GRID TASK FORCE LRIO – PUBLIC CONSULTATION

Local Redistribution of Injections and Offtakes Methodologies

This document explains the methodologies that Elia uses to redistribute the values defined in macro-scenarios (such as these used in the Federal Development Plan or the Adequation and Flexibility Study) on the national territory.

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Glossary

Note: the below glossary contains terms that are used in the present document, but also the correspondance between terms used in other documents and the present document.

Term	Definition
AdeqFlex 25	Adequacy and Flexibility Study 2026-2036, published by Elia on June 30th, 2025
Allocated Capacity	Capacity allocated to a client after the conclusion of a connection contract
Blackbook	(fr: *cahier noir*, nl:): document co-authored by Elia and the DSOs describing the evolution of the peak power for each node of the Elia network that interfaces with distribution networks, as well the list of relevant connection requests at distribution level, and technical characteristics of the relevant substations
Commune to Substation Mapping	Technology-specific matrix that distributes injections or offtakes at communal level to individual substations
Dynamic Portfolio Management	Yearly exercise, where the identified projects are evaluated against the most recent available expected materialization of the future needs
Elia Databases	All internal databases used by Elia that are relevant for the purpose of theses processes
EV Repartition Model	Model used by Elia to
Future Target Year	Individual Year of the Time Horizon
Future Year	see Future Target Year
Generation Referential	Static Data for Generation
Geographical Redistribution	Process that redistributes a Macro-Value on the relevant network node of Elia's grid
Growth Potential	Aggregated local capacities, neither reserved nor allocated, that are expected to be connected to the grid following a given macro-scenario
Load	The load is the smallest metered offtake entity. At transmission level, it can correspond to a single metered process (of an ELIA direct client), the offtake of a single DSO client (if the DSO provides the data to Elia) or an aggregation of GRD clients metered by ELIA.
Load Referential	Static Data for Load
Local Growth Potential	Local capacities, neither reserved nor allocated, that are expected to be connected to the grid following a given macro-scenario
Macro-Scenario	Illustration of possible future evolutions of the EU & Belgian electrical power system, into a coherent dataset. This dataset includes the future categorized

	electricity demand, the installed capacity by technology, cli-matic data,… As the name implies, macro-scenarios quantify the needs at aggregated level (national or regional, depending on the considered need), without specifying in more details where this need is located or will materialize
Macro-Value	Single aggregated value (typically at regional or national level), originating directly from a macro-scenario, or indirectly from a simulation of a macro-scenario
Reference Context	Anticipated evolution of the electrical grid (see Reference Grid), main characteristics of the facilities connected to the grid (see Static Data) and the its usage (see Running Values) over the defined Time Horizon.
Reference Grid	Network as it is expected to evolve based on the portfolio of infrastructure projects having at least a status “in study”.
Reference Injections & Offtakes	Forecast of the hourly injections and offtakes
Reference Year	Synthetic year used as first year when
Reserved Capacity	Capacity reserved for a client after the conclusion of a connection contract
Running Values	Anticipated injections and offtakes at each connection point provided on an hourly basis across the entire Time Horizon
Sector	Categorisation used for Loads
Static Data	Essential characteristics of facilities connected to Elia’s grid
Time Horizon	Time interval considered in the Reference Context or a Macro-Scenario (typically 10years or more)
Vector	see Reference Injections & Offtakes
Zonal Long-term Study	Grid study covering a subset of the grid and aiming at defining the infrastructure modifications that would be necessary to fulfil future usage in this subset.

Executive Summary

The electrification of industry, transport, and heating, along with digitalization, has introduced new electricity usages and increased the need for flexibility, storage, and demand-side response. These changes demand better anticipation of where electricity injections and offtakes will occur.

To address this, **Elia** has launched the **Task Force LRIO (Local Redistribution of Injections and Offtakes)** to engage stakeholders and gather sector-specific insights. This initiative aims to improve strategic grid planning by identifying future electricity usage locations, ensuring timely infrastructure development, and maintaining affordability and supply security. Examples like EV charging, industrial electrification, demand-side flexibility, and data center siting highlight the need for cross-sectoral knowledge beyond traditional grid development. The Task Force serves as a platform for dialogue and continuous improvement in grid development.

In this first iteration, Elia has presented how Local Redistribution is integrated into the Grid Development Processes, and more specifically into the Reference Contexts elaboration. The Reference Context, in Elia's terminology represents the best-estimate of the grid evolution, both in term of infrastructure and expected injections and offtakes and is a fundamental input for all grid studies (long term zonal studies, identification of system needs, client connection studies).

Local Redistribution is a series of technology-specific methodologies that are used to assign a current or future usage to a node of the network, as well as the hourly expected injection and/or offtakes for this usage for the studied period.

Key Messages about Grid Development Processes

- Local Redistribution starts from values originating from Macro-Scenarios, at national and regional level. These scenarios are co-created by Elia and the different stakeholders in the context of the Public Consultations of the Adequacy and Flexibility studies or the Federal Development Plan.
- Studies with a **national scope** use "Reference Injections & Offtakes" directly derived from macro-scenarios, that are elaborated in the context of public consultations (Adequacy and Flexibility or Federal Development Plan).
- Studies with a **local scope** use a "Local Reference Injections & Offtakes" that is built using all the known information and the potential in the zone under study, and the national Reference Injections & Offtakes for the other zones.
- When the known capacities are lower than the redistributed macro-target, a **Growth Potential** is defined for the missing capacity.
- When the known capacities exceed the redistributed macro-target, all known capacities are used in local studies, and only a selection is used in national studies.
- Transmission projects identified in grid development are going to realization only when the related need is expected to materialise (Dynamic Portfolio Management process)

Key Messages about Load Redistribution

- The evolution of Known Loads is based on a bottom-up exercise, where Elia first collects metering data, and then complete it with the requirements from its direct customers, Distribution System Operators, and Local Growth Potentials (for example, brownfields in development, in order to ensure a connection on time when the parcels will be sold). Direct customers enter their prospective development through the 'Load Management' in the EPIC portal, as scenarios with associated probabilities. DSOs provide their expectations about the peak evolution for each their coupling points on a yearly basis, in a joint exercise with Elia. This process is designed for Loads located on known locations, local redistribution is then implicit.

- Electric vehicles redistribution is based on a top-down model developed to distribute vehicles to Loads based on home communes, work communes and other locations. A redistribution key is created using this model, that is then used on composite charging profiles elaborated in the macro-scenarios to define the expected consumptions at local level. These macro-scenarios consider a variable penetration of the different charging modes (including smart charging or locally optimized charging).
- Hourly consumption profiles for heat Pumps are elaborated at macro-level for each year, and redistributed using redistribution keys based on relevant available statistics (heat demand per commune in Flanders, building stock composition in other communes).

Key Message about Generation & Storage Redistribution

- Generation & Storage forecast mostly consists of units that are known to Elia, either because they are already operating, or because they will be participating to CRM. Local Redistribution uses then a **bottom-up** approach.
- **Decentralized RES** (wind onshore and PV) are currently the only generation technologies where the macro-targets significantly exceed the known installations at local level. A Local Growth Potential is used to complete missing capacities, that is defined by the capacity that is expected to be installed in each commune, using a top-down approach.
- The development of **nuclear and wind offshore** is led by the Federal Authorities, Elia is providing technical support for the grid integration of these technologies.
- Renewable energy sources (wind onshore, wind offshore, and solar)and most Small Generation Units are dispatched first and are based on realistic representative profiles.
- Injection forecasts for nuclear, conventional units, turbojets and storage are built using an **economic dispatch model,** in order to meet the net forecasted demand.

1 Introduction

1.1 Transparency and Dialogue as Key Enablers of the Energy Transition

In support of the energy transition, network development has undergone significant transformation over the past five decades, becoming an increasingly complex and cross-sectoral challenge. As electricity continues to play a growing role in society, a deeper understanding of emerging sectors is essential to anticipate where new electricity usages are likely to arise. Recognizing that this insight is best sourced directly from the sectors themselves, Elia has established the *Task Force Local Redistribution of Injections and Offtakes (LRIO)*. This initiative aims to engage with stakeholders to identify future usage locations, thereby providing valuable input for strategic grid development.

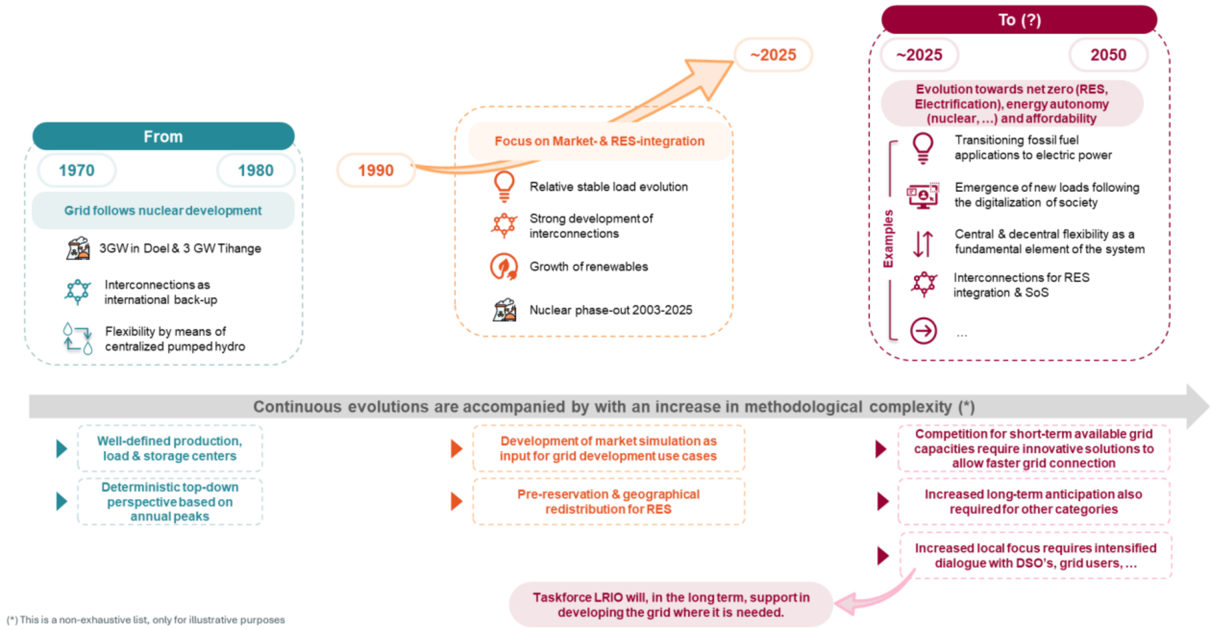


Figure 1 Evolution of Grid Development Drivers in Belgium

Starting with the development of Belgium's nuclear programme, network planning initially followed a top-down approach, where the grid was dimensioned based on expected annual peak offtakes. The generation fleet was centrally organised, with pumped hydro serving as the key contributor to system flexibility. Interconnections with neighbouring countries were limited and primarily considered as backup.

In the 1990s and the following decades, two major changes required to incorporate new processes in grid development methodologies: the liberalisation of electricity markets and the integration of renewable energy sources. The vertically integrated utility model was phased out, and distinct roles were defined and regulated. The development and operation of the transmission grid became the responsibility of the Transmission System Operator (TSO), which also oversees the **design and operation of the electricity wholesale market**. The TSO is tasked with connecting users to the grid and managing the dispatch of units according to market rules. Consequently, market simulations became a core component of grid development. From a grid development perspective, the **integration of renewable energy** introduced several challenges, particularly due to the decentralisation of generation. A growing number of smaller installations were expected to be built at unknown locations and at a much faster pace than transmission (or distribution) infrastructure could be developed. To ensure timely connections, new grid development methodologies were needed to predevelop the areas where renewable energy sources are likely to appear, and initiate the construction of transmission infrastructure when more certainty exists about the materialisation of the different projects. The European integration of electricity systems also increased the importance of interconnectors, which became active market participants.

The current decade marks a turning point in Belgium's energy transition. The continued integration of renewables increases the need for flexibility and storage, while new electricity usages have emerged through the electrification of industry, transport, and heating, as well as the digitisation of society. The role of interconnectors has been further strengthened. Digitalisation has also created new opportunities by enabling demand-side response—not only for large installations but also through the aggregation of thousands of smaller resources, often connected to distribution networks. Demand-side response has the potential to defer grid reinforcements by shifting consumption to less congested periods.

In this evolving context, short-term grid access is becoming a limiting factor for new developments, prompting a review of grid development and grid connection processes. The simultaneous rise in grid usage across sectors requires better anticipation of where new injections and offtakes will materialise. Grid development now involves a broader range of stakeholders and expertise to ensure the energy transition remains affordable and does not compromise security of supply.

To address these challenges, Elia has established the *Task Force LRIO (Local Redistribution of Injections & Offtakes)*. This initiative aims to **create transparency and dialogue** around the local redistribution of grid usage. After setting regional or national targets for additional electricity consumption, it is essential to geographically identify where injections and offtakes are likely to occur, to plan reinforcements or new infrastructure accordingly. The difference in development timelines between electricity infrastructure and client projects underscores the importance of anticipating future needs, and ensuring that, ideally, the time between a connexion request and its realisation is reduced at the maximum.

For example, the electrification of transport requires a better understanding of the movement of people and goods to determine where vehicles will be charged, and how charging is integrated into vehicle usage. This helps anticipate where grid connections will be needed, both for charging and for providing flexibility services. Similarly, the electrification of industrial processes demands insight into which processes are most suitable for electrification and can contribute to system flexibility. The digitisation of society increases demand for data centres, which also face location constraints.

These examples illustrate that grid development increasingly depends on cross-sectoral knowledge that extends beyond traditional electrical engineering. Since the most accurate insights are found within the sectors themselves, the Task Force serves as a platform to **collect evidence** that informs grid development and to present Elia's methodologies as part of a **continuous improvement process**.

1.2 Documents Submitted for Consultation

The following materials are submitted for consultation:

— The present Report.

The material submitted for the workshops (Slides and Minutes of Meetings) is NOT part of this public consultation.

The public consultation on this data will be open from 3 October 2025 to 17 November 2025 at 6:00 PM. Responses to the public consultation should be sent through the form made available during the Public Consultation on the following page: ***https://www.elia.be/en/public-consultation/20251003_public-consultation-for-the-task-force-lrio****.*

Please also indicate whether any parts of your response should be treated as confidential. By default, all answers will be published on our websites following the consultation and shared with stakeholders. Confidential responses, if clearly marked as such, will only be shared with the regulators, FOD Economie, the Federal Planning Bureau, and the Federal Minister of Energy at their request but will not be published.

In this public consultation, stakeholders are invited to review the data, challenge assumptions or methodologies and contribute by providing additional perspectives to help strengthen the robustness of Belgium's future energy system planning at local level.

1.3 Stakeholder's Engagement Prior to the Consultation

In preparation for the consultation, four workshops were held through the Task Force LRIO consisting of the members of Elia's Belgian Grid Working Group[1], that gathers a large variety of stakeholders (consumers, producers, organizations, academics, federations, DSOs…). As mentioned in the planning of Task Force, given in the Figure 2, the four workshops took place since May 15th, in which the following topics were discussed:

1. Kickoff: **https://www.elia.be/en/users-group/wg-belgian-grid/task-force-lrio/20250515-workshop**
2. Generation & Storage: **https://www.elia.be/en/users-group/wg-belgian-grid/task-force-lrio/20250624-workshop**
3. Load: **https://www.elia.be/en/users-group/wg-belgian-grid/task-force-lrio/20250904-workshop**
4. Interconnects & Open Questions: **https://www.elia.be/en/users-group/wg-belgian-grid/task-force-lrio/20251014-workshop**

During these sessions, Local Redistribution, its usage within Grid Development processes and redistribution methodologies were presented to stakeholders and discussed collaboratively. The slide decks and minutes from these workshops are available on the website, or directly through the links provided above. Please note that some values may have been updated since the publication of those materials. Accordingly, the slides and minutes are for reference only and do not constitute official content submitted for consultation.

[1] **https://www.elia.be/en/users-group/wg-belgian-grid**

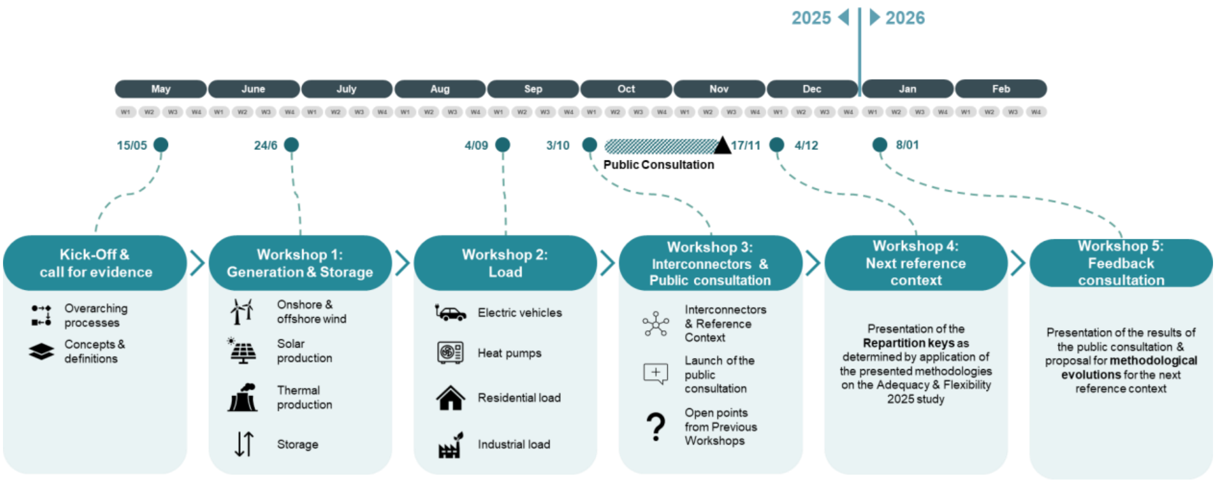


Figure 2 Key Milestones of the LRIO Task Force (Iteration 2025)

Elia would like to already thank all stakeholders that participated and contributed during the workshops.

2 Local Redistribution and Grid Development

Grid development studies rely on scenarios, that describe future usages at aggregated level (national or regional), but do not consider where the future additional usages will be located within the territory. Local Redistribution consist then in a set of methodologies that are used to locate potential grid usages defined at aggregated level (typically national or regional) on the territory. This repartition step is important to know where grid needs to be reinforced or further developed. The aim of this section is to describe how and where Local Redistribution fits within the overall processes of grid development. This section also highlights how grid development processes handle the uncertainty around the location of the materialisation of future grid usages: while the macro-scenarios highlights

Before diving into the content, it would be relevant to define some key terms that will be used frequently in the rest of the document:

- **Macro-Scenario**: illustrates possible future evolutions of the EU & Belgian electrical power system, into a coherent dataset. This dataset includes the future categorized electricity demand, the installed capacity by technology,… As the name implies, macro-scenarios quantify the needs at aggregated level (national or regional), without always specifying in more details where this need is located or will materialize. These scenarios are defined through public consultations, that take place in the context of the Adequacy and Flexibility study (every 2 years) or the Federal Development Plan (every 4 years) and are updated on yearly basis by Elia to support the connection studies, LT infrastructure adaptation studies and Dynamic Portfolio Management based on the latest available information
- **Reference Year**: An historical normalized year is used as base for the load forecast calculation. It starts on March 1st and finishes on February 28th or 29th to ensure that a continuous winter is present in the reference year. The Reference Year is built from metered data, that are corrected to take into account maintenance or outages, consumption attributable to heating and cooling and possible deviation due to exceptional circumstances.
- **Future Targeted Year**: forecasted year being studied within the time horizon of the Macro-Scenario.
- **Macro-Value**: aggregated value coming from a Macro-Scenario, for a specific technology and a given Future Year.

2.1 Local Redistribution Principles

Local Redistribution refers to a set of technology-specific methodologies used to assign capacity and project injections or offtakes at each network node. It can be performed using a top-down approach, where macro-values are distributed across the territory using technology-specific methodologies, or—when macro-values are derived from bottom-up data—by directly using local information.

Figure 3 illustrates a top-down approach using photovoltaics as an example. In this case, regional targets for 2030 are communicated by regional governments. The Macro-Values represent the expected yearly installed capacities, calculated through linear interpolation between the Reference Year and the 2030 target. Beyond 2030, a continued increase is usually assumed for in each region, except if specified otherwise. The construction of Macro-Values is detailed in the explanatory notes of the Macro-Scenarios and is subject to a public consultation.

Local redistribution is performed for each Future Year. It begins by accounting for known installations—either already built or in development with reserved or allocated capacity—using data from Elia Databases. The difference between the Macro-Value and known capacities is referred to as the **Growth Potential**, which is redistributed according to the methodology described in the Section *4.1*.

