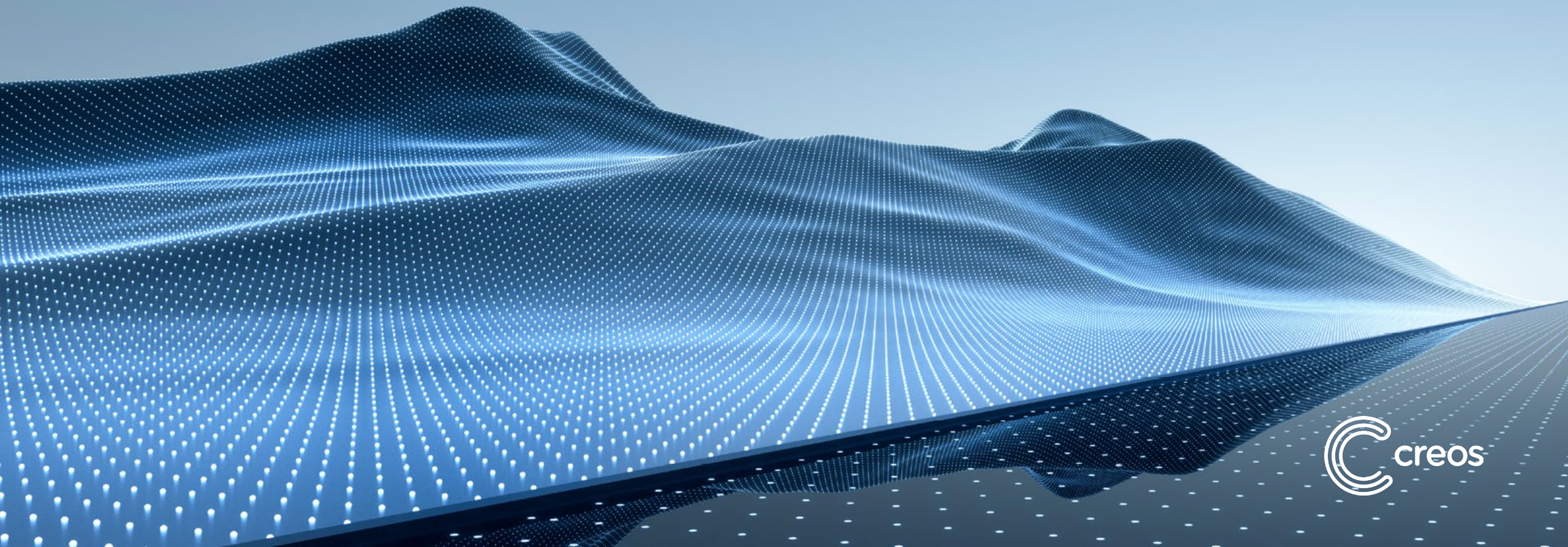
SCENARIO REPORT 2040 & NETWORK DEVELOPMENT PLANS

Caroline Schroeder

18/07/2025



By 2040, electricity demand in Luxembourg could rise by 60%, with local production set to more than double.

For Creos this is more significant than just more cables and substations—it's a whole new set of challenges.

The Network Development Plans, with the Scenario Report as their foundation, are designed to help us structure these challenges and guide us toward an electricity grid that is not only stronger—but smarter, more flexible, and more resilient.

From Policy to Planning – Structure of Today's Presentation

Regulatory and Strategic Context

1. Regulatory and Procedural Framework
2. National Energy and Climate Plan – the Basis for Scenario Development

Scenario Report Results

3. Historical Analysis
4. Projected Peak Load 2040
5. Projected Peak Generation 2040
6. Projected Peak Import 2040

Forward Steps

7. Elaboration of the Distribution Network Development Plan (DNDP)

1

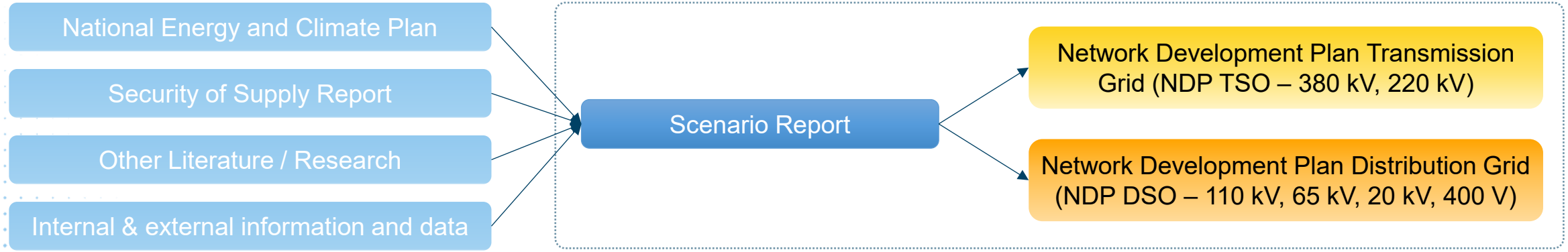
REGULATORY AND PROCEDURAL FRAMEWORK

creos

National Legal Requirements for Grid Development Planning

- Electricity grid operators are required to publish **ten-year Network Development Plans (NDP)** for their **transmission and distribution grids**. These plans provide information on planned investments and projects aimed at maintaining, reinforcing, and extending the grid.
- The network development plans should be based on estimates of future electricity consumption and generation loads, which constitute the **Scenario Report**. These estimates need to consider various scenarios, including demographic, economic and social developments, as well as national objectives and the measures set by the current government to achieve them.

