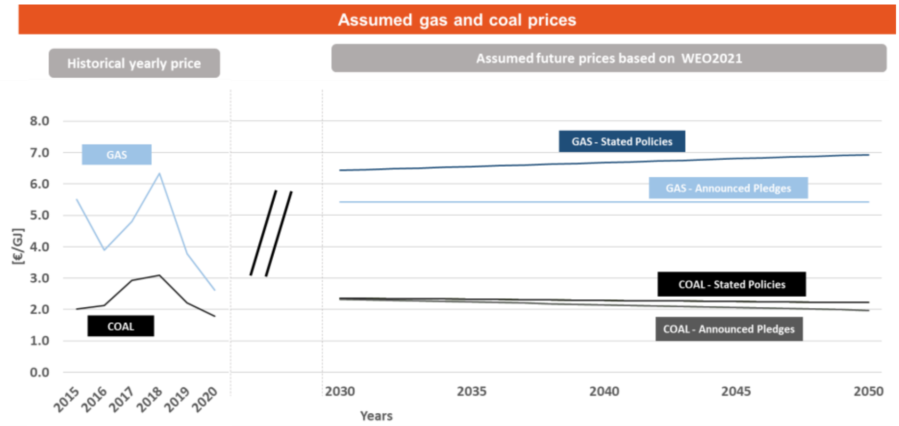

Figure 2.5.16 Historical yearly gas and coal prices and future price assumptions based the Stated Policy and Announced Pledges WEO 2021 scenarios.

2.5.10 DISPATCHABLE GENERATION

As explained in section 2.4, the scenarios are made adequate for every country. This is done by the means of an economic viability assessment which will add or remove capacity. The removal of capacity is performed on the basis of expected unit revenues in relation to its costs. The addition of capacity is done if the country does not comply with a certain reliability standard.

As from 2030, if new capacities need to be invested in, only carbon free options are used.

Based on the received feedback, Elia will consider different technologies when filling the requirements of dispatchable generation capacity. In addition to H2 turbines, synthetic methane and biogas turbines as well as natural gas fueled plants using CCS will be considered for new generation in the investment loop/economic viability assessment (depending on the scenario, in-line with what is done at TYNDP2022 level). The existing fleet will be considered to use a mixture of fossil and green gases in the transition period. The composition of this mixture will be varied between the scenarios, as is done in TYNDP2022 scenarios.

3 Conclusions

This first Belgian electricity scenario report provides the reader with context, storylines and quantified scenario data for Belgian electricity scenarios.

The scenario framework as detailed in this report is based on the European scenario framework, modifications due to state-of-art- modelling and feedback from stakeholders. For the latter, Elia has organized a call for evidence, workshops and task force sessions in order to exchange thoughts and ideas. This lead to the creation of a draft report which was publically consulted upon. Following this consultation, Elia consolidated the feedback into the final version of the scenario report.

Elia wishes to extend its sincere thanks to all members of the Task Force Scenarios for their openness and cooperation during the Task Force meetings, workshops and in bilateral exchanges and considers this first iteration of a scenario co-creation process a success in all respects.

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4 List of abbreviations and acronyms

- **AdFlex**: Adequacy & Flexibility study
- **CEP**: Clean Energy for all Europeans Package
- **CRM**: Capacity Remuneration Market
- **DE**: Distributed Energy
- **EC**: European Commission
- **EEZ**: Exclusive Economic Zone
- **ENTSO-E**: European Network of System Operators for Electricity
- **ENTSO-G**: European Network of System Operators for Gas
- **ERAA**: European Resource Adequacy Assessment
- **EV**: Electric Vehicle
- **FDP**: Federal Development Plan
- **FPS**: Federal Public Service
- **GA**: Global Ambition
- **IEA**: International Energy Agency
- **IoSN**: Identification of System Needs
- **NECP**: National Energy and Climate Plans
- **NTC:** Net Transfer Capacity
- **PV**: Photovoltaic
- **RES**: Renewable Energy Sources
- **TF**: Task Force
- **TSO**: Transmission System Operator
- **TYNDP**: Ten Year Network Development Plan
- **V1G**: EV with single optimised directional charging technology
- **V2G**: EV with bidirectional smart charging technology (Vehicle-to-Grid)
- **WAM**: With Additional Measures' scenario from the NECP

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