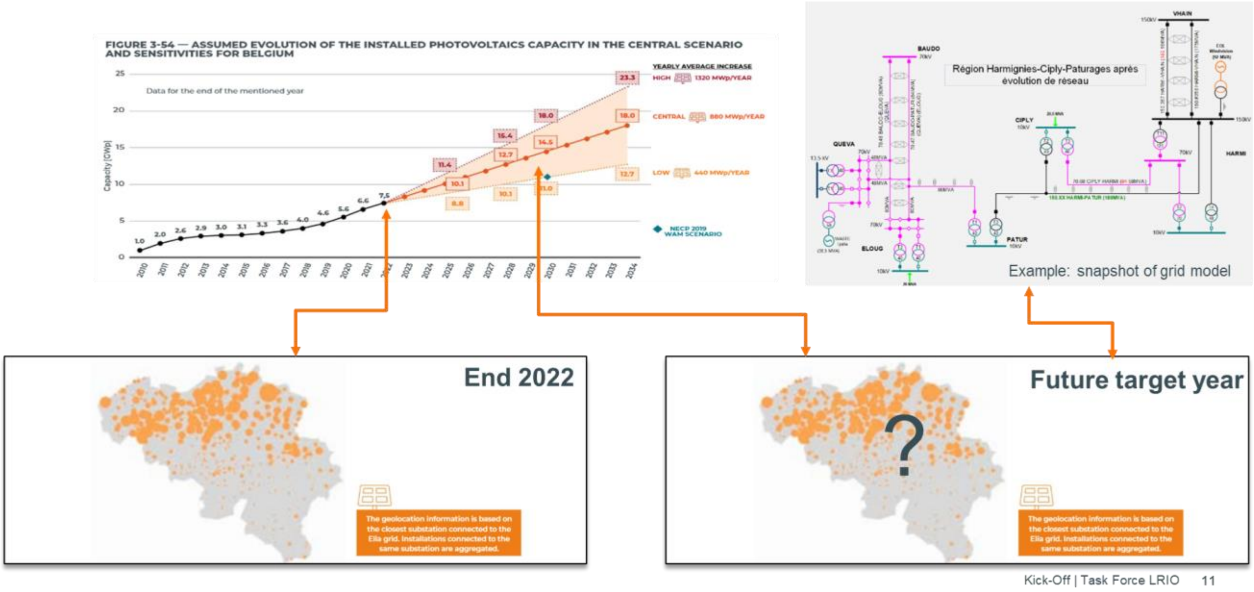


Figure 3 Redistribution of an aggregated target on the territory - Source: AdeqFlex2024-2034 (Elia), Plan d'Adaptation Wallon (Elia)

In contrast, Macro-Values for conventional thermal units are typically constructed by summing the capacities of known units, including existing installations and projects with signed CRM contracts, with no new capacity assumed, given the long development timelines and specific requirements for connecting large power plants and enabling market participation. Local Redistribution in this case is based on a snapshot from Elia Databases for the relevant technology.

Local Redistribution for offtakes uses a combination of top-down and bottom-up inputs. *Figure 4* illustrates existing and additional offtakes in a macro-scenario, considered as top-down inputs and providing information about the evolution of categorized existing usages, additional offtake for heating, e-mobility, and industrial usages. The known location of existing usages is considered as a bottom-up input used for redistribution. Similarly, projected evolutions in offtakes communicated by clients for their existing sites are also used as bottom-up inputs in the redistribution process. A top-down approach may however be applied for the electrification of the industry, for example to complete the projections done by clients, as the time horizons needed for network development are typically longer than what is communicated by clients. For electric vehicles and heat pumps, demand is expected to materialize at specific locations because of technical reasons, and technology-specific methodologies are applied to anticipate this demand.

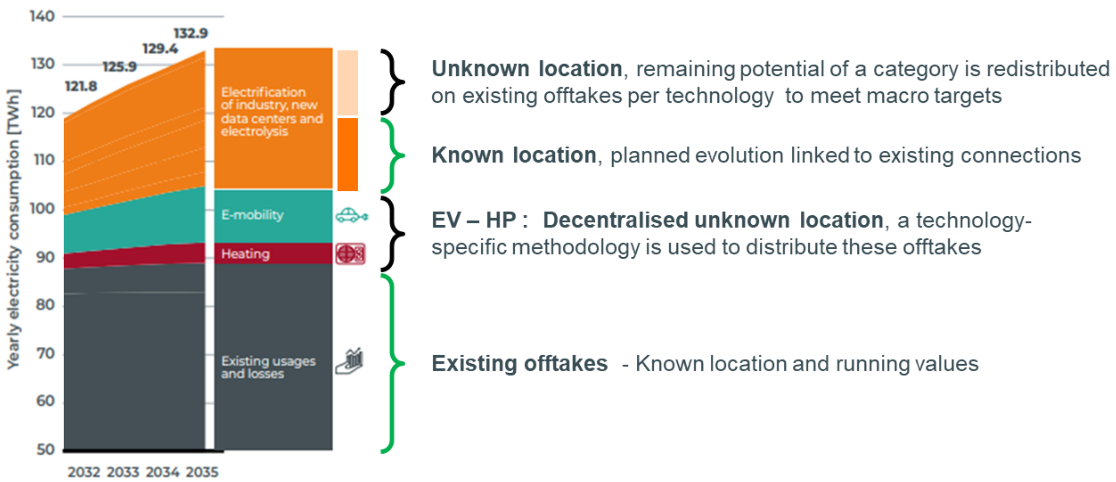


Figure 4 Example of top-down input used for the evolution of categorized usages.

2.2 Reference Context

The **Reference Context** represents the anticipated evolution of the electrical grid (Reference Grid) and its usage over a defined **Time Horizon**—typically 15+ years. It serves as a foundational input for various grid studies, and includes the key characteristics of facilities connected to the grid, the best-estimate evolution of loads and injections at the substation level, and a representation of the grid itself, including transmission projects expected to be commissioned within the Time Horizon. This section outlines the main components of the Reference Context and describes the overall process used to produce it. Technology-specific methodologies for **Local Redistribution** will be addressed in the following sections of this report.

The Reference Context is used as input for network studies and comprises the following elements:

— **Static Data**: These represent the essential characteristics of facilities connected to Elia's grid and serve as input for various grid development models. This includes connection points, rated capacity, technology type, sector of activity, short-circuit power injection, voltage or reactive power characteristics, maintenance schedules, etc.

— **Running Values**: These are forecasts of injections and offtakes at each connection point provided on an hourly basis across the entire Time Horizon.

— **Reference Grid**: The reference grid is the network as it is expected to evolve based on the portfolio of infrastructure projects having at least a status "in study". It regularly evolving based on the latest published Development Plans, or any publicly communicated update of timing of projects. At the level of the other countries, the reference grid is based on the information provided in the TYNDP and based on the most recent information exchanged between Elia and the other transmission system operators. At local level, the reference grid and static data are aligned to ensure that timing of connection of local actors match the needed infrastructure commissioning.

2.2.1 Reference Context Construction Overview

The construction of the Reference Context involves the following key steps:

1. **Reference Context Hypotheses:** This initial phase involves gathering the necessary data and formulating the assumptions that will guide the development of the Reference Context.
2. **Static Data Compilation:** Based on the hypotheses, relevant data are selected and formatted for use in subsequent steps.
3. **Running Values Estimation: Offtake Running Values** are estimated first, derived from the compiled Static Data. These values are then used as input to an **economic dispatch model**, alongside the Static Data for injections. The model outputs the **Injection Running Values**, ensuring that the resulting forecasts are aligned with market-based principles rather than purely technical assumptions.

The Reference Context requires three categories of input to be built:

- **Macro-Scenario** : see definition in Section *2.1*.
- **Grid Assumptions:** Assumptions for some major infrastructure projects, having a direct impact on the macro-scenario (e.g. cross-border infrastructure projects, infrastructure project allowing the connection of some majors actors (e.g. offshore wind, large demand user, …) are taken to ensure coherency with each Macro-Scenario. The Reference Grid is adapted to meet the grid assumptions.
- **Other Reference Inputs**: catch-all category for all the other inputs that are necessary to elaborate the Reference Context.

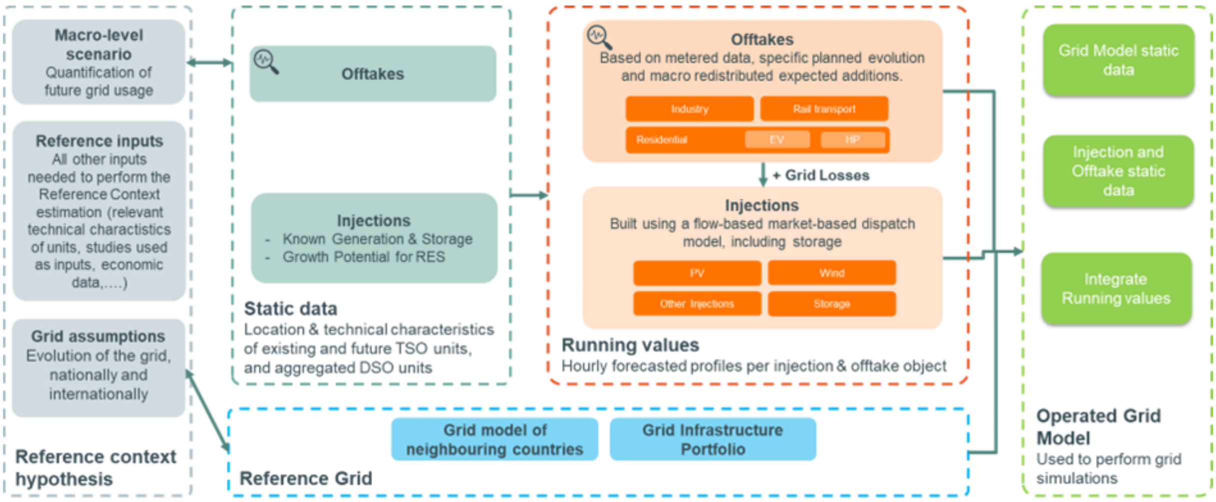


Figure 5 High Level View of the Reference Context

2.2.2 Offtakes Running Values Estimation

Offtake Running Values are estimated through different processes: one general process for known consumption evolution, and two dedicated processes for **Electric Vehicles** and **Heat Pumps**, as illustrated in Figure 6.

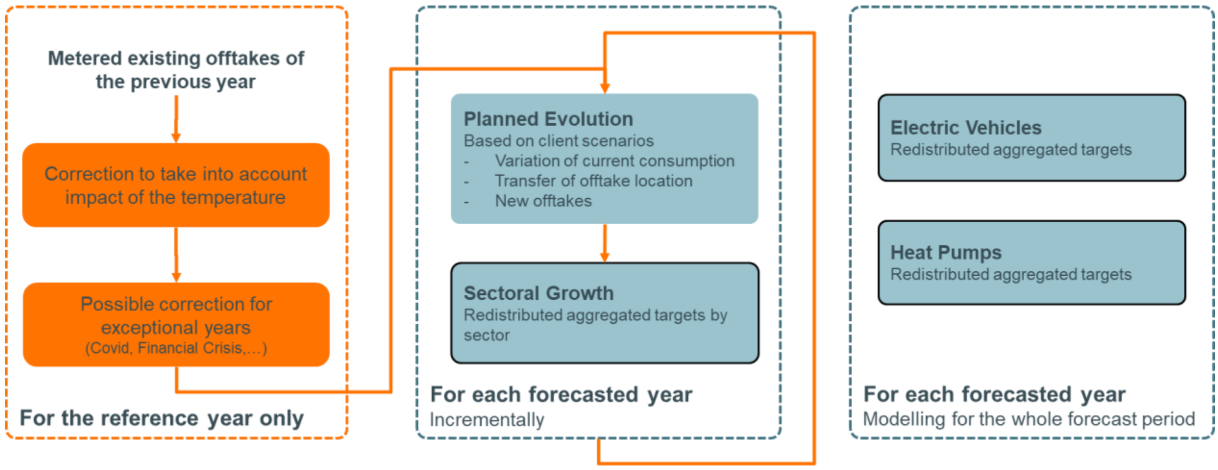


Figure 6 High Level View of the Offtake Reference Context

The general estimation process follows an **incremental approach**, where forecasted additional loads are added to the load of the Reference Year for the first Future Year, and to the previous Future Year for subsequent years. The Reference Year is based on metered data, corrected for anomalies, and normalized for two parameters: a temperature-based normalization, or **thermosensitivity**, to normalize residential consumption attributable to low or high temperatures, and an optional normalisation to account for exceptional circumstances such as the COVID-19 pandemic at international level, or temporary plant closures at local level.

Once the Reference Year is created, **expected additions** are added incrementally for each of the following years. These additions are based on realigned scenarios provided by Elia's clients, the expected evolutions for each coupling point provided by the DSOs and possible Local Growth Potentials. The values are then grouped by Sector (categorisation used for this exercise), and if the sectoral values don't match the corresponding Macro-Values, a scaling is performed to ensure a consistency with the Macro-scenario. Further details are provided in Section 3.1.

Running Values for **Electric Vehicles** and **Heat Pumps** are estimated using specific methodologies. Unlike industrial demand, these technologies are considered partially market-driven, such smart charging for electric vehicles or price optimization for heat pumps. The Local Redistribution methodologies for these technologies will be described further in Sections 3.2 and 3.3.

The Running Values for Known Load Evolutions, Electric Vehicles and Heat Pumps are then combined to produce the final Reference Offtakes.

2.2.3 Injection Running Values Estimations

Injection Running Values are estimated by using representative synthetic profiles for units that are assimilated to must run-units (wind onshore, PV, most small thermal units,..) and by simulating an **economic dispatch** for the other generation units, using the Antares simulator, described in *Box 1*. The process begins with the collection of **Static Data**, which is then processed to serve as input for the model. Antares generates the hourly expected output for each modelled unit or each aggregate of units (if they have been aggregated). The last part of this process is to assign the matching units to the relevant network nodes.

The initial step involves creating a snapshot of the **Elia Databases**, illustrated in *Figure 7*. This database contains all the necessary information for the model, including:

- Key characteristics of generation units (e.g., installed capacity, technology type, connection point, maintenance schedule, commissioning and decommissioning dates, profile used, aggregation status)

- Market parameters relevant to each unit.

The Elia Databases includes data on generation units connected to both Elia's transmission network and distribution networks. For units connected to distribution networks, as each local distribution network model is reduced, the units are aggregated and placed at the interface point between the transmission grid and local distribution grid

To compute the Running Values for generation and storage, a flow-based simulation is run. The Belgian transmission grid has been divided into Subdivisions, that are subsets of the transmission grid defined based on congestion-related constraints. Within each Subdivision, generation units are aggregated according to their technology and their expected operational profiles. As detailed in the *Generation* section, certain technologies are modelled assuming uniform behaviour across all units of the same type — such as *Decentralised Renewable Energy Sources (Wind/Photovoltaics)* — or are treated as must-run units, in which case a synthetic profile is applied per Subdivision (e.g., *Small Generation Units*).

The profiles for demand and storage facilities and their potential for demand-side response are also assigned to their respective Subdivision. To simplify modelling and reduce the simulation time, they may be aggregated.

This aggregated snapshot, containing information about generation, storage, and load, serves as a key input for the next step: the **economic dispatch model**.

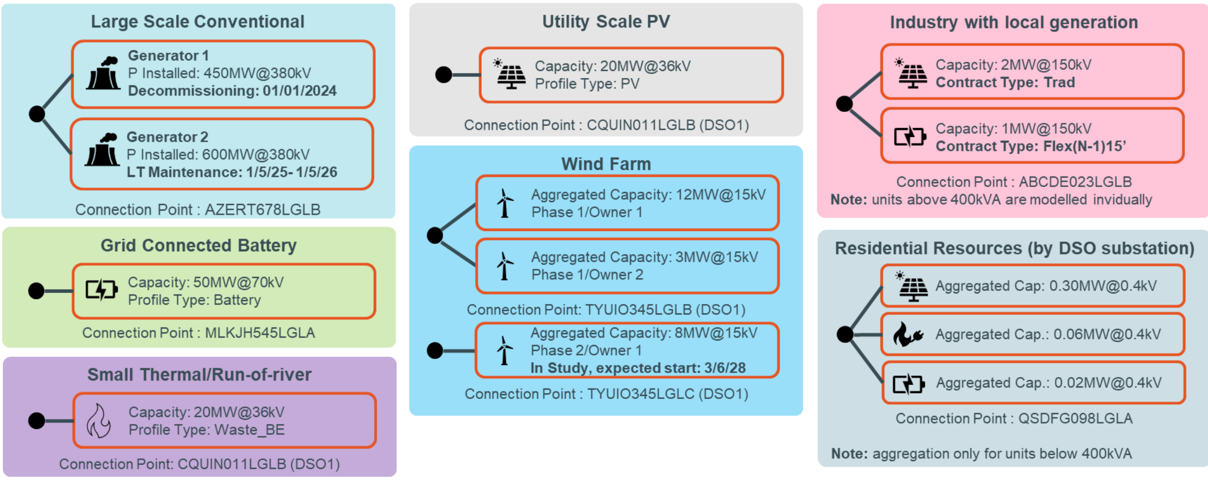


Figure 7 Example of Generation Data Represented in Elia Databases

The market-dispatch simulation, performed by the Antares simulator[2], is used to estimate the Running Values of the different units. To define the injections forecasts, four different categories of units can be distinguished:

- **Individually modelled units**: large units such as conventional units, pumped storage, nuclear,.. These units are modelled individually, using technical and economical parameters to define when to call them. The injections forecasts are an output of the model.
- **Must-run units**: assumed to inject regardless of the market conditions, for example because electricity generation is a by-product of another process (waste incineration or combined heat power). The injection forecasts are based on realistic representative profiles for the technology This units are modelled considering a single aggregated profile per Subdivision.

[2] A further description of Antares and economic dispatch is given in the Appendix A of the Adequacy and Flexibility Study, available at the following address: **https://www.elia.be/en/electricity-market-and-system/adequacy/adequacy-studies**

ANTARES Simulator

Antares Simulator is an open-source software developed by RTE. It is a sequential 'Monte Carlo' simulator designed for short- to long-term studies related to large interconnected power grids. It simulates the economic behaviour of a given transmission-generation system, across the period of one year and on an hourly basis.

Elia is using the software for more than 10 years and it is the tool used for performing the simulations used in the framework of capacity mechanisms calibration in Belgium (Strategic Reserves and more recently the market-wide CRM) but also for the Adequacy and Flexibility studies since the first edition in 2016.

For the creation of annual scenarios, Antares Simulator can be provided with ready-made time series or can generate those through a given set of parameters. Based on this input data, a panel of 'Monte Carlo' years is generated through the association of different time series (randomly or as set by the user). Then, an assessment of the supply-demand balance for each hour of the simulated year is performed by subtracting wind and solar generation from the load, by managing hydro energy and by optimising the dispatch and unit-commitment of thermal generation clusters, storage and demand side response. The main goal is to minimise the total cost of generation on all interconnected areas.

Finally, RTE international (RTE-i) has developed a collaborative approach around Antares Simulator, gathering different users to enhance the application, provide training, support, and development. TSOs amongst RTE-i Antares Simulator Users Club are: APG, Elia, EMS, Swissgrid, SEPS, IPTO, ELES, MAVIR, MEPSO, ESO, OST.

More Information: **https://antares-simulator.org/**

Box 1 Antares Simulator

- **Renewable Energy Sources**: assumed to inject regardless of the market conditions. If the production exceeds the system requirements, the energy in excess is considered as curtailment in the economic dispatch model. These units are modelled considering a single aggregated profile per subdivision and per technologies, and are directly related to the climate years (weather-related data, impacting the solar and wind production).
- **Storage Units**: are assumed to operate according to market rules for the one considered "in-the-market" (as defined in the macro-scenario, such as large-scale batteries, part of residential and vehicles-to-grid batteries). The Running Values are then an output of the economic dispatch model. It should be noted that offtakes from storage are handled as negative injections, rather than offtakes. Regarding the "out-of-market" storage (part of residential and vehicles-to-grid batteries), the profiles are pre-defined, according to assumptions and methodology described in the macro-scenario framework (Adequacy & Flexibility studies, Federal Development Plan).

The Antares software is also being used by Elia in other contexts, such as Adequacy & Flexibility studies, the simulation being described here is however focused on the hourly dispatch of the different units.