Scenario-Based Planning Process



Documents must be elaborated and submitted to the national regulation authority and the responsible ministry for review and possible modification every two years

Timeline Scenario Report & Network Development Plans

2023 | 2024 | 2025

March | April | June | December | February | May | 27 June – 31 July | Q3 2025

Publication & Public Consultation
Scenario Report 2040
Version 2023

Publication & Public Consultation
Network Development Plan
Transmission Grid 2024 – 2034

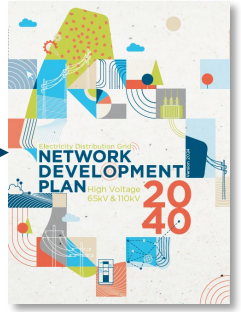
Preparations for the
Scenario Report 2040
Version 2024

Start of Publication & Public Consultation procedure
Scenario Report 2040 *Version 2024*

Start of preparations for the
DNDP 2025 – 2035

Public Consultation

– GOAL –
First draft of
Distribution Network Development Plan 2025 - 2035



2 NATIONAL ENERGY AND CLIMATE PLAN (NECP)

creos

NECP – the Basis for Scenario Development

The 2024 Scenario Report is based on the **National Energy and Climate Plan (NECP)** published in July 2024.

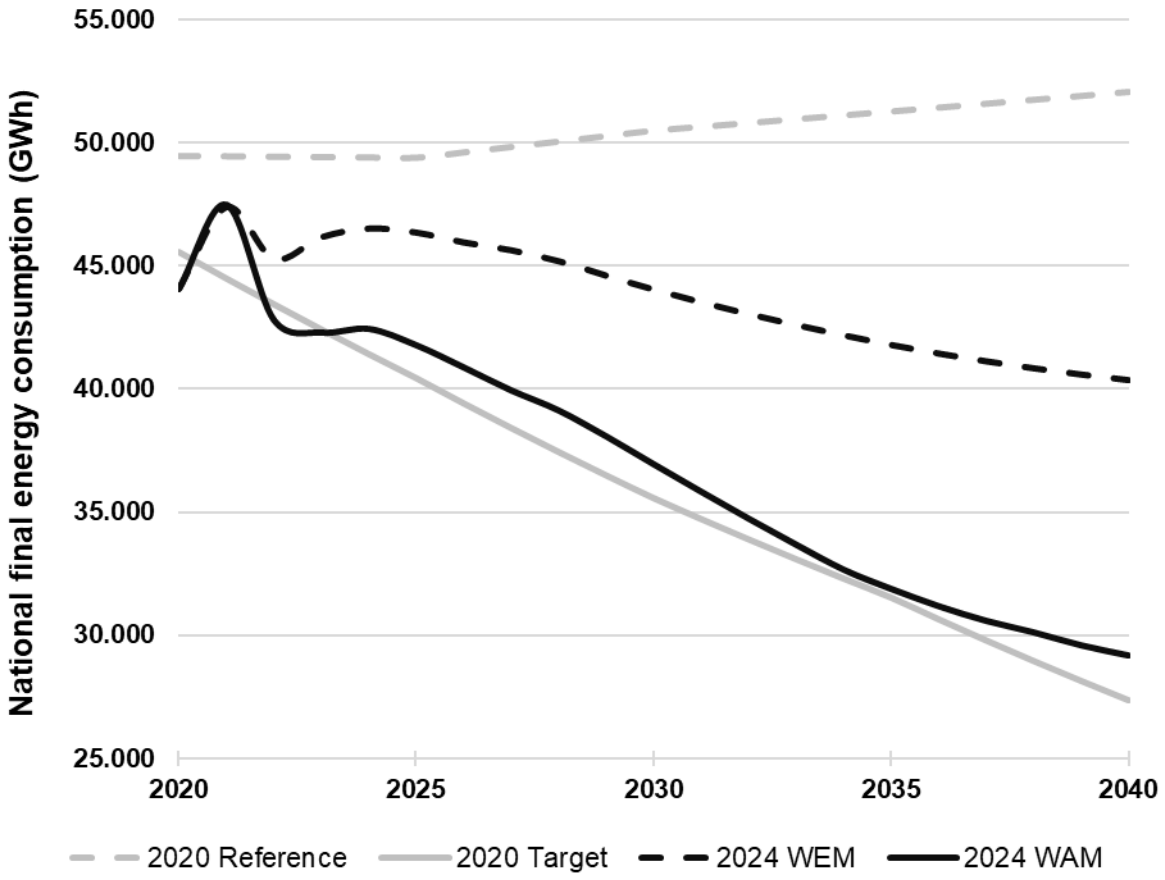
The NECP provides forecasts for the energy consumption in different sectors for two different scenarios:

- **WEM** (with existing measures)
- **WAM** (with additional measures)

Creos translates these forecasts into future **power requirements until 2040.**

To support this, STATEC provided detailed annual projections for both scenarios, covering various sectors and technologies. These were complemented by additional research and literature reviews to refine the underlying assumptions.