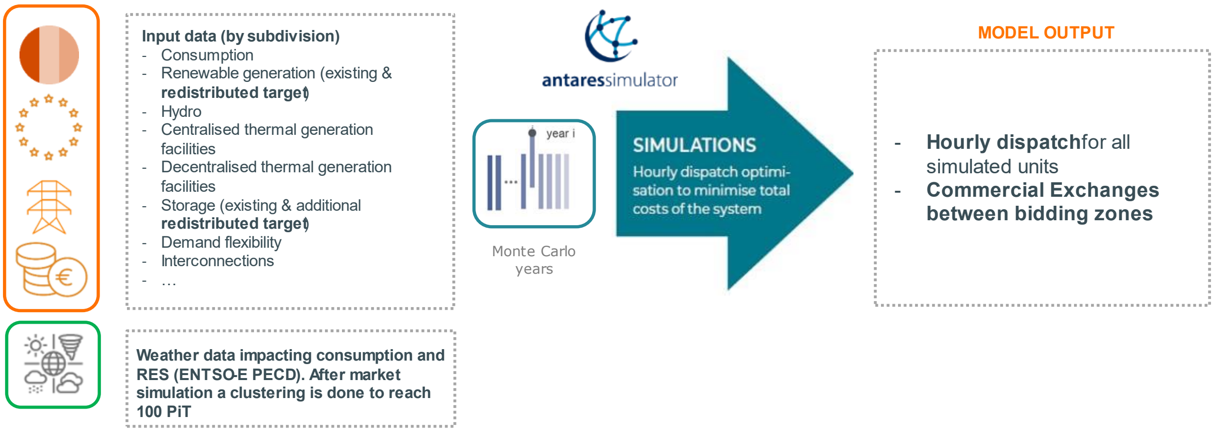


Figure 8 Building the Hourly Dispatch

The final step of the estimation of the Injections Running Values is the processing of the economic dispatch Output to assign the different injections to their respective substations. The process depends on the modelling approached that has been taken.

- **Individually modelled units** are assigned to their respective substations.
- **Must-run units** are assigned to their respective substations, and the profile that was aggregated is used at individual level.
- **Renewable energy sources** are assigned to their respective substations, and the profile that was aggregated per Subdivision is used at substation level.
- **Storage Units**: are assigned to their respective substations, and the profile that was aggregated per Subdivision is used at substation level.

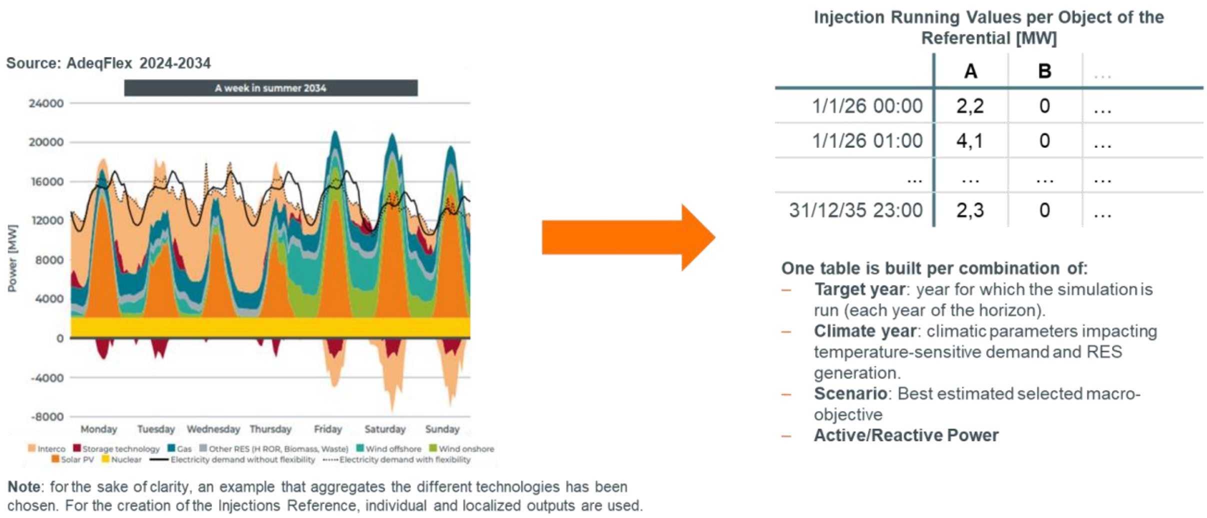


Figure 9 From Hourly Dispatch to Injections Running Values

2.3 Local Redistribution within grid development

Local redistribution are used in several steps of grid development processes. Before diving into the local redistribution methodologies themselves, this section will detail how grid development is organized within Elia, the different studies that are performed and the purpose they serve in the grid development process.

The aim of the grid development process is to identify the projects that will be necessary to meet the futures needs on the network. Future needs encompass the connection and management of the future injections and offtakes of the current and future users of the network. After their identification, a periodic exercise, the Dynamic Portfolio Management, prioritize the different projects depending on the probability that the needs covered by individual projects will materialize.

2.3.1 Grid Development Methodology Overview

Grid Development follows a methodology that comprises four main steps:

- **Macro-scenarios Definition**: see definition in Section *2.1*.
- **Needs Identification**: The Needs Identification consists of different kinds of studies (market, load flow, stability,…) performed at different future years and aims at the identification of the localized future needs in transmission capacity. The studies cover the whole span of federal and regional grids and analyses a Reference Context. This Reference Context consists of a) a Reference Injections & Offtakes, that is a best estimate evolution of the expected localized injection and offtakes for each future year and b) a Reference Grid, that is a model representing the expected grid infrastructure for each future year. To define the Reference Injections & Offtakes, local redistribution methodologies are applied on the values defined in the macro-scenarios.
- **Solution Elaboration**: to meet these future needs, Elia considers the following approaches sequentially:
    - maximal use of the existing infrastructure;
    - elaboration of new products and services;
    - **infrastructure adaptation** (grid reinforcement or extension). Infrastructure adaptation studies are performed on a subset of the network covering a subset of needs and potential solutions that should be optimized together. The aim of these studies is to identify the grid infrastructure projects that would fulfil the future needs resulting from a best estimate evolution of the expected localized injection and offtakes for each future year. In the of extra high-voltage networks where the subset of needs and potential solutions covers the whole country, the Reference Context described in the *Needs Identification* step, is used while for more local studies, a Local Reference Injections and Offtakes, that is tuned for the area of influence of the study. The Local Reference Context is built using the Local Reference Injections and Offtakes, and the same Reference Grid as the one used at national level.. It must be highlighted that the proposed grid infrastructure projects result from the comparison of different infrastructure solutions on different criteria such as safety, reliability, robustness, economic efficiency, sustainability and public acceptance. In order to evaluate the "robustness", other local reference contexts than the best estimate Local Reference Context are defined to ensure robustness of the proposed project to uncertainties in the local scenarios.
- **Dynamic Portfolio Management**: yearly exercise, where the identified projects are evaluated against the most recent available expected materialization of the future needs. The projects that have been selected through the Dynamic Portfolio Management are submitted for approval in development plans. This step is used as part of the definition of the Reference Grid.

The Figure 10 details further the interaction between the Reference Context and the Local Reference Context with the main steps of the Grid Development methodology.

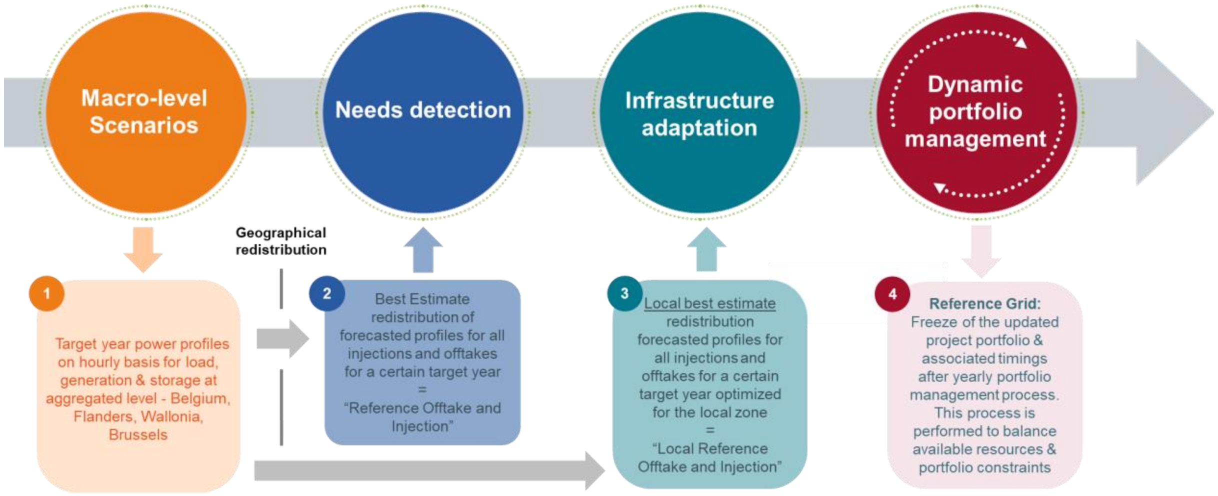


Figure 10 Main Steps in Grid Development

2.3.2 Reference Context versus Local Reference Context

As explained in the previous section, the "Reference Injections and Offtakes" or the "Local Reference Injections and Offtakes" are two different expected evolutions of localized injections and offtakes for each Future Year which are fully coherent with a Macro-Scenario but which are based on different geographical redistributions. Each of these geographical redistributions aim to achieve the objective to create an evolution of the expected localized injection and offtakes for each future year which is either a best estimate evolution at national level or a best estimate evolution at local level.

The comparison of the two Reference Injections and Offtakes is summarized in Table 1.

	REFERENCE INJECTIONS AND OFFTAKES	**LOCAL REFERENCE INJECTIONS AND OFFTAKES**
CONSIDERED INPUT	Input data are identical - if reference is created at the same moment - (e.g. Load Mgt from Direct Grid Users & DSOs, reserved & allocated capacities, growth potential by technology - geographically distributed, Input from Public Authorities & associated Agencies, …)	
CONSIDERED GROWTH POTENTIAL (IF APPLICABLE)	Remaining Growth Potential originating from Macro-Scenarios, redistributed using a technology-specific methodology and information from Local Growth Potentials in all zones.	Growth Potential, that is composed of: - For the Area of Influence, Local Growth Potential, based on bottom-up information - For the other areas; Remaining Growth Potential originating from Macro-Scenarios reduced by the Local Growth Potential of the Area of Influence, redistributed on the other areas using a technology-specific methodology and information from Local Growth Potentials of each other area.
AIM	Reaching a best-estimate redistribution at **macro-level** without privileging information from one area more than another	Reaching a best-estimate redistribution at **area-level** and being aligned while respecting macro-level values
PROCESS AND STUDIES RELYING ON IT	— Identification of System Needs — Dynamic Portfolio Management & associated timings — Best estimate scenario for extra-high voltage infrastructure adaptation & interconnections studies	— Connection studies (EOS/EDS) — Fine-tuning adaptation of the Dynamic Portfolio Management & associated timings based on local information and risks — Best estimate scenario of zone under local infrastructure adaption study

Table 1 Comparison between Reference Offtake and Injections and Local Reference Offtake and Injection

It must also be highlighted that the sum of the load and injection capacities of each “Local Reference Injections and Offtakes” is likely to be greater than the corresponding value defined in the macro-scenario and in the “Reference Injections and Offtakes”. Local studies are meant to propose infrastructure projects that satisfy all expected future needs in their area of influence, but it is not expected that all proposed infrastructure projects will be selected to go to realisation at the identified timing of the local infrastructure adaption study. In the Identification of System Needs, the likelihood of materialization of the different needs at a given time horizon are evaluated, and in the Dynamic Portfolio Management exercise, infrastructure projects are selected to satisfy the needs that are the most likely to happen.

In order to illustrate the difference between “Reference Injections and Offtakes” and the “Local Reference Injections and Offtakes”, let’s consider a situation where, 5GW of installed capacity for a given category of electricity usage is expected to be reached at national level at a given Future Year but 6GW of projects have already been reserved for this same future year. The best estimation of installed capacity at national level is, in this case, lower than the sum of reserved projects because, based on macro-economic indicators, it would be unlikely that all projects will be realized. For the “Reference Injections and Offtakes”, a project of 1GW in region A is not expected to be not realized at the given future year based on the local redistribution methodologies that will be described further down this document. However, when studying zone A, the project of 1GW will be considered in the “Local Reference Offtake and Injection” as, at local level, the best estimate is to consider that all reserved and allocated capacities will materialize at the forecasted date. In the context of connection studies of other grid users in zone A, the capacity of this project and the associated connection contractual engagement (P_{flex}, P_{firm}, E_{flex}) will be ensured. As well, in the context of the infrastructure adaptation studies, infrastructure will be proposed in order to meet the grid user’s needs. However, in the context of Dynamic

Portfolio Management, local infrastructure projects in zone A might be given a lower priority compared to other infrastructure projects as the likelihood that this 1GW capacity will be realized at the given target year is lower than the likelihood of other reserved capacities.

2.3.3 Building the Reference Injections & Offtakes or Local Reference Injections & Offtakes

The local redistribution methodology is based on a few key principles illustrated by the figures below.

The creation of a Reference Injections & Offtakes of a given future year starts from the comparison, for each considered category of electricity usage, at the aggregated level (i.e. national or regional level in Belgium), of

- the sum of the existing, reserved and allocated capacities, expressed either in GW of maximum power or TWh of energy consumption (see ①+④ in Figure 11)
- with the macro-level expectation at the considered horizon (expressed in GW or in TWh) (see ② in Figure 11)

Two situations can then occur, depending on if the sum of existing, reserved and allocated capacities is lower or higher than the macro-level expectation at the considered horizon.

2.3.3.1 Sum of existing, reserved and allocated capacities lower than the macro-level expectation

If the sum of existing, reserved and allocated capacities is lower than the macro-level expectation, the concept of Growth Potential is used to compensate for the difference. At macro-level a remaining growth potential (⑤) is defined to breach the gap (①+④+⑤=②)

Local Growth Potentials are local capacities, neither reserved nor allocated that are expected to be connected to the grid following a given macro-scenario. These Local Growth Potentials are defined based on inputs collected by Elia either in the context of the call for evidence associated to the taskforce “Local Redistribution of Injections and Offtakes” or in the context of best-estimate scenario building process of the local infrastructure adaptation study. The methodologies to define these Local Growth Potentials are technology specific and will be detailed further down this document. It however based on different information such as load evolution forecasting scenario provided by grid users & DSOs to Elia, input from public authorities & associated agencies, models of the evolution of the local electricity usage (e.g. electrical vehicle penetration and usage, heat-pump installation model, Wind or PV potential, …)

On Figure 11, Local Growth Potentials of each zone (a, b & c) are represented by the quantities 5a’, 5b’ and 5c’.

- At zonal level, these Local Growth Potentials together with the existing, reserved and allocated capacities of the zone are considered to build the “Local Reference Injections & Offtakes” of this zone while the Local Growth Potentials of the other zone are homothetically scaled down in order for the sum of the Retained Growth Potential to reach the macro-level remaining growth potential (⑤).
- In order to build the “Reference Injections & Offtakes” to be used at national or regional level, these Local Growth Potentials are homothetically scaled down in order for the sum of the Retained Growth Potential to reach the macro-level remaining growth potential (⑤), no zone is therefore privileged over the others.

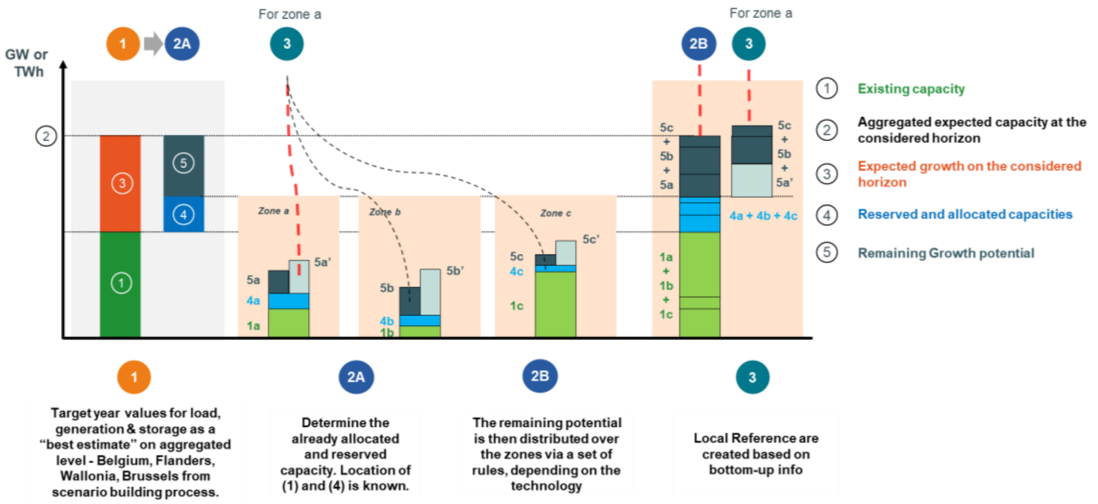


Figure 11 Local Redistribution when Allocated and Reserved Capacities

In case the "Reference Injections & Offtakes" or the "Local Reference Injections & Offtakes" needs to be updated, taking into account a new reserved capacity, in case the new reserved capacity falls within the Local Growth Potential as illustrated in Figure 12, this potential is reduced by the new reserved capacity in order to maintain macro-level expectation at the considered horizon. In case the new reserved capacity does not match with a Local Growth Potential, it will only be considered in the "Local Reference Injections & Offtakes" and not within the "Reference Injections & Offtakes".

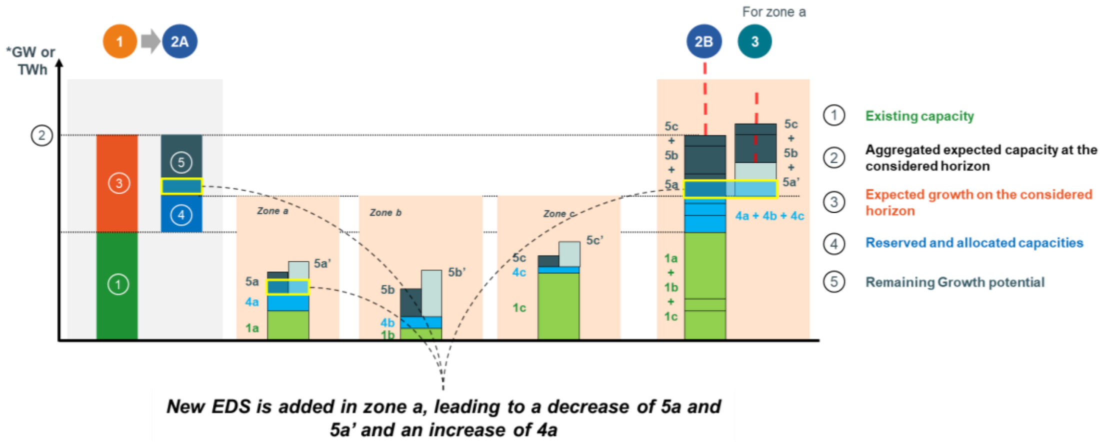


Figure 12 New EDS addition in the Reference Context

2.3.3.2 Sum of existing, reserved and allocated capacities higher than the macro-level expectation

If the sum of existing, reserved and allocated capacities is higher than the macro-level expectation, a selection between the reserved and allocated capacities needs to be performed as ①+④>②.

The reserved and allocated capacities are therefore ranked by grouping then into 4 groups, representing the likelihood of realisation.

- Capacities selected in the CRM or retained in a previous future year are considered first
- capacities under realization, permitting or having a go for realisation are then considered
- followed by the remaining allocated capacities
- and the reserved capacities

Inside a group, still with the aim to represent the likelihood of realisation, the capacities are sorted by the increase level of expected flexibility volume at the considered target year as identified in the grid connection study of the capacity.

Finally, the ranked capacities are selected to form the "Reference Injections & Offtakes" until the sum of the retained capacities ③ and the installed capacities ① allow to reach the macro level expectations (②). This is illustrated in Figure 13.

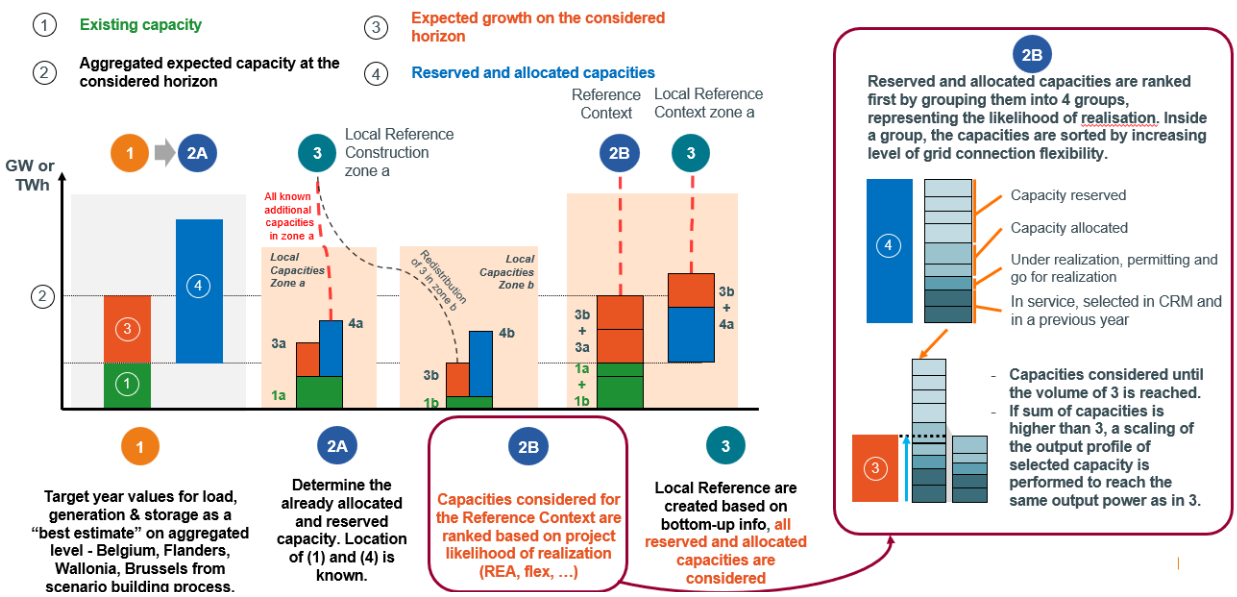


Figure 13 Local Redistribution when EDSs exceed the macro-value.

At zonal level, the best estimate is to consider that all reserved and allocated capacities will materialize at the forecasted date. The "Local Reference Offtake and Injection" of this zone is therefore build considering first all existing, reserved and allocated capacities of the considered zone. The remaining gap to reach the macro-level expectation is fill-in with the existing capacities of the other zone and by selecting the needed reserved and allocated capacities of the other zone following the approach described above until the sum of the retained capacities ③ and the installed capacities ① allow to reach the macro level expectations (②). This is illustrated in Figure 13.

2.3.4 Update of the Reference Injections & Offtakes or Local Reference Injections & Offtakes

As mentioned above, the Reference Injections & Offtakes is updated typically once a year based on the known information for the local redistribution (existing, reserved, allocated and Local Growth Potential) known at the time of this update. It is typically triggered by an update of the macro-level scenario and the need to perform a new "Identification of System Needs" study and a new "Dynamic Portfolio Management". Therefore, the elaboration of the development plans are triggering the creation of a new Reference Injections & Offtakes but intermediate updates, at the frequence of the year are performed by Elia.

The Local Growth Potentials are redefined following the inputs collected by Elia either in the context of the call for evidence associated to the taskforce “Local Reference Injections & Offtakes” or the creation of the best-estimate scenario of a local infrastructure adaptation study. The frequence of the local infrastructure adaptation study depends on the development needs of a given zone as identified by the identification of system needs. As an example, major updates of the infrastructure development plans for the zone of Liège 150kV & 220kV were studied in 2014, 2019 and 2025, each leading to a major update of the growth potential of this zone.

It is therefore important to highlight the major updates of the growth potential and infrastructure development plans for a given zone are asynchronous tasks while other updates (methodological, mathematical models, …) are performed synchronously, typically each year. This is summarized in Figure 14.

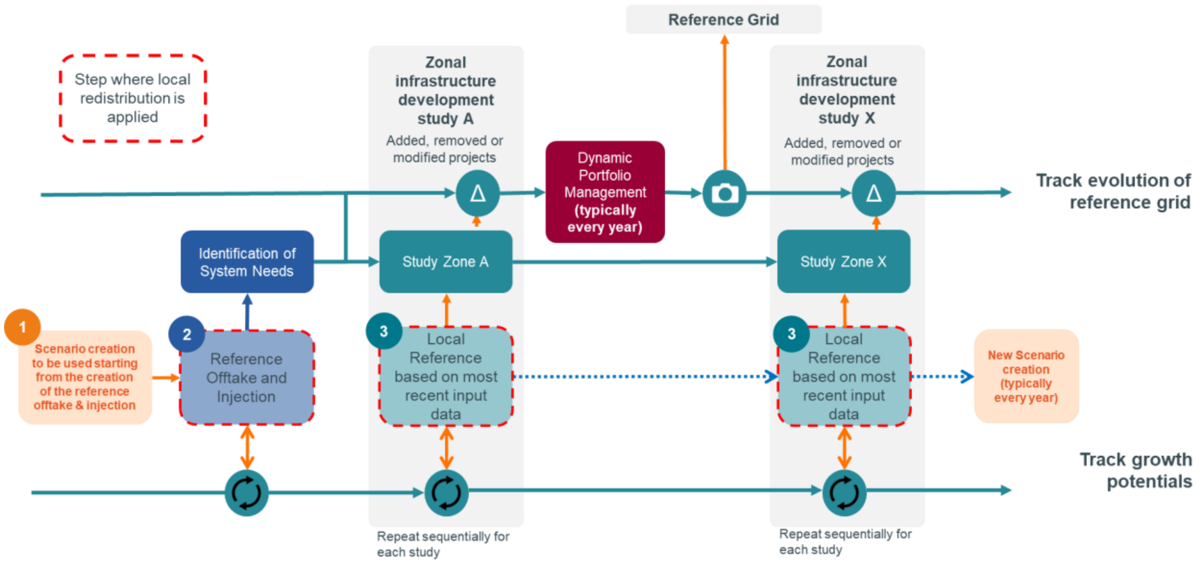


Figure 14 Chronology of the different studies

2.3.5 Dynamic Portfolio Management and Development Plans

As mentioned above, Dynamic Portfolio Management is a yearly exercise, where the identified projects are prioritized in order to bring the highest added value to society. It is based on the most recent “Reference Injections and Offtakes” and therefore considers the latest information on the evolution of the existing, reserved, allocated and Local Growth Potentials) known at the time of this update. The impact of this “Reference Injections and Offtakes” on the needs to adapt the portfolio of infrastructure project is analysed in the context of the “Identification of System Needs” study.

As an example, based on the latest evolution of local injection and offtake, a planned infrastructure project could be delayed by one year without impacting the safety, reliability or operating cost of the system while a newly identified congestion could be avoided by advancing by one year the commissioning of an infrastructure project.

As illustrated in Figure 15, this process is performed every year and snapshots (illustrated by the camera symbol in the figure) of this project portfolio is integrated in the “Federal Development Plan”, “*Plan d’Adaptation Wallon*”, “*Plan de Développement Bruxellois*” and “*Vlaamsinvesteringsplan*”.

It must however be noted that as these snapshots are not taken synchronously, the effect of an updated “Reference Injection and Offtake” and the effect of new infrastructure adaptation studies can be seen from one to another.

Additionally, Figure 15 illustrates the needed time to create “Reference Injections and Offtakes” (about 6-9 months), to identify system needs (about 3 months), to perform the “Dynamic Portfolio Management” (about 3-6 months) and to consult, adapt, submit and validate a development plans.

Therefore, a “Reference Injections and Offtakes” build is S2 2025 will serve as input for a Federal Development Plan 2028-2038 expected to be validated in Q1 2027.

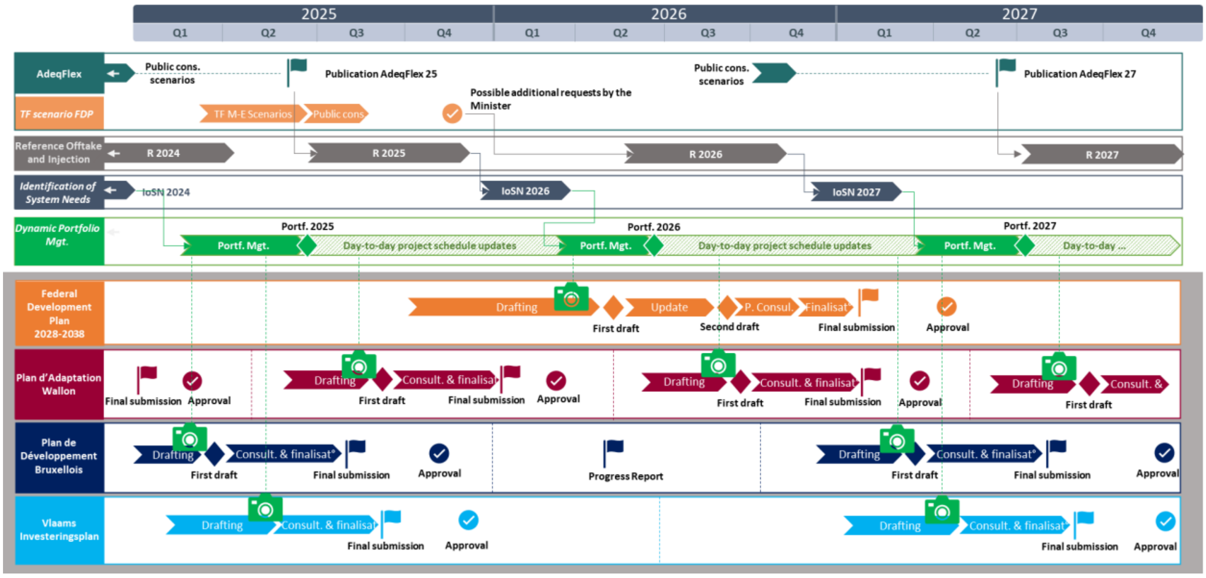


Figure 15 Timeline of the Development Plans

The timelines of Figure 14 and Figure 15 also support the need of separate Task Force for Local Redistribution.

First, Local Redistribution methodologies are used when building Reference Contexts and Local Reference Contexts. The construction of Reference Contexts follows the finalization of Macro-Scenarios, that are currently elaborated in the context of the public consultations for the Federal Development Plan and the Adequacy and Flexibility studies. The impact of Local Redistribution goes typically beyond the scope of these consultations. In development plans, Local Redistribution has indeed a proportionally larger impact on Regional Development Plans. Local Redistribution is also irrelevant for the core purpose of Adequacy and Flexibility studies, but the Macro-Scenarios are valid inputs for the construction of Reference Contexts.

Second, the Local Redistribution methodologies themselves are not updated frequently, as the development or update of a methodology is typically driven by infrequent events (creation of a new category, definition of a political target,…). In this context, it is important to distinguish the methodologies from their inputs: changes in inputs can invalidate the results of the application of a methodology, without invalidating the methodology itself. For example, a key step in the methodology used for wind-onshore is the definition of zones “free of legal restrictions”. A regulatory change that impacts how these zones are being defined will require to execute the methodology with most recent regulatory restrictions, but the methodology itself remains unchanged and valid.

Having a separated Task Force focusing on methodologies was considered to be the most suitable approach: first, it creates a platform focusing more specifically on local grid development, and second, the uncoupling of the workshop and public consultations from the co-elaboration of macro-scenarios (that are elaborated under a framework defined in the legislation) enables a greater flexibility to inform or consult when a change in the methodology is required.

3 Load Redistribution Methodologies

This section will detail how local redistribution methodologies are being used to compute a best-estimate of the different Loads on the network. From a grid perspective, a Load is generally defined as the smallest metered offtake entity. At ELIA level, it can correspond to a single metered process (e.g. for a direct clients), the offtake of a single DSO client (if the DSO provides the data to ELIA) or an aggregation of DSO clients metered by ELIA. At DSO level, a load is identified by a unique EAN. For local redistribution purposes, 3 categories have been defined:

- **Known Loads Evolutions**: bottom-up exercise based on the load forecasts that has been communicated by clients and Distribution System Operators to Elia. Elia clients include already connected clients (ELIA direct clients or DSOs) and clients having signed a connection agreement, even if the connection itself hasn't been built yet. Local Growth Potentials, that are loads that are expected to materialized and that have not been reserved or allocated, are also part of the Known Load Evolutions.
- **Electric Vehicles**: top-down approach, where new electric vehicles are redistributed between home, work and public charging, with profiles that are defined according to a mix of natural charging, local optimisation or market-based optimisation.
- **Heat Pumps**: top-down approach, where residential and tertiary heat pumps are redistributed between com-munes, with profiles that are defined according to a mix of no optimisation and local optimisation.

The output of each of these methodologies is a yearly table, that gives best-estimate consumption for each of the Loads for each hour of the year. The results for each year are then combined to have the Reference Offtakes.

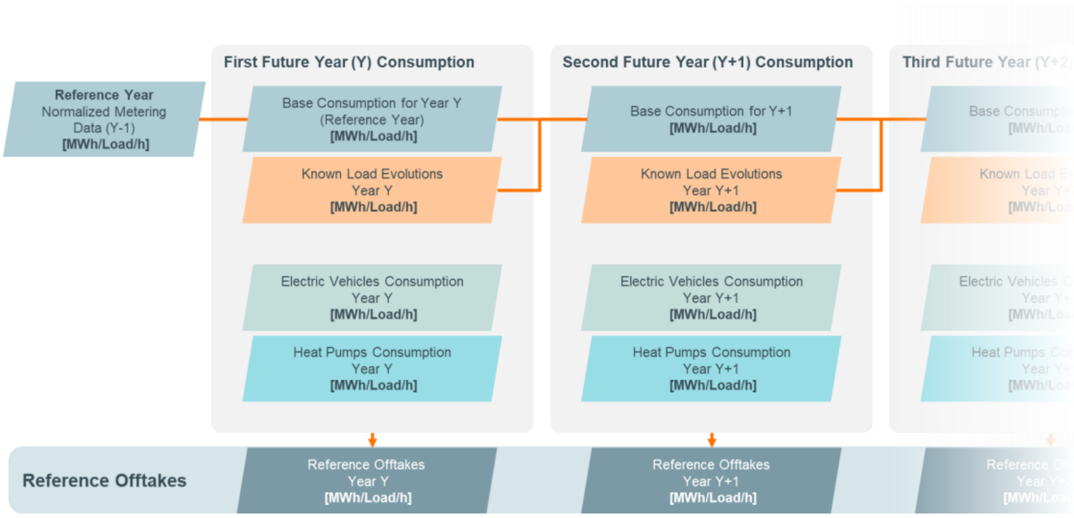


Figure 16 Building the Offtakes Reference Context

3.1 Known Loads Evolutions

> *Elements and assumptions to which we want to draw attention and especially welcome feedback on:*
>
> - Do you have specific reasons and/or sources which could justify a different redistribution of Known Loads Evolu-tions (or confirm the proposed one)?

As detailed in the section 2.2.2, the construction of the Running Values for the Known Load Evolutions starts with the construction of a Reference Year based on metered data and then normalized to remove deviations attributable to temperature or exceptional variations. The Running Values are built by adding year-over-year variations to the Reference Year for the first year, and the last computed year for the next years.

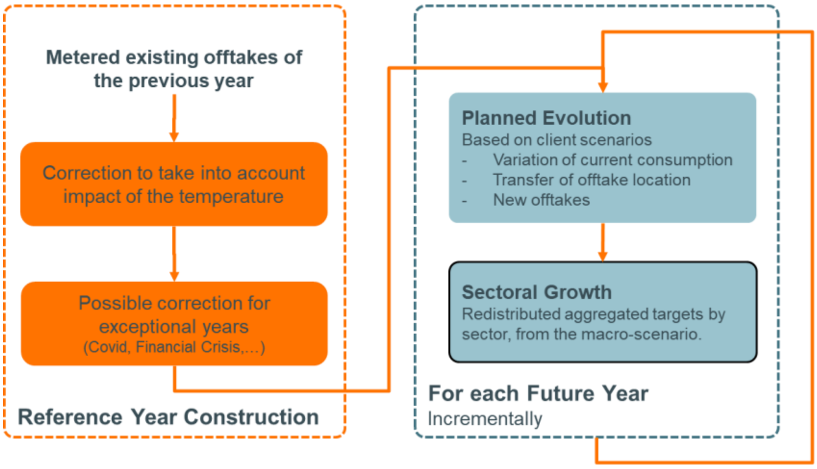


Figure 17 Known Load Evolutions Overview

3.1.1 Reference Year Construction

The Reference Year is the year that will be used as starting point for the forecasting of the evolution of the Known Load. It is built by normalizing metering data from the last complete year. Two criteria are being used for normalization:

- **Thermosensitivity**: the consumption attributable to residential heating and cooling is normalized, to have an electrical consumption that would have been consistent with a standard temperature year.
- **Individual growth rates:** that is meant to correct consumption differences attributable to exceptional variations in consumption, and where it can be reasonably assumed that the consumption will partially recover for the next years.

3.1.1.1 Data Preparation

The starting point of the Known Load Evolutions is a complete year of measured data, for each Load of the network, that is then checked for consistency and categorised. The Reference Year starts on March 1st, to include in the measurements the most recent winter, that is dimensioning in terms of network. Data is being extracted at hourly intervals.

The following consistency checks are then performed:

- Correction for n-1: when a node goes down on the grid, the load of this node is transferred to other nodes. When downtime nodal information is available, the load transferred to other nodes is reassigned to the node at the origin of the downtime.
- Abnormal consumption spikes are identified.
- The meter generation is considered on a case-by-by case basis, depending on the meters availability: if a separate meter is available for generation, it is taken into account if the main meter measures the net load; if no separate meter is available, but information about a production linked to the load is available, a generic profile is added to the measurement to compute a gross load.

Finally, Loads are categorized: the categorization unit for this exercise is called a Sector and can represent a single category of clients or a group of mixed clients. When a Load can potentially be assigned to different sub-sectors, the chosen sector is the one that contributes the most to the peak. For each sub-sector, a realistic representative profile is generated based on measurements of different loads of the same subsector. The choice of the Sector for a Load depends on the Sector that is the most representative for the peak contribution of this Load. The final outcome of this step is an hourly table, containing the Sector used for each, as represented in Table 2.

In the current Reference Injections & Offtakes, three Sectors are being considered: Industrial (subdivided into Tertiary, Chemicals; Engineering; Food - drink and tobacco ;Iron and steel, Non-ferrous metals; Non-metallic minerals, Paper – pulp; Textiles – leather, Data centres, CCS, Electrolysers, other industry), Residential and Rail Transport.

Peak per Load [MW]	2022-03-01 00:00:00	2022-03-01 01:00:00	...	Sector
ABCNO015LD1	8.2	9.2	...	Industrial
ABCNO015LD2	18.2	16.4	...	Residential
ABCST015LD1	27.3	27.4	...	Industrial
ABCST015LD2	23.5	21.3	...	Residential
ABCST015LD3	15.9	13.5	...	Residential
...	...	...	...	...

Table 2 Measured Consumption per Load and Sectorisation

For the next Revision of the Reference Injections & Offtakes, the revised sectors presented in Table 3 will be used. It should however be noted that the list is reviewed periodically, depending on the needs expressed through the macro-scenarios or the respective evolution of the different categories of load.

Sector Name
Chemical Industry (incl. Raffineries)
Siderurgy
Data Centers
Electrolysers
Other TSO-connected industries
Rail Transport
Distribution – Flanders
Distribution - Wallonia
Distribution - Brussels

Table 3 Revised Sectors List

3.1.1.2 Thermosensitivity

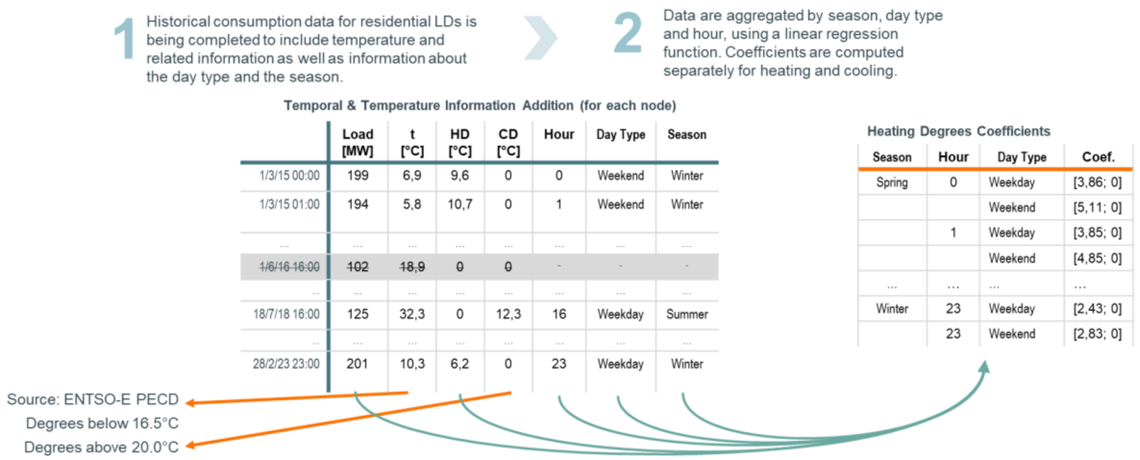
The thermosensitivity step aims to normalize the consumption attributable to temperature the Reference Year, as the impact of the temperature for this particular year may not be representative enough for the needs of grid development. For example: an exceptionally mild winter will underestimate the needs linked to heating during winter, the normalization will aim to increase the consumption used in the Reference Year. The base assumption for thermosensitivity is that heating or cooling is activated when a temperature is below or above a certain threshold (16.5°C for heating, 20°C for cooling). Metered data is then influenced by the temperatures that happened in the Reference Year.