Final Energy Demand Outlook: Comparing Old and New Scenarios



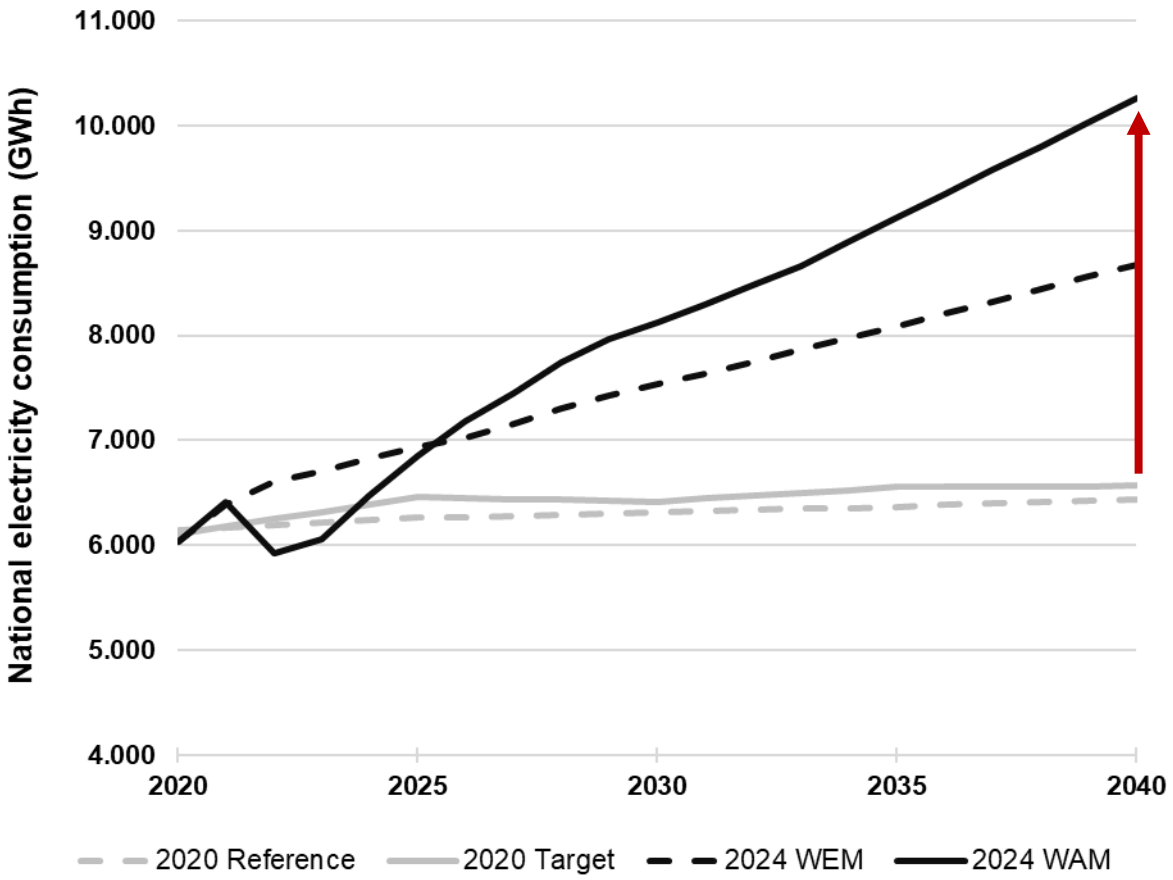
The **2020 NECP** included two scenarios: a **Reference** and a **Target** pathway.

In the **2024 update**, these have been replaced by the **WEM** (*With Existing Measures*) and **WAM** (*With Additional Measures*) scenarios.

Both the 2024 **Target** and **WAM** scenarios anticipate a comparable and steady decline in final energy consumption across all carriers.

In contrast, the **WEM** scenario projects a less ambitious trajectory—yet still more pronounced than the original 2020 **Reference**.