Thermosensitivity is based on the concept of **heating-degree** and **cooling-degree**. Heating-degrees represent the number of degrees below the heating threshold value (defined as 16.5°C), a temperature of 12°C would then count for

4,5 heating-degrees (16,5°C-12°C = 4,5HD). Similarly, cooling-degrees represent the number of degrees above the cooling threshold temperature.

The process for the thermosensitivity correction consists of two steps:

- **Computation of the correction coefficients**: the correction coefficients represent the additional consumption if the temperature goes one extra degree beyond or below the threshold temperatures, to which temperature applies. These coefficients are computed for each node by performing a linear regression between the "Consumption" for the node and the matching heating/cooling degree. To refine this computation, a separate coefficient is defined for each combination of hour, day type (weekday/weekend) and season. This step is illustrated in Figure 18.
- **Application of the correction coefficients**: the presumed effect of temperature is removed, at Load level, from the metered data if the measured temperature is beyond the threshold temperatures, and if needed a new consumption is added so that the consumption matches the one that would have happened if the temperature were matching the temperature of the Normalizing Year, that is the representative year used for the Thermosensitivity step. This step is illustrated in Figure 19.



	Load [MW]	t [°C]	HD [°C]	CD [°C]	Hour	Day Type	Season
1/3/15 00:00	199	6,9	9,6	0	0	Weekend	Winter
1/3/15 01:00	194	5,8	10,7	0	1	Weekend	Winter
...	...	...	...	...	...	...	...
~~1/6/16 16:00~~	~~102~~	~~18,9~~	~~0~~	~~0~~	-	-	-
...	...	...	...	...	...	...	...
18/7/18 16:00	125	32,3	0	12,3	16	Weekday	Summer
...	...	...	...	...	...	...	...
28/2/23 23:00	201	10,3	6,2	0	23	Weekday	Winter

Season	Hour	Day Type	Coef.
Spring	0	Weekday	[3,86; 0]
		Weekend	[5,11; 0]
	1	Weekday	[3,85; 0]
		Weekend	[4,85; 0]
...	...	...	...
Winter	23	Weekday	[2,43; 0]
	23	Weekend	[2,83; 0]

Figure 18 Computation of the Heating or Cooling coefficient

1 For each node, heating-degrees (HD) are computed for the Reference Year, and the Normalizing Year (for temperature).

2 Temporal categorization information is added to the filtered table, in order to retrieve the additional consumptions coefficients.

3 The difference between HD for the Reference Year and the Normalizing Year, along with the matching coefficient are used to compare the difference in consumption

	Load [MW]	t [°C]	tnorm [°C]	HD [°C]	HDnorm [°C]	Hour	Day Type	Season	HDnorm-HD	Coefficient	Additional Load [MW]	Norm. Load [MW]
03/01/2023 00:00	199	6,9	8,2	9,6	8,3	0	Weekday	Winter	-1,3	2,43	-3,16	196
03/01/2023 01:00	194	6,4	7,9	10,1	8,6	1	Weekday	Winter	-1,5	2,43	-3,65	191
...	...	...	...	...	...	...	...	...	...	...	...	...
04/03/2023 18:00	102	18,9	15,4	0	1,1	18	Weekend	Spring	1,1	1,58	1,74	104
...	...	...	...	...	...	...	...	...	...	...	...	...
18/06/2023 20:00	125	16,8	18,4	0	0	16	Weekend	Summer	0	0,63	0	125
...	...	...	...	...	...	...	...	...	...	...	...	...
29/02/2024 23:00	201	10,3	8,6	6,2	7,9	23	Weekday	Winter	1,7	2,56	4,35	206

Figure 19 Temperature Normalisation of the Consumption of the Different Loads

3.1.1.3 Individual Growth Rates

Individual Growth Rates have been introduced to include in the process a possibility to correct temporary and exceptional changes in consumption. The known loads evolutions being an incremental process, an anomaly in the first year will be propagated in the next years if it is not adjusted. At local level, a plant can for example be closed for a few months for an overhaul. At international level, high electricity prices were also observed during the European Energy Crisis of 2022, which triggered a lower consumption.

The Individual Growth Rates are a factor, defined for each Load and for each hour of the year, that is used to scale the load. To apply an Individual Growth Rate, a series of condition must be met:

- The origin of the variation must be clearly identifiable and have a temporary and exceptional nature.
- There's a justifiable expectation that the consumption will recover, totally or partially, in the next year.

Because of their exceptional nature, IGRs are defined on case-by-case basis by expert view to reflect a plausible evolution of the consumption.

The process defines the IGRs at load level, but an identical rate can be applied to all Loads in the country, in an area or for a sector if the consumption has been similarly impacted by a larger scale event. For example, the *Figure* 20 illustrates the application of IGRs in the context of the European Energy Crisis of 2022: during the first half of 2022, the consumption was in the same order of magnitude than in the previous years. When the energy crisis hit, a significant decrease in consumption could be observed. IGRs have then been applied homothetically to the whole country to ensure that the consumption in the third and fourth quarters of the Reference Year 2022 were aligned on the consumption of the previous years.

Figure 20 Individual Growth Rates, the case of 2022

3.1.2 Planned Evolutions

Planned Evolutions is a bottom-up exercise, where Elia centralizes the collection of information from different stakeholders to anticipate, for each node of the network, the new loads, the evolutions of existing loads and the transfer of loads. Three different tracks are in place for the Planned Evolutions:

- **Direct Clients[3]** : Scenarized evolutions from direct clients about their injections, offtakes and storage, through the Load Management. Provided by the clients, challenged by the KAMs periodically.
- **Blackbooks** : peak power evolutions for the different connection points of distribution networks on a 7-year time horizon, and details CAPACs. Co-authored by Elia and the DSOs.
- **Local Growth Potentials** : plausible consumptions not yet covered by connection contracts.

Elia collects then the information from the different tracks is then centralized, under a form illustrated in Table 4.

TYPE	YEAR	POWER [MW]	COSΦ	SOURCE	DESTINATION	…
NewPower	2023	1,4	1	AZER015LD1		…
NewPower	2023	23,2	1	QSDF036LD1		…
ExpansionReduction	2023	-2,2	1	WXCV015LD2		…
Transfer	2023	50%	1	ERTY036LD1	RTYU026LD2	…

Table 4 Example of output of the Planned Evolutions

3.1.2.1 Direct Clients

The evolution of the future needs for Direct Clients comes from the Load Management Module of the EPIC Platform[4], an online portal made for Elia's customers to allow them to access metering data, invoicing, contacts,… Load Management is one of the modules of this platform and is meant to enter information about future evolutions of not only the variation in loads, but about storage and behind-the-meter generation. The platform also allows clients to enter different load scenarios with an associated probability, and each scenario can hold more granular information about the nature of the future loads (E-boilers, heat pumps,…). A screenshot of the platform is given for illustration in Figure 21.

[3] including the clients that have signed a connection agreement for a not yet realized connection.

[4] **https://www.elia.be/en/customers/customer-tools-and-extranet/epic**

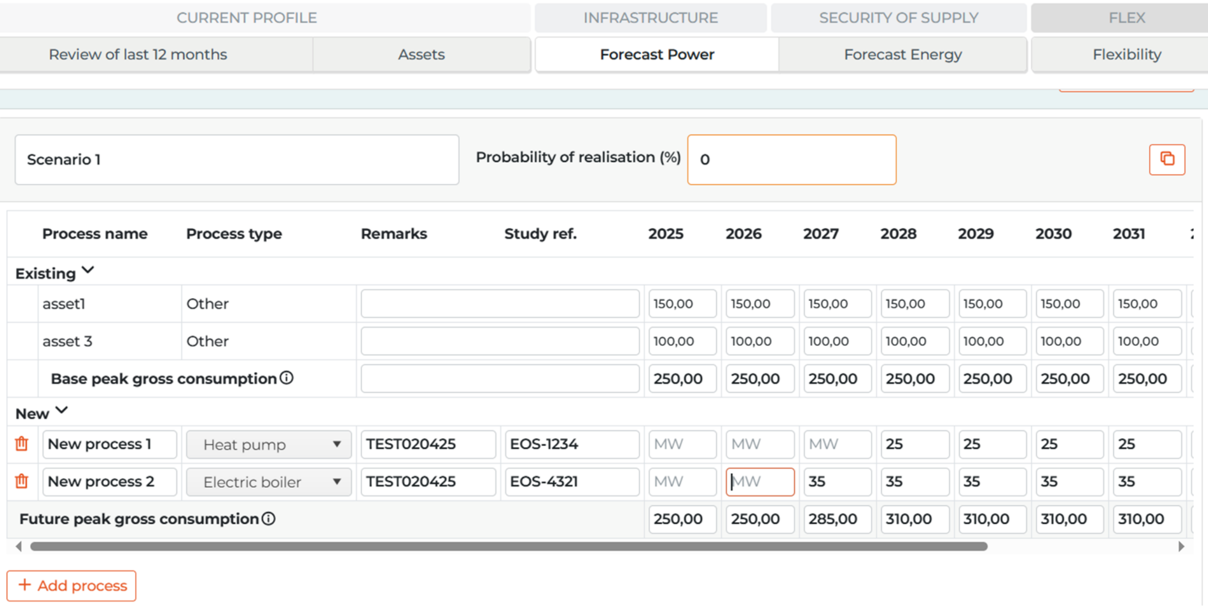


Figure 21 Forecast Power Load Management

The Client Scenarios from the Load Management are a fundamental input of the Macro-Scenarios. In this context, Elia reviews the different client scenarios for the elaboration of the Macro-Scenarios. As an illustration, the Clients Scenarios submitted in the framework of the last Macro-Scenario definition, were subsequently realigned into coherent Elia scenarios. For the largest customers (a few a responsible for largest part of the increase), this was carried out on an individual basis, as their impact on energy consumption and network dimensioning is significant. For the remaining smaller customers, starting from their scenarios, it was assumed that these would be experiencing similar circumstances as bigger customers from the same industrial sector, ensuring a consistent evolution at sectoral level.

The approach chosen for the local redistribution of the offtakes depends on the consumption of the customers: for the largest customers, the individual evolutions from the macro-scenario are considered directly and are associated with their connection points. The trends chosen for the sectoral level are applied to the connection point of the other customers, adjusted for their respective capacities.

It should also be noted that, in the Load Management, Clients have the possibility to go beyond their PPAD. In the context of Grid Development, any load forecast, after scenario realignment, beyond the PPAD is taken into account, and could be assimilated to a Local Growth Potential. Capacities in excess after realignement are then taken into account for grid development but are not reserved or allocated for the client at the origin of the additional capacity: this capacity will be reserved and then allocated after a standard EDS study, for the first customer of the same category that requests that capacity.

3.1.2.2 Blackbooks

Blackbooks describe the evolution of the peak power for each node of the Elia network that interfaces with distribution networks, as well the list of relevant connection requests at distribution level, and technical characteristics of the relevant substations, as illustrated in Table 5 Example of Information Contained in a Blackbook.

Blackbooks are cowritten by Elia and the DSOs. Elia prepares the Reference & Forecast Reports. They contain the proposed measured consumption peaks and Sn-1, as well as , the current relevant network information (transformers characteristics, new high-voltage lines,…) and the grid evolution previously provided by the DSOs.… These reports are submitted to the DSOs. Then, a meeting is organized with the representatives of the DSO and Elia (Customers &

Grid Development) to align on the consumption peaks, to discuss results, to address key points and collect their updated local forecasts and eventual corrections. At the end of these meetings, Elia prepares the final reports, that are sent to DSOs, regional regulators and Elia's Grid Development Plan.

Opal ID	Study	Description	LD Type	Cosφ	Power		
					2024	2025	...
MONNO015PP0		MONNOYER		1,00	37,00	37,00	...
		Sn-1			48,00	48,00	...
MONNO015LGLA							
MONNO015LD2		MONNOYER LOCALINDUSTRY	i	0,98	10,01	10,01	...
2026	Detail Study	Ripage de 100 % sur LocalIndustry					
MONNO15LD3		MONNOYER DSO	r	1,00	26,99	26,99	...
2025	Detail Study	Modification de 0,9 MW (Local Industry)					
2024	Detail Study	Modification de 1,6 MW (CPO)					

Table 5 Example of Information Contained in a Blackbook

3.1.2.3 Local Growth Potentials

Elements and assumptions to which we want to draw attention and especially welcome feedback on:

- What authoritative entities can provide information about local growth potentials, such as brownfields being developed, besides local development agencies (such as *Provinciale Ontwikkelingsmaatschappijen* in Flanders, *Agences de développement territoriales* in Wallonia) or regional investment companies (*Wallonie Entreprendre* and *Participatiemaatschappij Vlaanderen*)?

Local Growth Potentials are considered to be plausible consumption that are not yet covered by reserved or allocated capacities. Local Growth Potentials are created to include these plausible future loads into the definition of the needs, and to develop a portfolio of projects that could address these needs. For example, a Local Growth Potential could be created for a brownfield being developed, as the future users are not yet identified and cannot therefore request a connection. In concertation with the competent authorities, some capacity can already be considered in the grid development studies to accelerate the connection of the future clients that will purchase land in the considered brownfield. Another example would be industrial electrification of distribution-connected clients, where the materialization of the needs happens typically in short time horizons (max 5 years), while the duration required for a transmission project can exceed 10 years: the anticipation of these needs is assimilated to a Growth Potential. More generally, capacities announced in the Load Management but not covered by PPADs of existing clients could be assimilated to Local Growth Potentials.

3.1.3 Sectoral Growth Correction

The previous steps (construction of the Reference Year and Planned Evolutions) were based on a bottom-up approach, where information is compiled from the local level. In terms of consistency, there is then a possibility that the values obtained in these processes are different from the Macro-Values. As the network is designed to answer the needs defined in the Macro-Scenario, a correction may be carried out to ensure a good alignment between these two data sources. This correction is made at Sectoral level, by applying homothetically a correction factor to all loads of a same Sector, for each of the Future Years, as illustrated by Figure 22. The correction factor is the ratio between the sum of the energy requirements for the different Loads in the considered Sector and the corresponding Macro-Value (always expressed in terms of energy).

While the intention is to minimize this Sectoral Growth Correction, discrepancies may appear for reasons such as:

— **More recent data available**: because of timelines mismatch between the elaboration of the Macro-Scenarios and the computation of the Reference Injections and Offtakes, more recent data could be available from the Load Management. In this case, the most recent Load Management is used for the Local Redistribution, and the Sector Growth Correction ensures a good alignment with the Macro Targets.
— **Discrepancy between energy and capacity in scenario definitions**: Macro-scenarios are typically expressed in terms of energy, while Client Scenarios are based on expected peak capacity. A variation of the capacity factor over time may introduce a discrepancy between the bottom-up information and the Macro-Value.
— **Impact of flexible processes**: market-driven processes (such as e-boilers) also impact the relation between the requested peak power and the energy requirements.

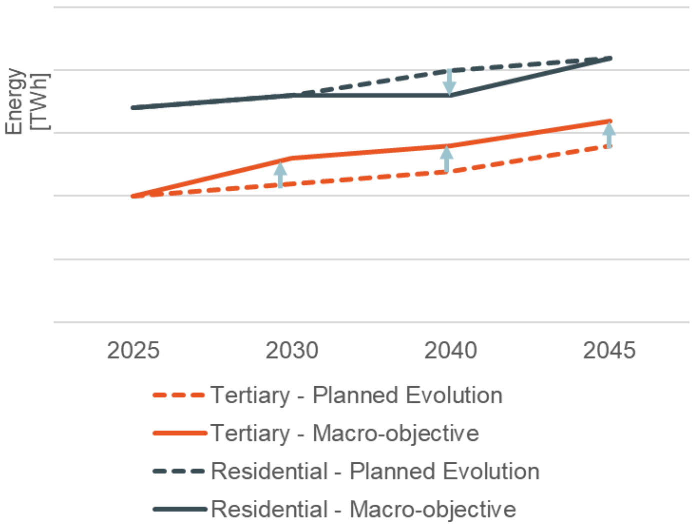


Figure 22 Application of Sectoral Growth Corrections

3.2 Electric Vehicles

The local redistribution for electric vehicles charging aims to produce a profile per substation of the load attributable to the electric vehicles that have been added between the Reference Year and the studied Target Year. The load attributable to electric vehicles in circulation in the Reference Year is indeed considered to be part of the existing load, and are not modelled in this process.

For the purpose of redistribution, a specific methodology has only been developed for personal vehicles and light duty vehicles, based on the movements between common locations, such as home, work and other points of interests. Based on these movements, locational profiles are being developed. The additional demand created for heavy duty vehicles (lorries, buses and coaches) is however foreseen in the macro-scenarios and is redistributed with the personal vehicles.

3.2.1 Personal Vehicles and Light Duty Utility Vehicles

Elements and assumptions to which we want to draw attention and especially welcome feedback on:

- Do you have specific reasons and/or sources which could justify a different redistribution of charging needs for personal vehicles and light duty vehicles (or confirm the proposed one)?
- Are there studies or governmental programmes, tender/concession specifications or private/public partnerships specifications that can inform better about the future local implementation of charging infrastructure (and more specifically about the location and installed capacities) along transportation infrastructure in Belgium, including on lands that are not owned by the entities in charge of the transportation infrastructure?
- Are there studies or governmental programmes, tender/concession specifications or private/public partnerships specifications that can inform better about the future local implementation of on-street charging infrastructure (and more specifically about the number of chargers and their installed capacities)?
- Are there studies that can inform the co-occurrences of electric vehicles chargers, photovoltaics, heat pumps, and small-scale batteries behind the meter?

Personal Vehicles and Light Duty Vehicles includes personal cars and vans. The overall process is based on a top-down approach, where vehicles are allocated to communes, where charging needs are defined (home, work and public). This allocation is based on statistics collected at communal level (type of housing, parking spots,…) and transportation statistics and surveys.

The process is summarised in Figure 23, and includes 3 steps. First, the data is being prepared for the EV Repartition Model, where energy needs and possibles locations are being defined. Secondly, an hourly repartition key is being defined using the EV repartition model, that aims to allocate a percentage of the macro-consumption to different substations. Finally, the redistribution key is applied to the hourly profiles that have been generated during the elaboration of the macro-scenarios. These profiles have been generated for each year, considering for a combination of different charging modes: natural charging, charging optimised locally or optimised according to market rules.

The repartition model is run for each target year, and considers the needs associated to all vehicles added in the previous target years and the vehicles added in the current target year.

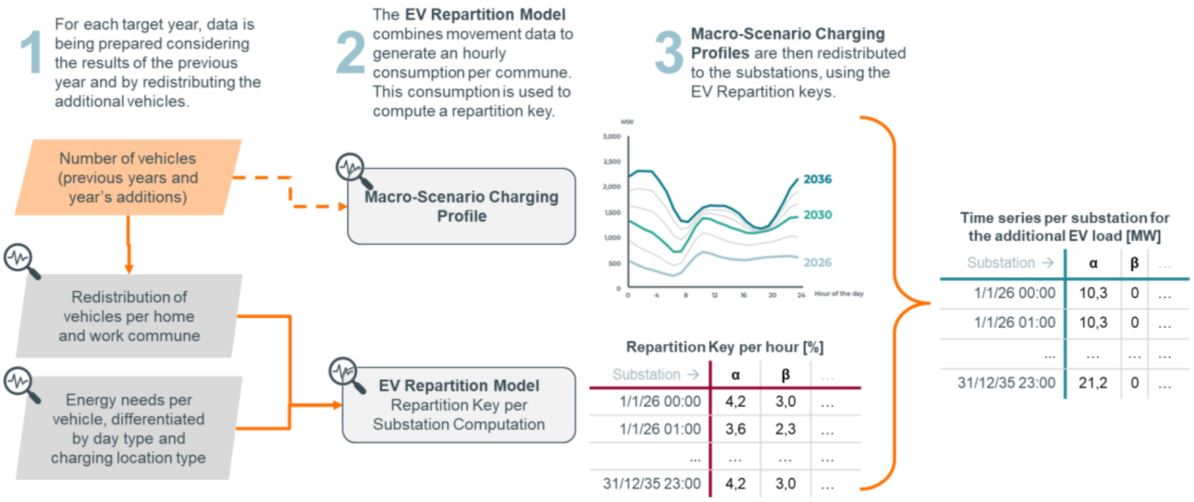


Figure 23 Overall Process for Personal and Light Duty Vehicles Charging

Processing Vehicle-related Data

The first step of the repartition is to compile the needs for the EV Repartition Model, and most importantly on one hand the redistribution of the additional vehicles per *home* and *work* commune and on the other hand the energy needs per vehicle and charging location.