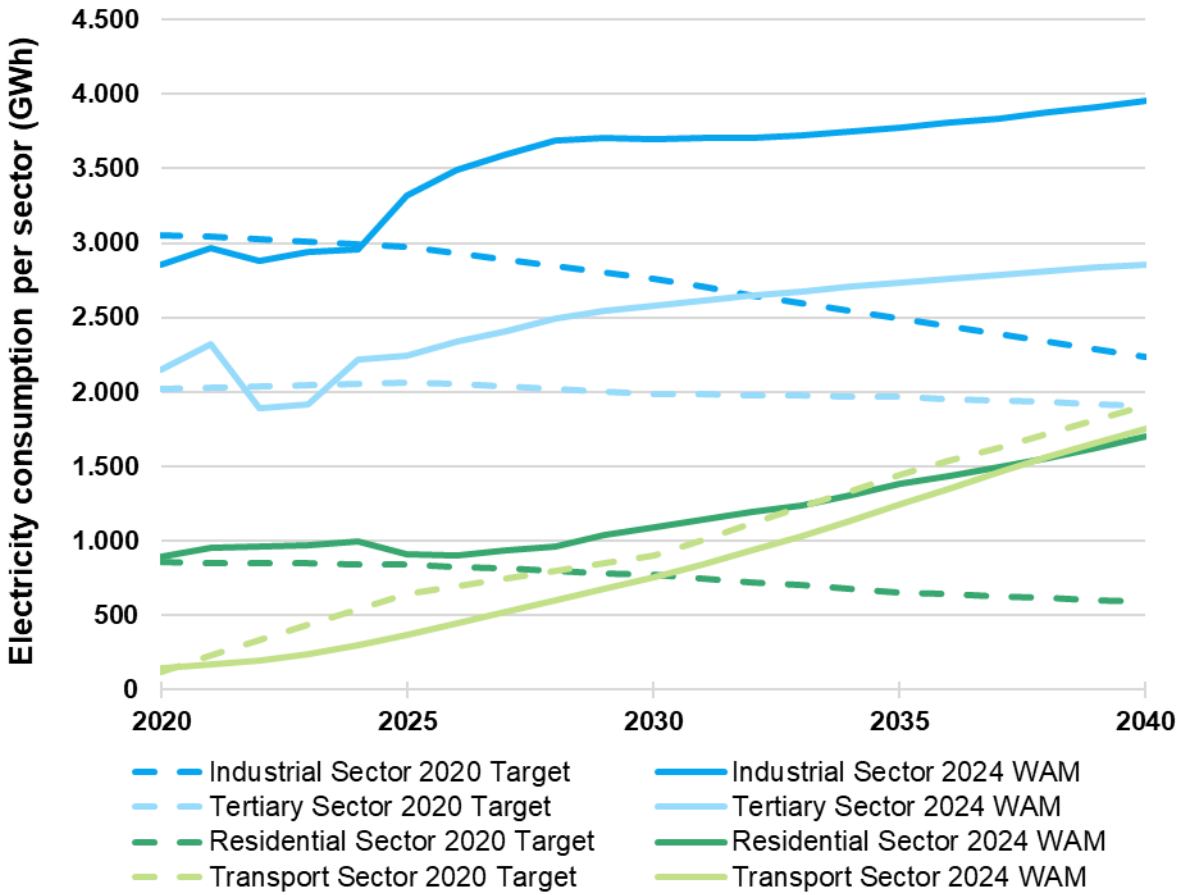
Updated NECP Projects Sharp Rise in Electricity Demand by 2040



While the **2020 NECP** projected electricity consumption to remain relatively **stable** in both its **Reference** and **Target** scenarios, the **2024 update** anticipates a **significant increase** under both **WEM** and **WAM** pathways.

This reflects accelerating electrification across sectors such as mobility, heating, and industry.

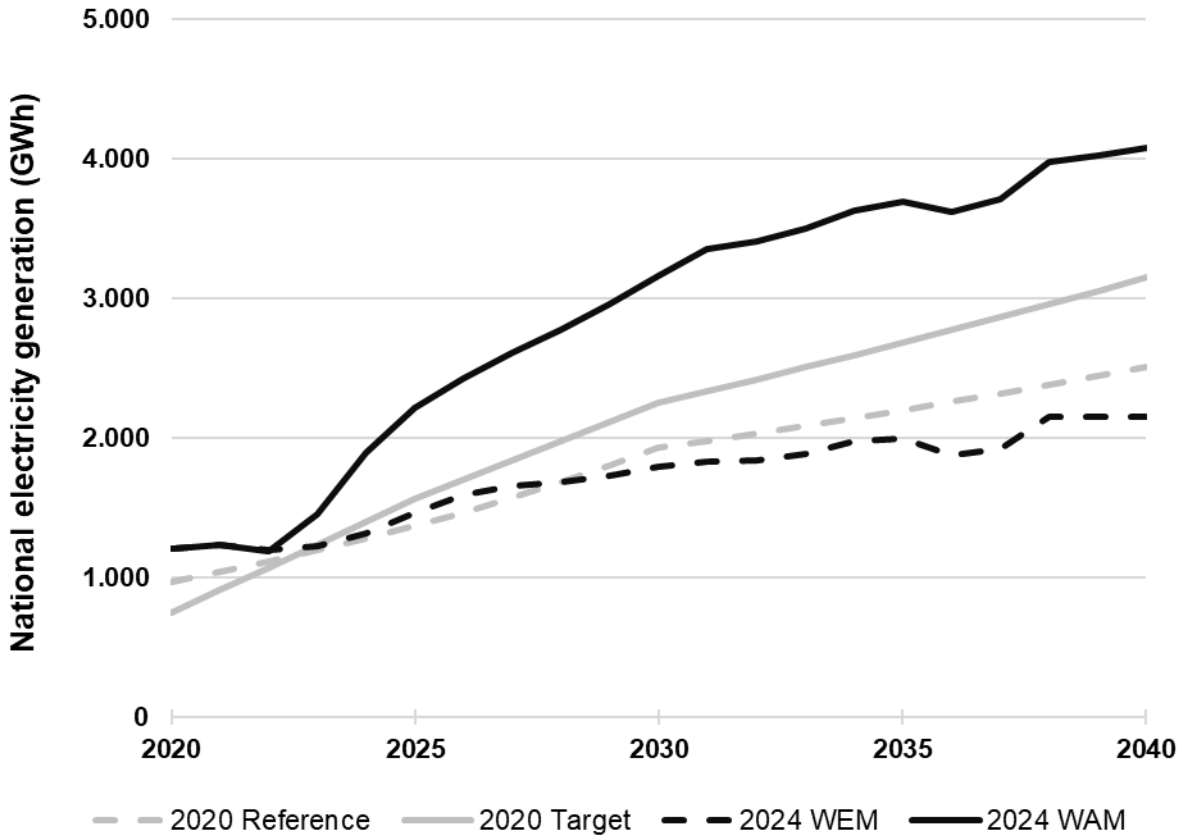
Electricity Demand Set to Rise in All Sectors