The redistribution of the additional vehicles per *home* and *work* commune starts by assigning vehicles to *home* communes, from which the *work* communes are deducted. The **assignment to the *home* communes** is based on general statistics based on statistics on the *Number of Vehicles per Households*, that takes into account vehicle ownership and the attribution of a company car. The share of individual housing is used to compute a "EVs attraction score", assuming that residents of individual houses are more likely to have electric vehicles than residents in appartements. To **assign the *work* communes**, a redistribution key is built by combining *Home/Work Trip Matrix* and the *Modal Split*. The *Home/Work Trip Matrix* is the result a survey made by the Mobility FPS that lists the *work* communes associated to each *home* commune. The *Modal Split* is another survey from the Mobility FPS that lists the share of each mode (car, train, transit, foot) for each commune. The combination of these two datasets allows to infer the share of *home* vehicles that are used to commute, and to which communes they commute to.

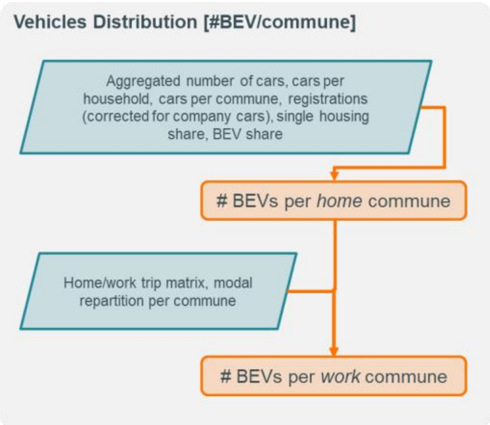


Figure 24 Vehicle Redistribution

The second input that is needed for the EV Repartition Model are the daily energy requirement per vehicle and per charging location (home, work or public). First, the **daily energy needs** per vehicle and per day are computed. The total energy need per vehicle derives from the average milage, from which commuting distances are removed. Commuting distances derive from the *Home/Work Trip Matrix* for the number of vehicles per commune and statistics over the *Average home/work Distance by commune* for the commuting distances. A mileage distribution between the types of days (weekday outside holidays, weekday during holidays, Saturday, Sunday/bank holidays), provided by the Mobility FPS, allows a more granular temporal distribution of the energy needs. The daily average needs are translated into a **daily total consumption per charging location** by considering different charging behaviours (mainly at home, mainly at work and mainly in public), influenced by indicators given at communal level such as the percentage of households with charger access, the percentage of workplaces with private parking and charging,…

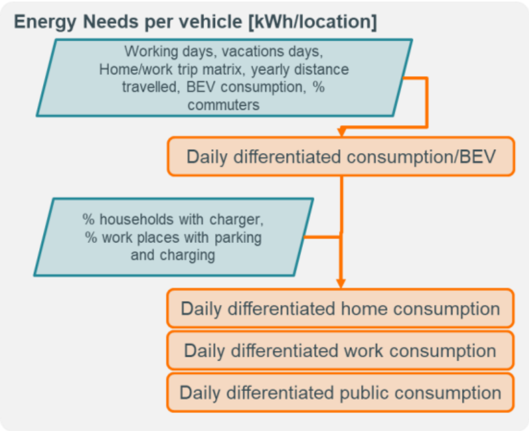


Figure 25 Energy Needs per Vehicles

Generation of hourly repartition keys, per Load

In the previous step, data about the location of the vehicles locations and their energy needs has been compiled, the second step is to process this data further in the EV Repartition Model to get time series that give the additional load per commune and per charging type, by simulating the movements of the different vehicles, and assigning a matching consumption when they arrive at a destination and the vehicle is connected to a charger.

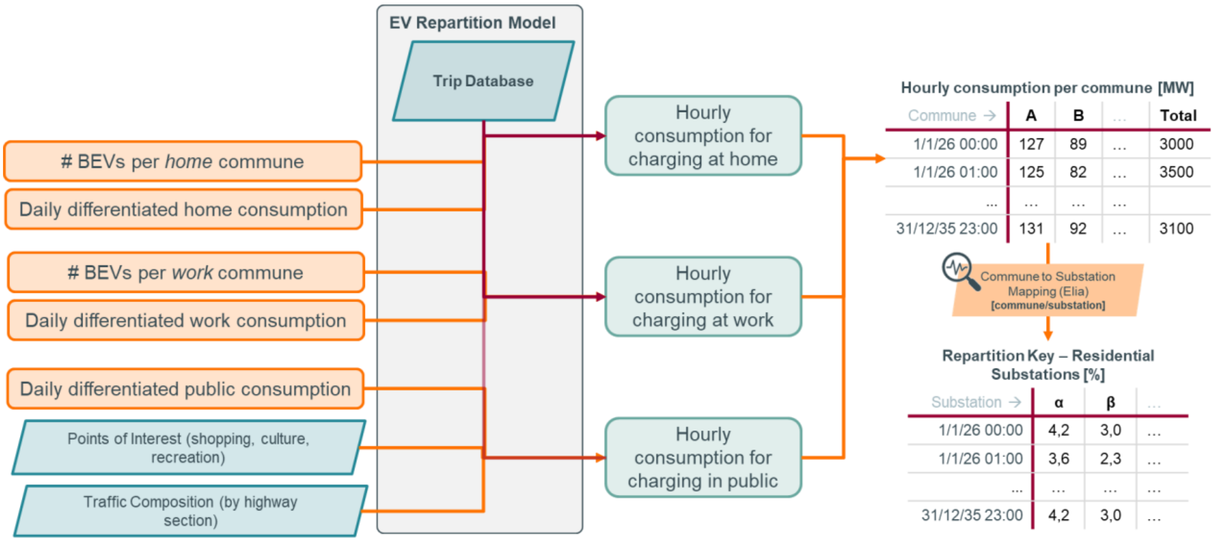


Figure 26 Generating Natural Charging Profiles per Commune

The starting point for this step is the Trip Database, that is a survey collected by the FPS Mobility in 2017. In the survey, it has been asked to the surveyed drivers to log for each trip taken the starting time, the arrival time, the starting point, and the destination point and the reason of the trip (commute, culture, shopping, recreation,…). The Trip Database is used to infer the habits of the drivers across communes, assuming consistent departure times and trip reasons, but using the home/work distributions from the different statistics to have representative distributions of the vehicles at national level. For example, when a home/work commute is being logged in the Trip Database, matching commutes will be created from starting from the different home communes to the matching work communes, and considering the modal split given per home commute to have a representative number of commutes per car.

For trips other than commutes, two data sources are being used. For charging at destination, Points of Interests from OpenStreetMap, are taken as source dataset: it is assumed that the vehicles will travel to the closest point of interest of the considered type. For *en-route* charging, along highways, usage statistics about traffic composition are being used to define additional consumptions linked to distance.

The combination of these different sources enables the generation of charging profiles for each Load. Assuming that vehicles are charged when they arrive at destination, the departure times, arrival times, starting communes, destinations and energy needs can be used to have a geographical and temporal distribution of the vehicles, from which charging profiles can be derived, for home, work and public chargers. To transpose these profiles to Loads, Elia uses a methodology such as described in the section "*6.1* Commune to Substation Mapping". For electric vehicles, the chosen Loads are the ones marked as residential. Finally, the hourly energy needs are transformed into regional repartition keys, where each Load represents a percentage of the total regional consumption for the hour.

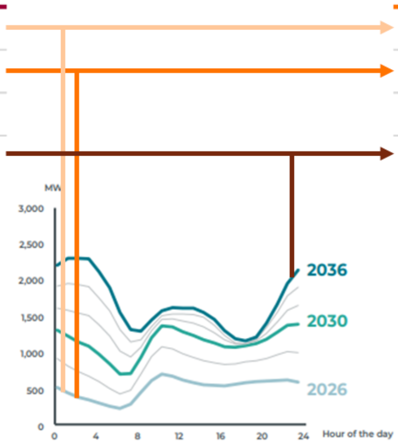
Market-based Optimisation Correction

The hourly energy needs charging infrastructure are defined in the macro-scenarios for each Target Year and for each region, and are redistributed using the repartition keys computed in the previous step for the matching year, as illustrated in Figure 27.

The generation of these hourly energy needs depends on the share of different charging modes (charging when plugging, smart charging, local tariffications rules,…), market signals and regional optimisations, which are part of the elaboration of the macro-scenario, and are shortly described in Box 2Box 2.

Repartition Key [%]

Commune →	A	B	…
1/1/26 00:00	4,2	3,0	…
1/1/26 01:00	3,6	2,3	…
…	…	…	…
31/12/35 23:00	4,2	3,0	…



Additional load [MW]

Commune →	A	B	…
1/1/26 00:00	21,2	14,8	…
1/1/26 01:00	17,1	11,2	…
…	…	…	…
31/12/35 23:00	93,0	65,3	…

Figure 27 Market-based Optimisation Correction (Personal Cars & LDV)

Elaboration of the charging profiles at Macro-Level

The macro-scenarios consider 5 charging modes, that are described in Table 6 and represented in Figure 28**Error! Reference source not found.**. The Natural Charging profile is generated by aggregating the results obtained by the EV Repartition Model at regional level. The construction of the other profiles is explained in the study from which the macro-scenario originates from. Depending on the Target Year, the number of additional vehicles and the share of each charging mode, an aggregated profile for all personal cars and light-duty vehicles is compiled. Such aggregated profile is represented in Figure 29.**Error! Reference source not found.**

MODE	RATIONALE	MODELLING
V0	Charges when plugging	Natural profile (predefined time-series)
V1**H**	Charging to minimize costs, depending on regional tariffs and/or maximize PV self-consumption	Locally optimized profile (pre-defined time-series)
V1**M**	Charging aligned to match market conditions	Market-based profile optimised on dynamic pricing
V2**H**	Charging and discharging to minimize costs, depending on re-gional tariffs and/or maximize PV self-consumption	Locally optimized profile (pre-defined time-series)
V2**M**	Charging and discharging aligned to match market conditions	Market-based profile optimised on dynamic pricing

Table 6 EV Charging Modes (Personal cars and LDV)

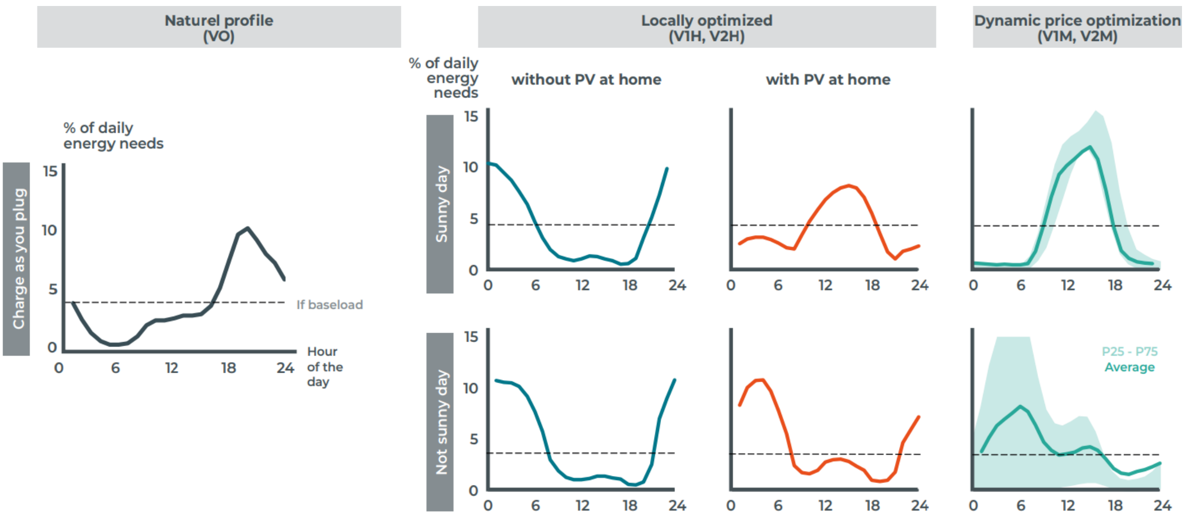


Figure 28 EV Charging Profiles for 2036 (Personal Cars and LDV), from AdeqFlex 25

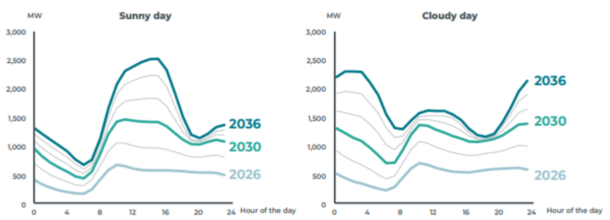


Figure 29 Aggregated EV Charging Profiles (Personal Cars and LDV), from AdeqFlex 25

More details can be found in the Appendix D of the AdeqFlex25 Study: **https://issuu.com/eliagroup/docs/adequacy_and_flexibility_study_for_belgium_2026-2**

Box 2 EV Charging Profiling at Macro Level

Key Data Used for EV Charging

The following section lists the different datasets that are used by EV Repartition Model.

- Trip Database : « Monitor Study Adults 2017 », FPS Mobility
- *Number of Vehicles per Households* : Statbel, https://statbel.fgov.be/en/themes/mobility/traffic/vehicles-household
- Modal Split by commune : *Enquete WWV 2017 - Modale verdeling per gemeente (werkplaats en woonplaats)*, FPS Mobility
- Average home/work Distance by commune 2011, FPS Mobility
- Mileage distribution: *Enquête Monitor 2019*, FPS Mobility
- Household type distribution: Building Stock 2024, Statbel
- Vehicle Registrations company and private car: *Statbel*

3.2.2 Heavy Duty Vehicles, Coaches and Buses

Elements and assumptions to which we want to draw attention and especially welcome feedback on:

- Are there studies or governmental programmes, tender/concession specifications or private/public partnerships specifications that can inform better about the future local implementation of charging infrastructure (and more specifically about the location and installed capacities) along transportation infrastructure in Belgium, including on lands that are not owned by the entities in charge of the highways?
- Are there studies that can inform better about the future local implementation (and related energy needs) of the logistical sector in Belgium – charging strategies, use-cases, preferred location for charging depending on the kind of use-cases, expected penetration by segment?

For the other categories of vehicles, the general assumption is the load attributable to these vehicles will materialize in the load management or connection requests will be made for new sites. The demand associated to these vehicles is considered at macro-level, and is currently redistributed using the model for personal vehicle. The methodology for the creation of a dedicated growth potential for heavy-duty vehicles is currently being prepared.

3.3 Heat Pumps

Elements and assumptions to which we want to draw attention and especially welcome feedback on:

Heat Pumps

- Do you have specific reasons and/or sources which could justify a different redistribution in heat pumps (or confirm the proposed one)?
- Can statistics be communicated about heat demand per commune in Wallonia and in Brussels?
- To improve the redistribution of energy needs in urban and rural communities, are there studies that can inform Elia about the temperature differences attributable to “urban heat islands” and more specifically on their impact on local energy consumption?

The local redistribution methodologies are applied for heat pumps that are expected to be added within the forecast horizon, existing heat pumps being considered part of the existing demand. The expected demand of these heat pumps is then redistributed among communes and then substations.

The hourly regional consumption of the additional heat pumps, for each Target Year, is an output of the macro-scenario. The general process for Local Redistribution, illustrated in Figure 30, is to split aggregated heat demand time series (one per region and per target year, with an hourly step) into a load between communes, using a region-specific repartition key. The different time series are then grouped into a consistent dataset, at national level, to which a commune to substation mapping is applied (see Commune to Substation Mapping). The choice of the repartition key depends on the data availability at regional level: currently, the repartition key is based on the heat demand[5] per commune in Flanders, and on Statbel's Building Stock[6] for Wallonia and Brussels. The profiles per commune are then mapped to residential Loads, using the methodology in the section "6.1 Commune to Substation Mapping".

Elia reviews periodically the data published by regional authorities to use the most appropriate source if new or updated data is published.

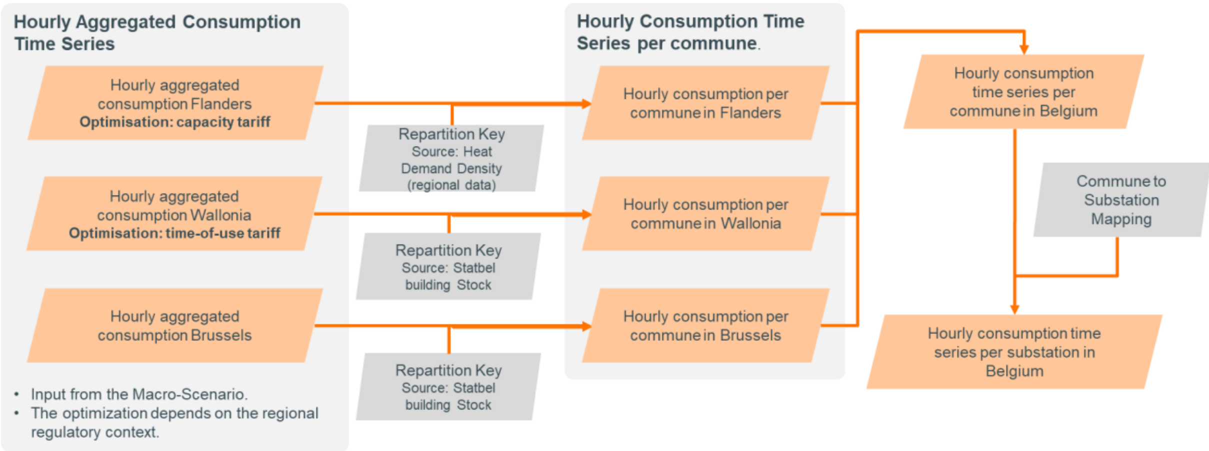


Figure 30 Redistribution Methodology for Additional Heat Pumps

3.4 New Categories

Considering the expected development of the electrical system, new Loads belonging to categories that are not formally defined yet are expected to materialize in the near future. The approach chosen by Elia to consider them in the Reference Injections and Offtakes depends on the nature of these Loads, and the anticipated requirements for the category:

— Loads that are communicated through the submission of an EDS are integrated into the Known Load Evolutions stream, and a new subcategory (and associated profile) may be created if the category contributes significantly to the peak. This approach has recently been adopted for data centres.

— Technologies or usages for which penetration targets are officially set are being assigned Local Growth Potentials and specific methodologies are being developed to anticipate the materialization of the needs, and to develop the network anticipatively. This approach has been recently chosen for Wind onshore, PV, electric vehicles and heat pumps for space and water heating.

It should also be noted that the categorization described in this section relates to the categorization for modelling or redistribution purposes, and not to the categorization that is used in Macro-Scenarios.

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[5] **https://www.vlaanderen.be/datavindplaats/catalogus/warmtekaart-2019-warmtevraagdichtheid-per-gemeente**

[6] **https://statbel.fgov.be/en/open-data/cadastral-statistics-building-stock-24**

The recent Macro-scenarios have however highlighted the development of new categories of loads, mainly data centers, carbon capture and electrolysis,…. Elia would like to make use of the present consultation to improve the understanding of these new categories, through the questions that are asked below.

Elements and assumptions to which we want to draw attention and especially welcome feedback on:

Data Centers

- In terms of land use, on what kind of ground affectations can data centers be built?
- Are there any geographical restrictions that would disqualify a terrain plot? (floodable area, proximity to certain land uses,...)
- Are there special infrastructure requirements for construction of the project? If yes, which ones?
- What factors would be enablers to the development of a data center project (physical proximity to clients)?
- What factors would discourage the development of data centers?
- How is the optical fiber network/market organised? Are there some analogies with gas or electricity networks, with “transmission” and “distribution” and what would be the relevant thresholds to go from one category or another?
- What are the typical lead times to develop the optical fiber network? It would be appreciated if the answer categorised by data center type, installed IT power, bandwidth requirements?
- Is there a map that exists and presents the optical fibre network, if possible in a GIS format?
- If using the land area as proxy to foresee the needs, what is the expected evolution of MW needed per ha to be foreseen? How the cooling technology influences these needs? Is there a difference between the data center types? (AI model training or collocation for example)
- How critical are the synergies with heat networks for the business case?

Carbon Capture

- In terms of land use, on what kind of ground affectations can carbon capture facilities be built?
- Are there any geographical restrictions that would disqualify a terrain plot? (floodable area, proximity to certain land uses,...)
- Are there special infrastructure requirements for construction of a project? If yes, which ones?
- Is the connection to a CO_2 capture network a necessity, and if yes, are there thresholds in terms of capture capacity that would require the connection to a CO_2 capture network?
- If using the land area as proxy to foresee the needs, what is the expected evolution of MW needed per ha to be foreseen?
- Are there studies that would allow to quantify the possible synergy between carbon capture and electrolysis, for the generation of green methane?