Contrary to the **Target** scenarios of the **2020 NECP**, **electricity consumption** is now **projected to increase significantly across all sectors** until 2040, according to the updated **2024 NECP**.

The **transport sector** is the only area where the updated trend remains **consistent** with the previous version.

2024 NECP Confirms Long-Term Growth in Local Generation



Compared to the updated consumption outlook, trends in national electricity generation remain **largely consistent** between the 2020 and 2024 NECP versions.

The **WAM** scenario reflects **more ambitious renewable deployment**, while **WEM** and earlier targets show more **gradual growth**.

However, in all cases, **the increase in electricity demand clearly outpaces local production growth** — underlining the importance of grid integration and cross-border capacities.

3

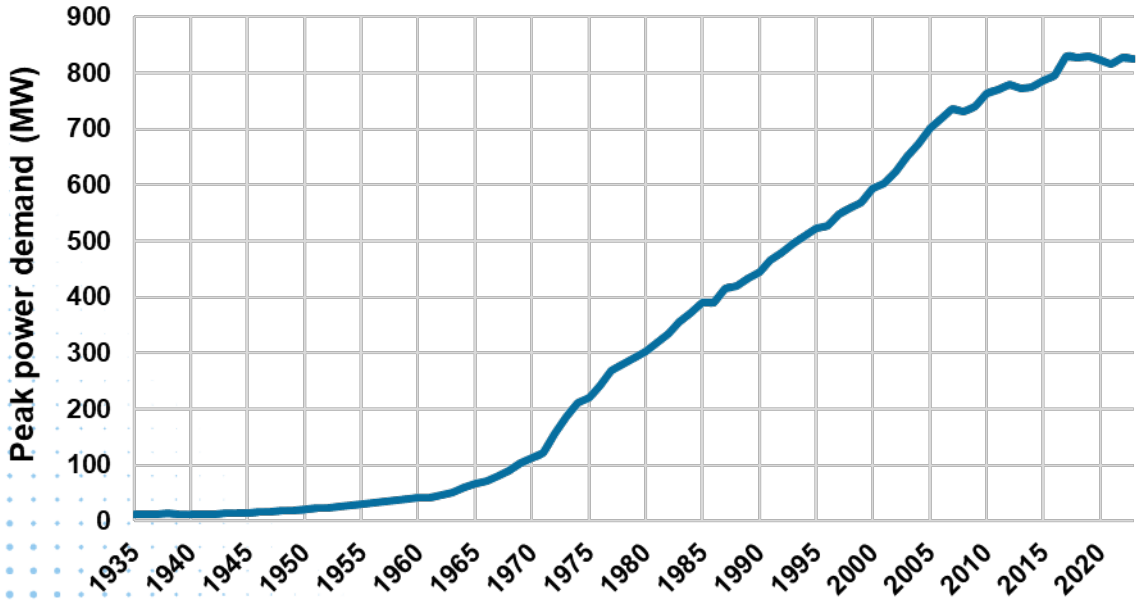
HISTORICAL ANALYSIS

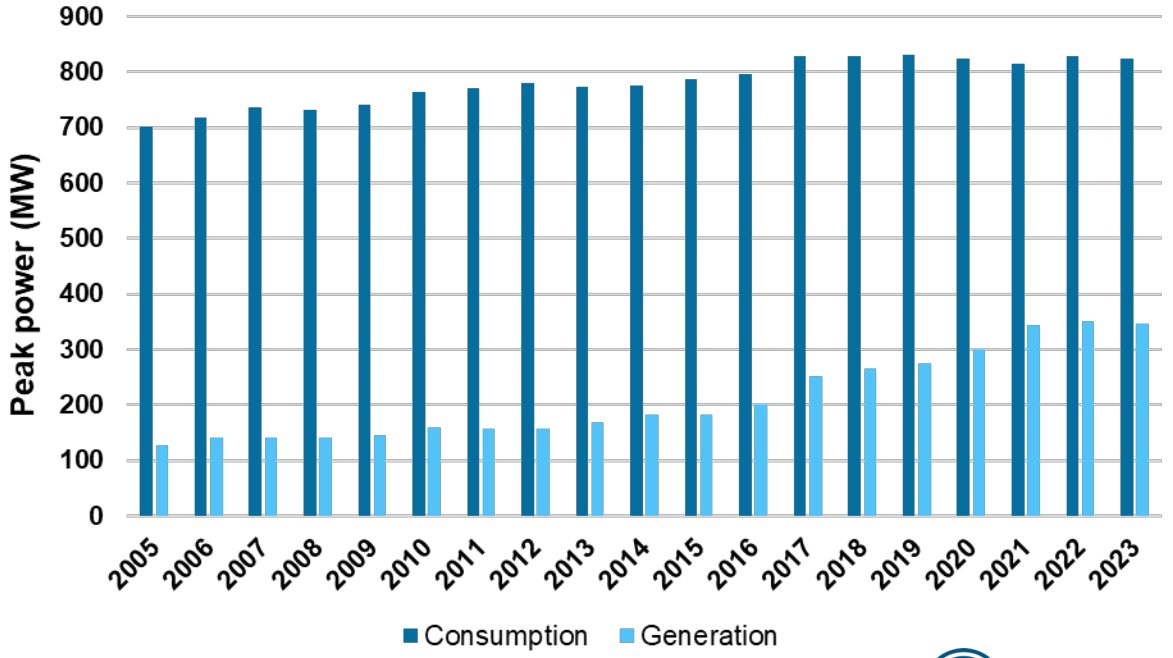
creos

Peak Demand and Generation Loads on the Creos Grid

In **2023**, the **peak load** on the Creos grid reached **824 MW**, while local **peak generation** only reached **345 MW**.

Peak consumption and peak generation are **not aligned**, and that Luxembourg relies on significant imports during critical demand periods.

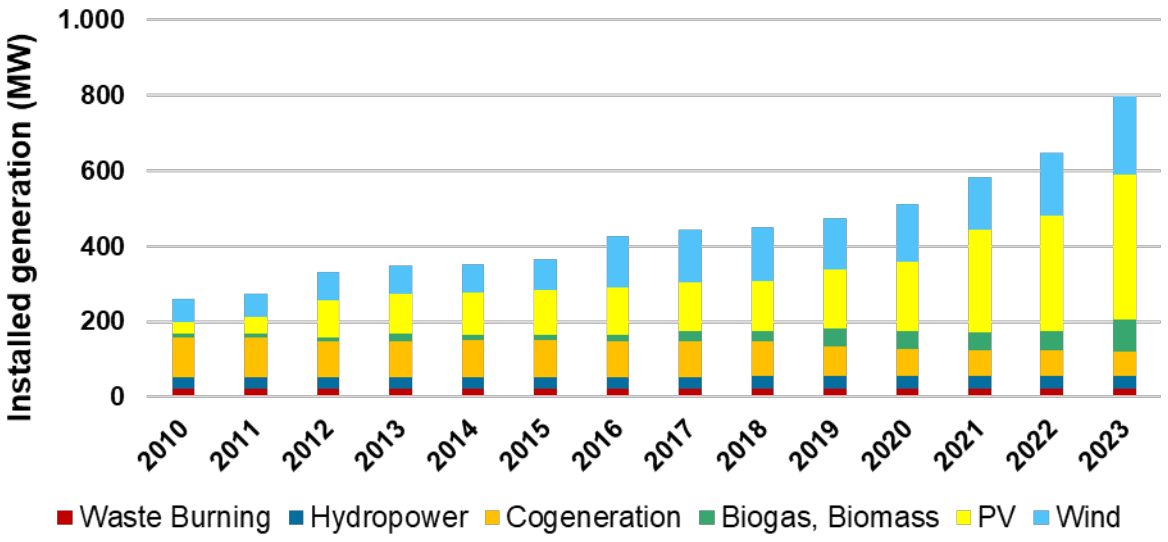


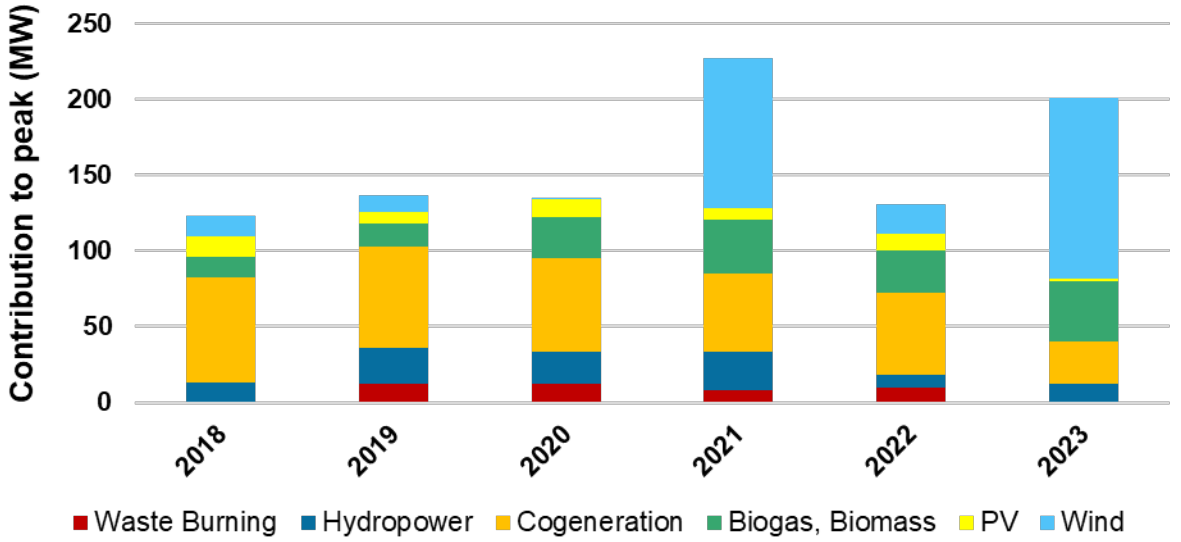


Installed Capacity vs. Peak Contribution: A Growing Gap

Installed capacity rose from 250 MW in 2010 to **800 MW in 2023** (946 MW in 2024), but its **contribution to peak load is not guaranteed**.

Photovoltaic output is **limited** during winter peaks, and **wind generation** is **highly variable** – from near zero in 2020 to strong peaks in 2021 and 2023. Gas-based **cogeneration** is **declining**, while **biomass and biogas** are **growing** with added capacity. The contributions from **hydropower and waste burning** remain **minor**, with maintenance having a major impact due to the few installations.