Electrolysers

- In terms of land use, on what kind of ground affectations can electrolysers be built?
- Are there any geographical restrictions that would disqualify a terrain plot? (floodable area, proximity to certain land uses,...)
- Are there special infrastructure requirements for construction of the project?

- What factors would be enablers to the development of an electrolyser project (physical proximity to clients or to the hydrogen/gas network)?
- What factors would discourage the installation of electrolysers?
- Are there studies that would quantify the potential of self-consumption of the produced hydrogen?
- If using the land area as proxy to foresee the needs, what is the expected evolution of MW needed per ha to be foreseen?
- Are there studies that would allow to quantify the possible synergy between carbon capture and electrolysis, for the generation of green methane?

4 Generation Redistribution Methodologies

The following section will detail how Static Data and Running Values are computed for the different generation technologies. Static data represents the key characteristics of the different units, and are used as input for the different models (dispatch model, grid model), while Running Values represent the expected hourly injections at the relevant objects of the Reference Context.

	Technologies part of this category	**Static Data – new units**	**Running Values - driver**	**Profiling**	**Growth Potential**
Decentralised RES	Wind onshore Solar photovoltaics	Growth potential redistributed per commune, represented as fictive units	Must-run based on climatic data.	PV: single profile Wind: single profile	Based on the technical potential
Conventional Units	Classical, CCGT, OCGT, Large CHP	Known characteristics	Economic Dispatch	Individual, as output of the market model	N/A
Small Generation Units	Diesel/Gas Motors, Incineration Station, Turbojet, DSO-connected Combined Heat Power, Fuel cell, Hydro – Run-of-River	Run-of-river: growth potential distributed on existing units Other technologies: redistribution based on known installations	Must-run based on historic data,, with the exception of turbojets, that are part of the economic dispatch	Aggregated per subdivision.	N/A (except for Run-of-River)
Wind offshore	Wind offshore	Known characteristics	Must-run based on climatic data.	Generic profile for offshore wind.	Based on targets agreed at Federal Level
Nuclear	Nuclear	Known characteristics	Economic Dispatch	Individual, as output of the market model	Based on targets agreed at Federal Level

Table 7 Comparison of the different generation technologies

4.1 Decentralised Renewable Energy Sources (Wind/Photovoltaics)

Elements and assumptions to which we want to draw attention and especially welcome feedback on:

All technologies:

- Do you have specific reasons and/or sources which could justify a different redistribution of installed onshore wind or PV capacity (or confirm the proposed one)?
- What is the technical potential for the repowering of PV and Wind onshore?
- What criteria is typically used by facilities owner (wind onshore and PV) to initiate the repowering of their installations?

At the time of writing of the present report, Decentralised Renewable Energy Sources are the only generation technologies that have a growth potential significantly larger than the installed, reserved and allocated capacities. The compilation of Static Data is then based on two flows: known projects are redistributed according to their known location, following a bottom-up approach, and the difference between the macro value and the known aggregated capacities, the Growth Potential, are redistributed proportionally to the technical potential of each commune, following a top-down approach. The technical potential is defined as the capacity that can potentially installed in a given area while fulfilling regulatory constraints, without considering economic profitability or permitting.

The estimation of the technical potential is based on geographical analysis and follows a three-step process:

1. Research of the positive areas where generation units can be installed;
2. Estimation of the number of reference generation units that can be installed in the positive area;
3. Aggregation of the reference units to provide a potential expressed in terms of capacity.

For wind onshore, the positive areas are the land that is free of legal restriction, and not already in the vicinity of existing wind turbines, and on the capacity is defined by counting the number of reference wind turbines that can be installed this land, by respecting an interdistance criteria between wind turbines (existing and/or potential). For solar photovoltaics, the positive areas are surfaces where solar panels can potentially be installed, and a reference solar panel requiring 1 square meter of ground/roof is considered.

It should be noted that wind onshore and photovoltaics use the same methodology because the technical potential, expressed in MW per commune, is considered an input for both technologies. As detailed further, the methodologies used to estimate this technical potential are technology-dependent and also take regional differences into consideration.

4.1.1 Technical Potential estimation

The Technical Potential for a technology is defined as the capacity that can be installed in a zone and/or the energy that can be produced in a zone, considering that all sites where the technology can be installed on all sites of the zone where it can be installed. The research of the technical potential follows 3-step process if the aim is to identify the Technical Capacity Potential or a 4-step process if the aim is to identify the Technical Energy Potential.

1. **Positive areas screening**: positive areas are zones where production units can be installed, the methodology to identify them depends on the region and the technology. For **wind onshore**, the positive areas are defined through a geographical analysis process, with the goal to identify zones where no or limited legal restriction apply. This process is carried out per region, considering the regional legal restrictions. For **solar photovoltaics**, the positive areas are the available roof surface per commune or the areas where utility-scale PV could potentially be installed (depending on the hypothesis that are taken in the selection process).
2. **Production units allocation**: once the positive areas are being identified, production units are allocated on the positive areas. In the simplest cases, the surface is taken as a direct proxy such as in PV, where a capacity per square meter can be assumed. Another option can be used to distribute algorithmically the units on positive areas, such as in wind where an algorithm can be used to maximize the number of wind turbines to install on the positive areas, while respected a minimal distance between the different units (potential wind turbines and/or existing wind turbines).
3. **Energy Yield Assessment (only for Technical Energy Potential)**: once the potential units are allocated, it is possible to estimate the expected energy yield, either by using a generic generation profile or by estimating the

BREGILAB: Balancing Belgium's Electricity Grid with Renewable Energy

The **BREGILAB** (Belgian Renewable Grid Injection Limit Algorithm and Battery deployment) study is a research initiative aimed at optimizing the integration of renewable energy sources—primarily wind and solar—into Belgium's electricity grid. Funded by the **FPS Economy's Energy Transition Fund**, the project is led by a consortium including **EnergyVille**, **VITO**, and **UHasselt**.

To gain insight into the possibilities regarding renewable energy in Belgium, the BREGILAB project investigated how the current availability of wind and sun is distributed across Belgium, and where and how much potential renewable wind and solar energy generation are additionally (technically) feasible. This was done with the help of the **Dynamic Energy Atlas (DEA),** which is used to map and analyze both the current and the potential electricity generation of wind and sun.

A key finding of the BREGILAB study is that Belgium has a **technical potential of 118 GW** from rooftop PV and onshore wind, capable of generating up to **132 TWh annually**—well above the current national electricity demand of ~80 TWh. However, only a fraction of this potential (6% for PV and 17% for wind) is needed to meet Belgium's 2030 renewable energy targets under the National Energy and Climate Plan (NECP).

A similar trend applies for 2050. As the data from the BREGILAB project were used as input for the PATHS 2050 platform – which tries to provide insight into how we can achieve climate neutrality in Belgium by 2050, based on various scenarios – we see that **90% of the calculated potential in wind and PV is included as part of the future energy system**.

Ultimately, BREGILAB provides a robust, data-driven foundation for policymakers and grid operators to plan a cost-effective and spatially optimized transition to a renewable-powered electricity system in Belgium.

Links

- BREGILAB - DEA Dashboard: **https://report.vito.be/t/DynamicEnergyAtlas/views/Bregilab/Belgium?%3Aembed=y&%3AisGuestRedirectFromVizportal=y**
- BREGILAB - Report: **https://energyville.be/wp-content/uploads/2022/12/BREGILAB_WP3_RESGeneration_Methodology_final.pdf**

Box 3 Bregilab Study

potential yield using technology specific processes. In this step, a correction factor is typically applied to take park losses into account (such as internal cabling, step-up transformers, inverters, wake losses,…).

4. **Aggregation per Commune**: the results at this stage are given per production unit. To have a Technical Potential per commune, an aggregation of the individual units is being performed.

The process that has been described above is generic, currently Elia uses the Technical Potentials per commune from the Bregilab study, described in Box 4. Since the publication of this study, the technical and regulatory evolutions require to review the Technical Potentials. For wind onshore, the most significant changes in Flanders being the introduction of a setback distance for inhabitations and in Wallonia the possibility to build wind farms in forest areas with low biodiversity and an explicit preference for repowering. For solar PV, a reanalysis needs to be performed to have an up-to-date view of the roofs where PV panels are already installed, as the installation of solar panels has accelerated since the compilation of the data of the study.

4.1.2 Static Data Compilation

The compilation of Static Data is a process composed of two flows, one to build a redistribution key that will be used to map a Growth Potential aggregated by commune to a Growth Potential by substation, and the second to estimate the growth potential per region. The outputs of these two flows are combined to obtain the growth potential that can be allocated to each relevant substation.

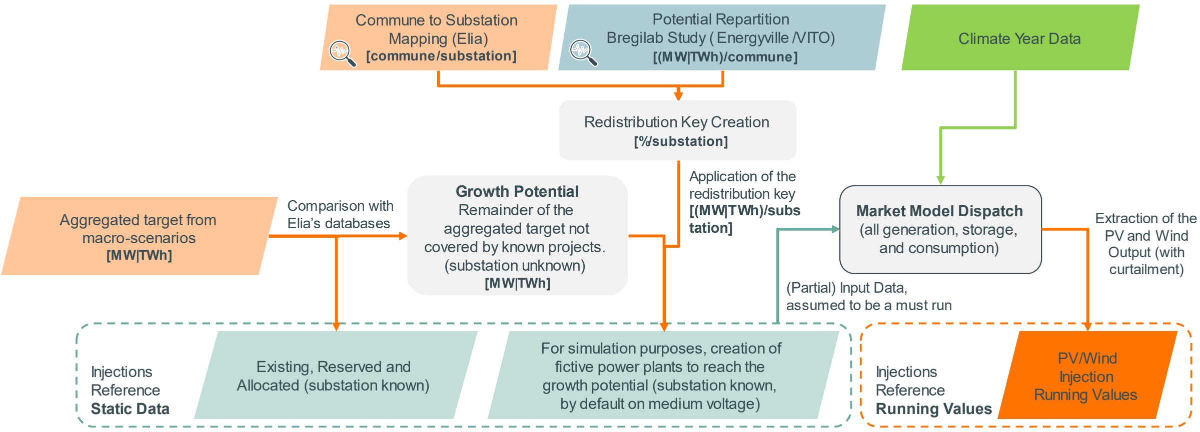

Figure 31 Redistribution Methodology for Decentralized Renewable Sources (Wind/Photovoltaics)

The first flow, illustrated in Figure 32, is used to define repartition keys (one per region), that will be used to redistribute the growth potential on the different substations. It requires **technical potential per commune** and a **mapping** to match a commune to the relevant substations, as described in the section Commune to Substation Mapping. The considered substations for Wind Onshore and PV are respectively at medium-voltage level and at the coupling points with distribution networks. The Commune to Substation Mapping is applied to the Technical Potential by commune (Step 2), to obtain a Technical Potential per substation, and a repartition key is built per region by dividing the Technical Potential per substation by the total of the region (Step 3).

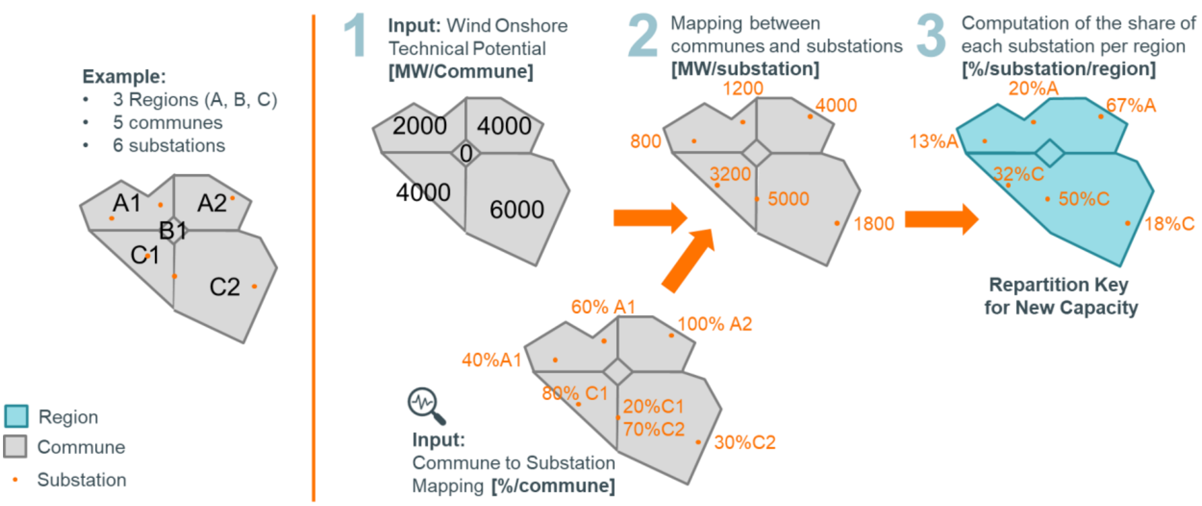

Figure 32 Creation of the repartition key for additional capacity

The second flow, to estimate the Growth Potential per region, requires the **aggregated installed capacity target**, that is defined in macro-scenarios, and a **snapshot of the Elia Database** for existing, reserved and allocated capacities for the considered region. The static data for known projects derives directly from the snapshot of the database. The

growth potential at regional level is defined as the difference between the aggregated installed capacity target and the sum of the existing, reserved and allocated capacities for the considered technologies (Step 2). The resulting value is an aggregated missing capacity, that will be redistributed on the regional territory with the repartition keys computed earlier (Step 3).

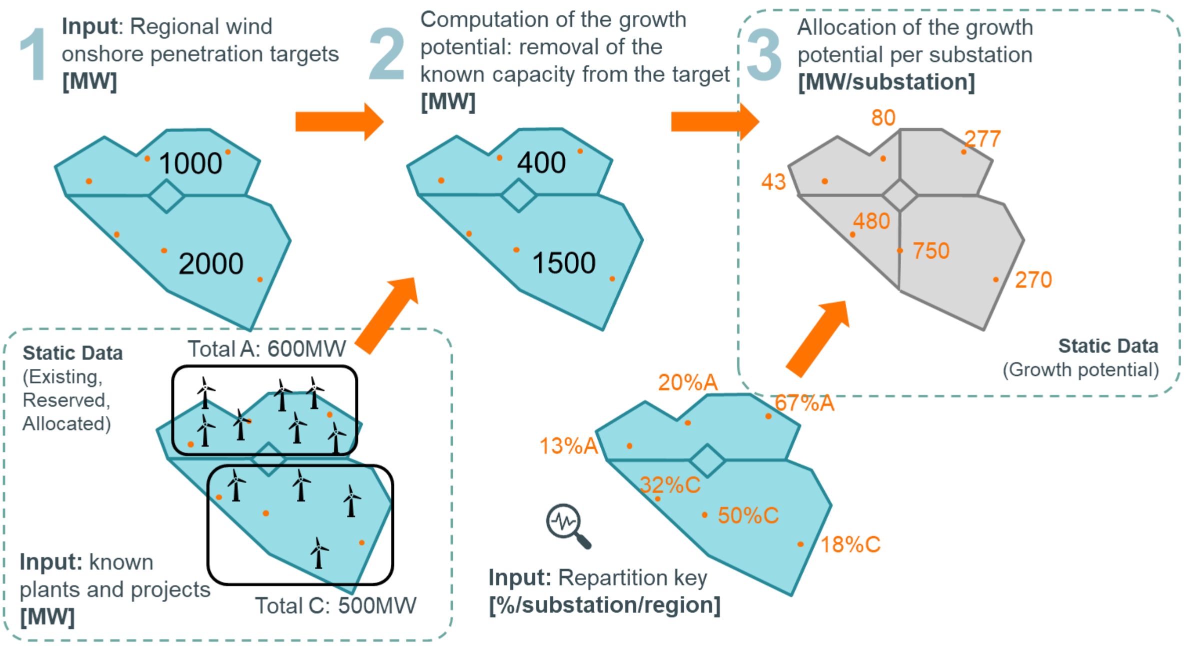

Figure 33 Creation of the repartition key for additional capacity

4.1.3 Running Values Estimation

Running Values for offshore wind are computed based on realistic specific profiles, and are assimilated to must-run units. The curtailment is computed in the economic dispatch simulation, and is removed from the generation in the flow-based grid simulations.

4.2 Conventional Units (OCGT, CCGT, TSO-connected CHP)

Elements and assumptions to which we want to draw attention and especially welcome feedback on:

All technologies:

- Do you have specific reasons and/or sources which could justify a different redistribution in conventional units (or confirm the proposed one)?

Technogies covered by this section: Classical, CCGT, OCGT, Large CHP

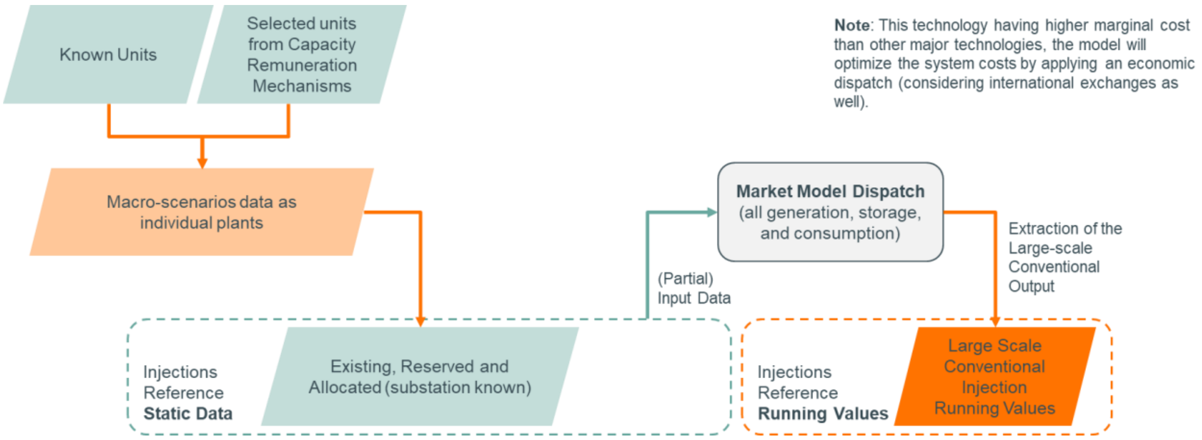

Figure 34 Redistribution Methodology for Large Conventional Units

4.2.1 Static Data Compilation

Static data in the case of conventional units derives directly from a snapshot of Elia Databases, considering the units that are selected in the macro-scenario for which redistribution is performed. Conventional units being modelled individually in the macro-scenarios, the Static Data is the bottom-up data being provided for the elaboration of the macro-scenario.

In the last macro-scenarios, all existing capacity are assumed to be available for the entire horizon, unless a closure has been officially announced (based on legal documents published by capacity holders, either article 4bis notifications[7] or data published through REMIT[8]). New capacity with a contract within the framework of the Capacity Remuneration Mechanism is considered for the macro-scenario and then for redistribution.

4.2.2 Running Values Estimation

Conventional units are modelled individually in the economic dispatch model. Being modelled individually with the own technical characteristics, the output of the economic dispatch model includes the hourly output of the different power plants, that is being used directly for the Running Values.

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[7] **https://economie.fgov.be/fr/themes/energie/securite-dapprovisionnement/electricite/mecanismes-de-capacite/mecanisme-de-remuneration-de**

[8] **https://umm.nordpoolgroup.com/**

4.3 Small Generation Units

Elements and assumptions to which we want to draw attention and especially welcome feedback on:

All technologies:

- Do you have specific reasons and/or sources which could justify a different redistribution of small generation units (or confirm the proposed one)?

Technogies covered by this section: Diesel/Gas Motors, Incineration Station, Turbojet, DSO-connected Combined Heat Power, Fuel cell, Hydro – Run-of-River

Small generation units is a catch-call category that consider all other technologies with a small installed capacity that connected directly to the transmission network. Despite the technological differences between the categories, the methodologies used to compile the Static Data and generate the Running Values are however generally consistent, with some exceptions that will be detailed in the present section.

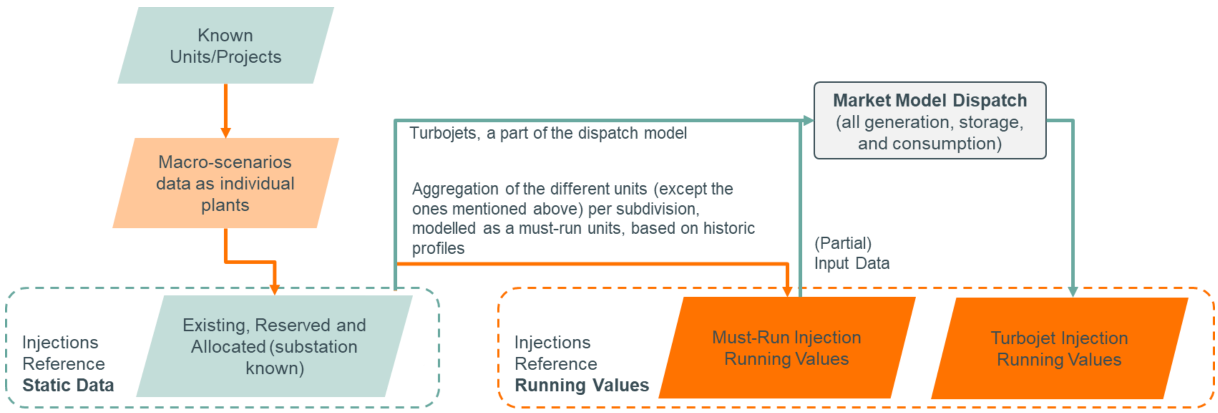

Figure 35 Redistribution Methodology for Small Generation Units

4.3.1 Static Data Compilation

Static Data for Small Generation Units is based on a snapshot of the known units, connected to both transmission and distribution network. For modelling, the units that are not modelled individually are aggregated by Subdivision.

Run-Of-River is the only technology for which a growth potential is considered. This growth potential being limited, the approach to redistributed is to assign a growth potential to each existing installation, proportionally to the installed capacity.

4.3.2 Running Values Estimation

By default, Small Generation Units are considered must-run, the Running Values are then built by using a yearly historical profile. For some of these units (CHP, waste), it is justified as electricity production is a by-product of the installation operation.

At the time of writing, the only exception for Small Generation Units are turbojets units, that participate to the market and are modelled individually: the Running Values are then the output of the market dispatch model.

4.4 Wind offshore

Unlike other technologies, the development of wind offshore farms in Belgium has been organised around tenders, where the Federal Government submits offshore lots with a grid access with a capacity and a connection point that has been defined before the start of the tendering procedure. The value for Growth Potential and the Connection Point are agreed with the Federal Authorities in the context of the Federal Development before the tendering procedure starts and is considered an input for this procedure. By contrast, for almost all other technologies, the developer applies for a connection and chooses the capacity and the location of the project.

4.4.1 Static Data Compilation

The integration of additional capacity wind offshore into the Reference Context starts before the beginning of the tendering process and before projects are known. A first phase aims at the approval a conceptual grid design in the Federal Development Plan. In another phase, detailed studies are performed to finalize the grid development process for the required capacity and sign a connection contract with the selected bidder.

The first phase is organised in 3 steps: agreement on the political intentions, conceptual grid design and Federal Development Plan. The agreement on the political ambitions is a combined process, where Elia follows the long-term ambitions of the authorities, through channels such as general policy statements, non-binding agreements with neighbouring countries, or National Energy & Climate Plans to the EU. These ambitions are then integrated into the macro-level scenarios that are discussed in the context of the Federal Development Plan, through a public consultation and direct dialogue with the Federal Authorities. These macro-scenarios are then used to inform a **conceptual grid design**, that will define the grid reinforcements that are needed to connect the proposed capacity and to distribute the generated energy across the transmission grid. An approval by the Federal Minister in charge of Energy, in the context of the Federal Development Plan formalizes the **need** for connecting offshore wind as well as the **grid connection point**. Once approved, the Reference Injections & Offtakes are updated to include a **Growth Potential for offshore wind** and the Reference Grid is updated to include the **proposed transmission projects**. In this phase, the location of the individual wind farms and their capacity is not known with precision.

The second phase starts with the formalisation of a wind offshore target in a Federal Law, and aims on one hand to conclude the detailed studies for the connection of this offshore capacity and on the other hand to sign a connection contract with the selected bidder. This phase is organised in three steps: detailed grid design, connection study and tendering process. The **detailed grid study** is elaborated to allow the connection of the offshore wind target that is set by law. This detailed grid design is then approved by ministerial decree. The Growth Potential and the Connection Points are updated to align with the approved grid design. A **generic EDS** is also delivered to the Federal Authorities, and will be used as input for the tendering process. The objective is to clarify the technical aspects of the future connection and make them public. Following this generic EDS, the Growth Potential is reduced by the Reserved Capacity defined in the generic EDS. In the last step, the **tendering process** is organised by the Federal Authorities to meet the target set by law. At the issue of this process, Elia signs a connection contract with the selected bidder, and the Reserved Capacity is transformed into an Allocated Capacity, and adjusted to match the terms of the contract.

4.4.2 Running Values Estimation

As for wind onshore, Running Values for offshore wind are computed based on a realistic specific profile, and are assimilated to must-run units. Curtailment is also computed in the economic dispatch simulation.

4.5 Nuclear

As wind offshore, nuclear development is coordinated at Federal level, Elia supporting the Federal Authorities to implement the proposed measures. In May 2025, the law requiring a phase-out of nuclear energy in 2025 has been abrogated. Beyond the lifetime extension of the existing reactors, the discussions about additional capacity for nuclear energy in Belgium is still at a very preliminary stage.

4.5.1 Static Data Compilation

Existing capacity is redistributed considering the location and characteristics of the power plants. Potential further lifetime extensions are under investigation by the Belgian Government. The impact of these extensions on the Reference Context is limited to operational schedule, as the location of the power plants is known.

New capacity has been announced by the government in the Federal Government agreement, but the practical implementation of this new capacity is yet at a very preliminary stage. A wide range of specific investigations is required as new nuclear sites are subject to several constraints, of which the transmission system is one. Elia at this stage doesn't have a formal view on the potential sites for additional capacity. As soon as candidate sites are known, Elia will support the exercise by performing all required grid studies.

4.5.2 Running Values Estimation

Running Values for nuclear are an output of the economic dispatch model, are individual reactors are part of the economic dispatch and are modelled individually.

5 Storage Redistribution Methodologies

5.1 Large Pumped Storage

Elements and assumptions to which we want to draw attention and especially welcome feedback on:

- Do you have specific reasons and/or sources which could justify a different redistribution of large pumped-storage (or confirm the proposed one)?

The redistribution of large-scale pumped storage derives from the assumptions used in the macro-scenarios. At the time of writing of the present report, only two installations have been considered in the recent macro-scenarios: Coo and Plate-Taille. A recent study[9] realised by ICEDD, ULiège and ULB (published in July 2024) on the potential for future hydro-storage shows a potential for up to 822 MW (3.836 MWh) for additional storage capacity, divided over 17 potential new hydro storage sites. In absence of concrete projects and giving the lead time to develop such capacities, no Growth Potential is currently foreseen in the Reference Context for this category, but their individual characteristics would be considered if future projects are expected to materialize.

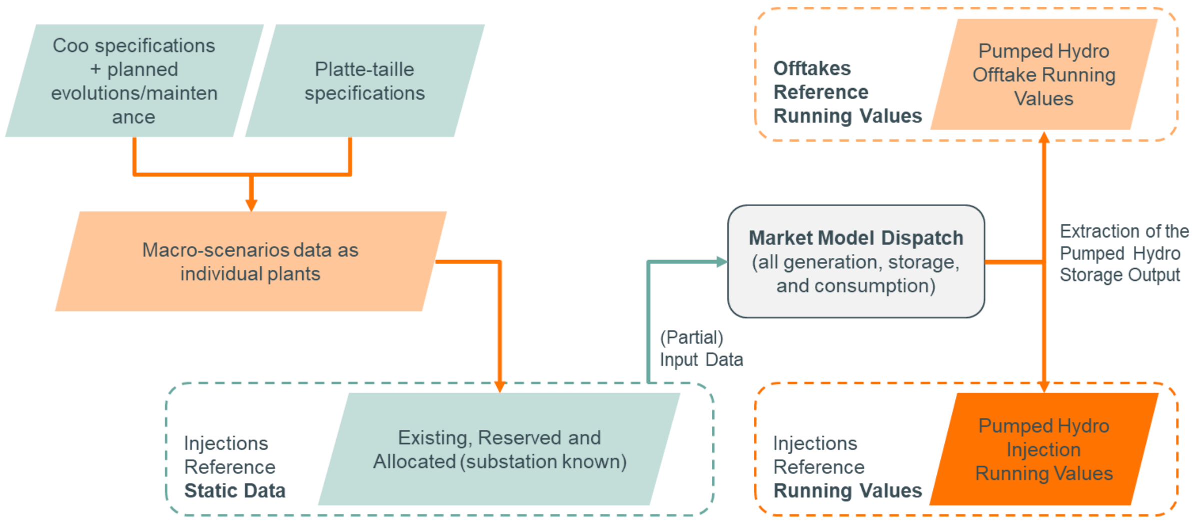

Figure 36 Redistribution Methodology for Pumped Storage

5.1.1 Static Data Compilation

Static Data for large-scale hydro directly is based on a snapshot of Elia Databases, considering the technical characteristics of the installations and the operation schedules published in REMIT.

5.1.2 Running Values Estimation

Running Values for large pumped storage, both for injections and offtakes, are an output of the economic dispatch model. Coo and Plate-Taille are assigned to their assigned Subdivision, and modelled individually. As large-scale batteries, it is important to note that pumped storage is optimized assuming a perfect foresight, meaning that their dispatch is to be seen as optimal from a system point of view in order to minimise the total system costs.

[9] https://ecosysteme-economiecirculaire.wallonie.be/publication/cartographie-du-potentiel-de-stockage-d-energie-par-pompageturbinage-en-region-wallonne/

5.2 Large-Scale Batteries

Elements and assumptions to which we want to draw attention and especially welcome feedback on:

- Do you have specific reasons and/or sources which could justify a different redistribution of batteries (or confirm the proposed one)?

Large scale batteries are defined as the battery systems connected to the transmission network.

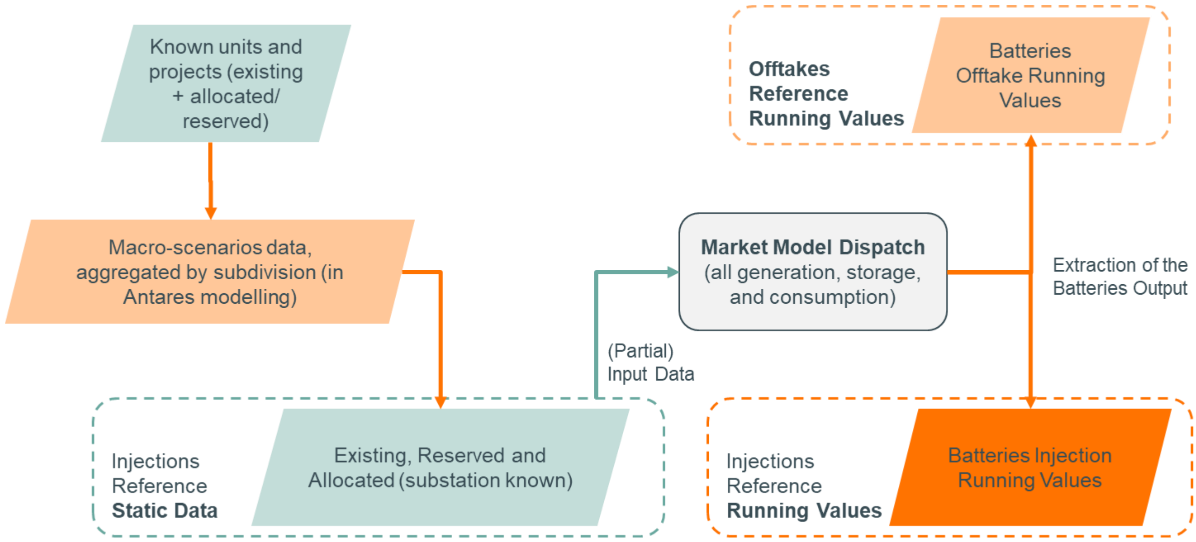

Figure 37 Redistribution Methodology for Large-Scale Batteries

5.2.1 Static Data Compilation

Static Data is based on a snapshot of the known units. For the purpose of computing Running Values, batteries are aggregated into one unit by Subdivision.

5.2.2 Running Values Estimation

Running Values for large-scale batteries, both for injections and offtakes, are an output of the economic dispatch model. With the assumptions for modelling, the economic dispatch model generates a single profile for the battery fleet.

5.3 Small-Scale Batteries

Elements and assumptions to which we want to draw attention and especially welcome feedback on:

- Do you have specific reasons and/or sources which could justify a different redistribution of small-scale batteries (or confirm the proposed one)?
- What local subsidies are in place for the installation of small behind the meter batteries, and what are their expected impact.
- Are there studies that can inform the co-occurrences of electric vehicles chargers, photovoltaics, heat-pumps, and small-scale batteries behind the meter?

Small-scale batteries are batteries connected to distribution networks. The local redistribution of small-scale batteries is assumed to follow PV installations, and follows therefore the methodology used for solar PV, where the regional targets are redistributed per commune and then aggregated per Subdivision.

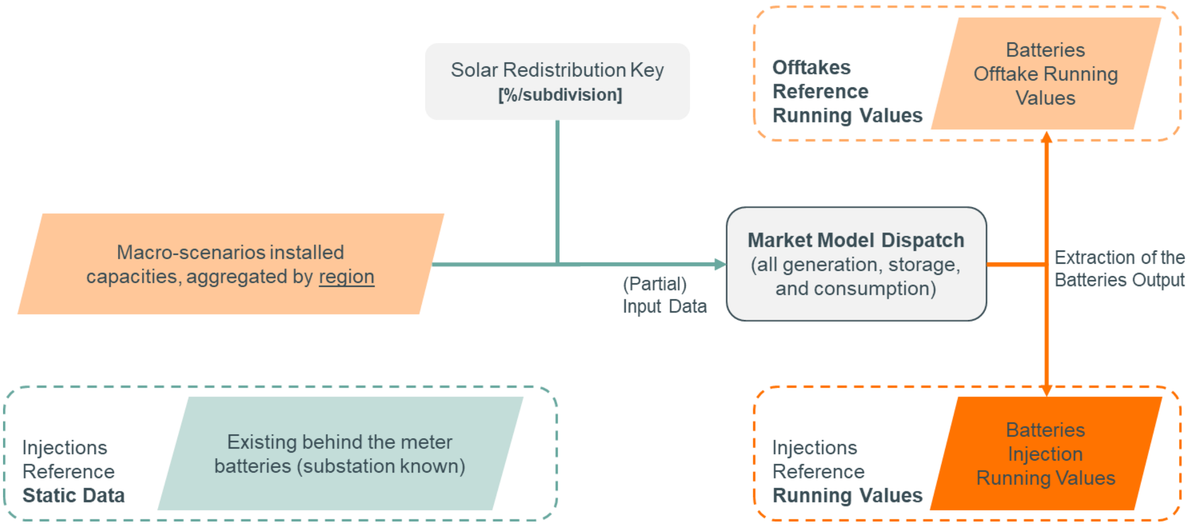

Figure 38 Redistribution Methodology for Small-Scale Batteries

5.3.1 Static Data Compilation

Unlike other storage technologies, no snapshot of Elia Database is used as input for economic dispatch model. Instead, a redistributed growth potential is being used in the economic dispatch model, using a reference battery defined in the macro-scenario.

5.3.2 Running Values Estimation

Running Values for small-scale batteries, both for injections and offtakes, are either an output of the economic dispatch model (for the part being considered “in-the-market” according to the macro-scenario), or a pre-defined time-series (following the methodology and assumptions discussed in the macro-scenario framework) .

6 Other Methodologies

6.1 Commune to Substation Mapping

The Commune to Substation Mapping is a methodology used to redistribute values allocated to points belonging to one dataset to another dataset, using the geographical proximity as main indicator to define the repartition key. In the context of LRIO, this methodology is typically being applied to redistribute values (population, RES Growth Potential,…) given at municipal level to the relevant substations or planning points. For the sake of clarity, the rest of the explanation will consider that the original dataset are communes, and the destination dataset are substations, but the methodology can be used between two datasets containing points. The initial choice of substations also depends on the values to be redistributed, for example, for wind onshore capacities, only substations at medium voltage are considered, while for solar photovoltaics, the chosen substations are the coupling points between the transmission and distribution networks.

The result of the Commune to Substation Mapping process is a two-dimensional array, that gives the share of the reference value that is allocated to each substation for each town. The value matching a commune and a substation represents the factor that is applied for a value given at communal level to have the matching value at substation level. For example, considering the example given in Table 8 and Figure 39, if the population is redistributed, the population assigned to the Substation 1 would be 100% of the populations of Commune B and C, while 54% of the population of Commune B would be assigned to Substation 2.

Repartition Key	Commune A	Commune B	Commune C
Substation 1	0	1	1
Substation 2	0,54	0	0
Substation 3	0,46	0	0

Table 8 Example of Commune to Substation Mapping

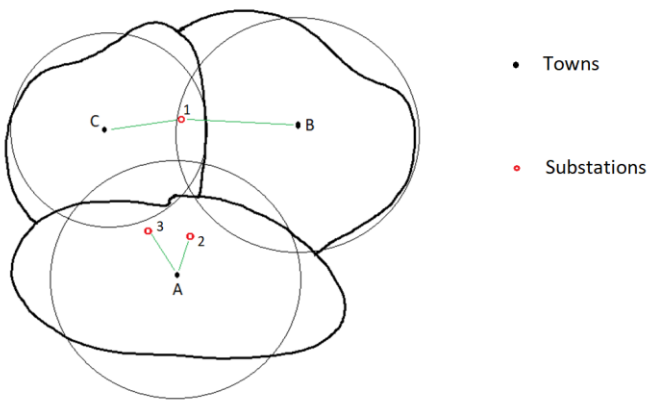

Figure 39 Redistribution Methodology for Small-Scale Batteries

The construction of this Commune to Substation Mapping is based on the following sequence:

1. **Computation of the distance between communes and substations**

The distance between communes and substations, expressed in kilometres, are computed using a formula that depends on the coordinate system. For coordinates expressed in decimal degrees, the following formula is being used, where *dist, lat* and *long* represent respectively the distance, the latitude and the longitude, and the *subs* and *com* indices represent respectively the substation and the centre of the commune:

$$dist = \cos^{-1}(\sin(lat_{subs}) * \sin(lat_{com}) + \cos(lat_{subs}) * \cos(lat_{com}) * \cos(long_{subs} - long_{com})) * 6371$$

The Table 9 shows distances that could have been computed in the example given in the previous section.

Distance [km]	Commune A	Commune B	Commune C
Substation 1	20	5	7
Substation 2	4	10	25
Substation 3	5	15	12

Table 9 Distance between substations and towns

2. Normalization of the different distances, by commune.

The next step of the process is the normalisation of the distance, where distances between a commune and substations are scaled to obtain a value, that falls within the range between 0 and 1, where 0 would be used for a substation located at the centre of the commune, and 1 represents the distance to the furthest substation. It is computed by dividing the distance between a substation and a commune by the distance between that commune and the furthest substation. For our example, the result of this computation is given in Table 10.

Normalised Distance	Commune A	Commune B	Commune C
Substation 1	1	0,33	0,28
Substation 2	0,2	0,66	1
Substation 3	0,25	1	0,48

Table 10 Normalised distance between substations and towns

3. Computation of the distance score

Then, the distance score is computed by using the following formula:

$$score = -\log(dist_{norm})$$

Using a logarithm gives a proportionally greater score to the nearest substations. The result of this computation for our example is given in Table 11.

Distance Score	Commune A	Commune B	Commune C
Substation 1	0	0,481	0,553
Substation 2	0,699	0,180	0
Substation 3	0,602	0	0,319

Table 11 Distance score between substations and towns

4. Selection of the nearest substations

To prevent that a value given at commune level is redistributed to all substations, a selection of the substation is made based on the geographical proximity or the location of the substation. For a given commune, a substation is kept if one of these three following conditions is met:

1. The score of the substation is higher than the *commune score* (see below).
2. The substation has the same NIS code than the commune.
3. The substation is the nearest to the town.

If none of the conditions for a substation and a commune are met, the associated score is set to 0.

The *commune score* is given in the formula below, it is computed by from the radius of a circle that has the area of the commune ($A_{commune}$), and by dividing it by the distance between the commune and the furthest substation of the commune ($dist_{furthest}$).

$$s = \sqrt{\frac{A_{commune}}{\pi}} \times \frac{1}{dist_{furthest}}$$

Table 12 illustrate this step in our example.

Normalized distance	Commune A	Commune B	Commune C
Substation 1	0	0,481	0,553
Substation 2	0,699	0	0
Substation 3	0,602	0	0
Total	1,301	0,481	0,553

Table 12 Final Distance Score for Each Substation

5. Normalization of the score

Finally, the selected Distance Scores are scaled, so that they can be used as repartition keys to redistribute a value allocated to one or several substations. It should be noted that a substation can potentially have a score for one or several communes. The scaling of each Distance Score is performed by commune, where each Distance Score is divided by the sum of the Distance Scores of each commune. The result of this final computation is given in Table 8.

The normalized score of each substation and commune combination is considered to be share of the commune that is allocated to each substation.

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