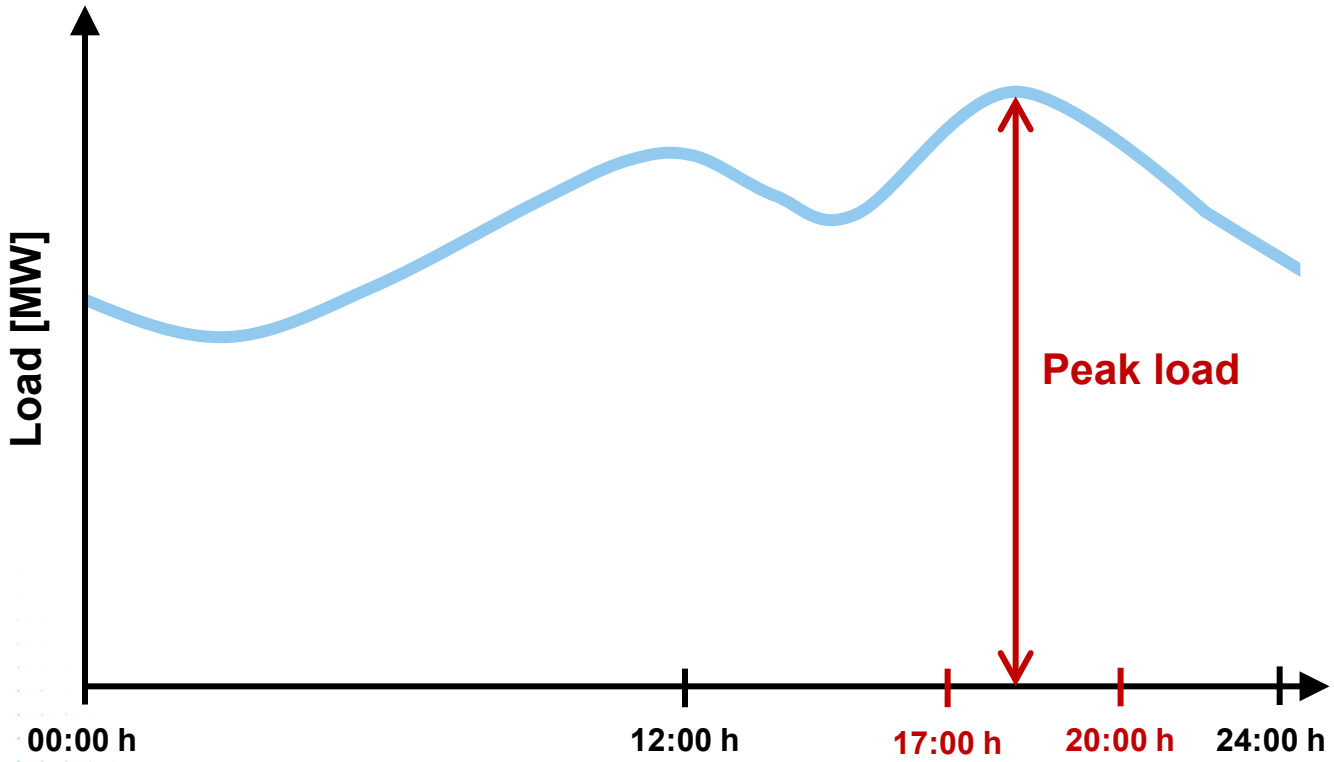


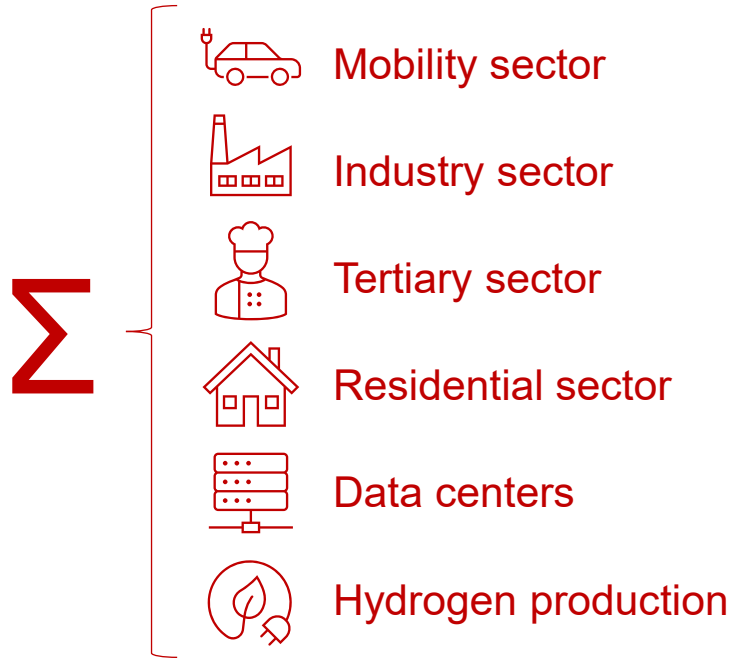
4

PROJECTED PEAK LOAD

creos

Cold-Day Load Curve: Evening Peak as Key Planning Challenge

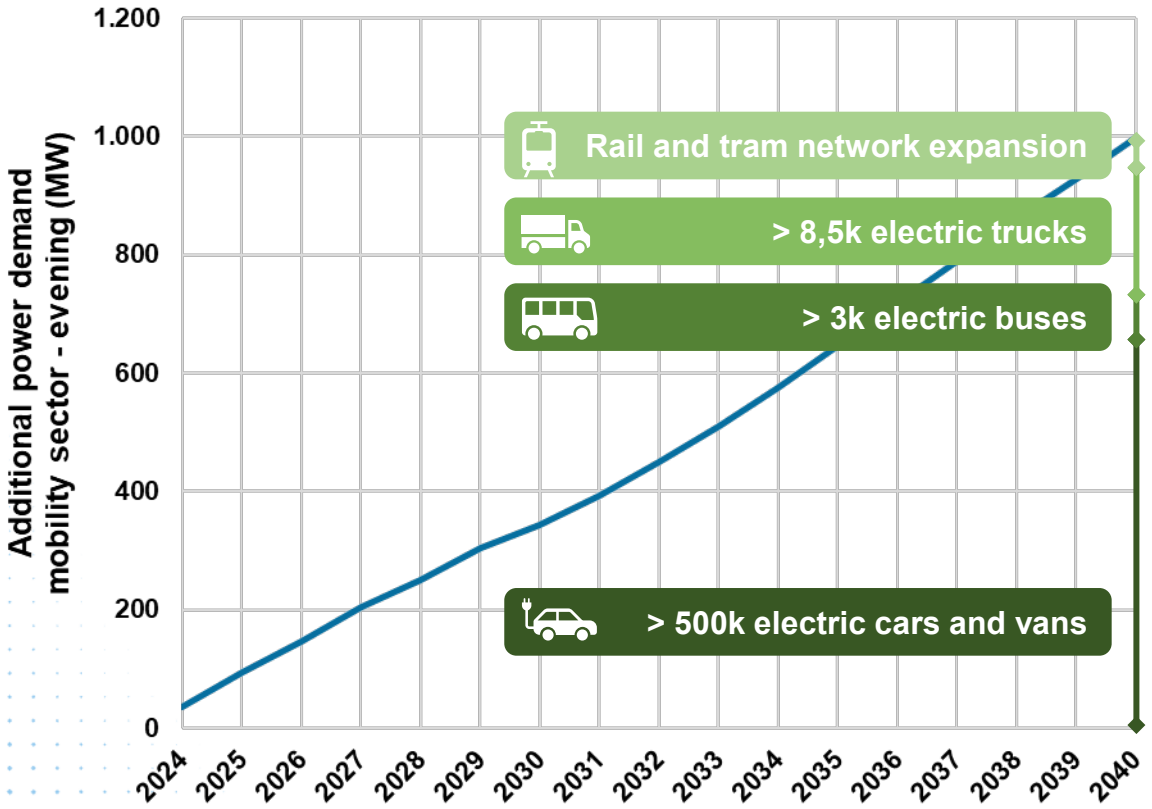




In this Scenario Report, we analyze projected midday and evening peaks in a high and low estimate scenario. On cold days, the **evening peak** is consistently higher – making it the most **critical** period **for long-term grid planning**.

The following slides therefore focus on high estimate evening peak load, calculated as the sum of the loads from all major consumption sectors.

Electric Mobility: Driving Nearly 1 GW of Additional Evening Load



Without the deployment of smart charging, peak shaving, or other flexibility measures, the **unmanaged evening peak load from electric mobility** could reach **up to 1,000 MW by 2040**.

This includes:

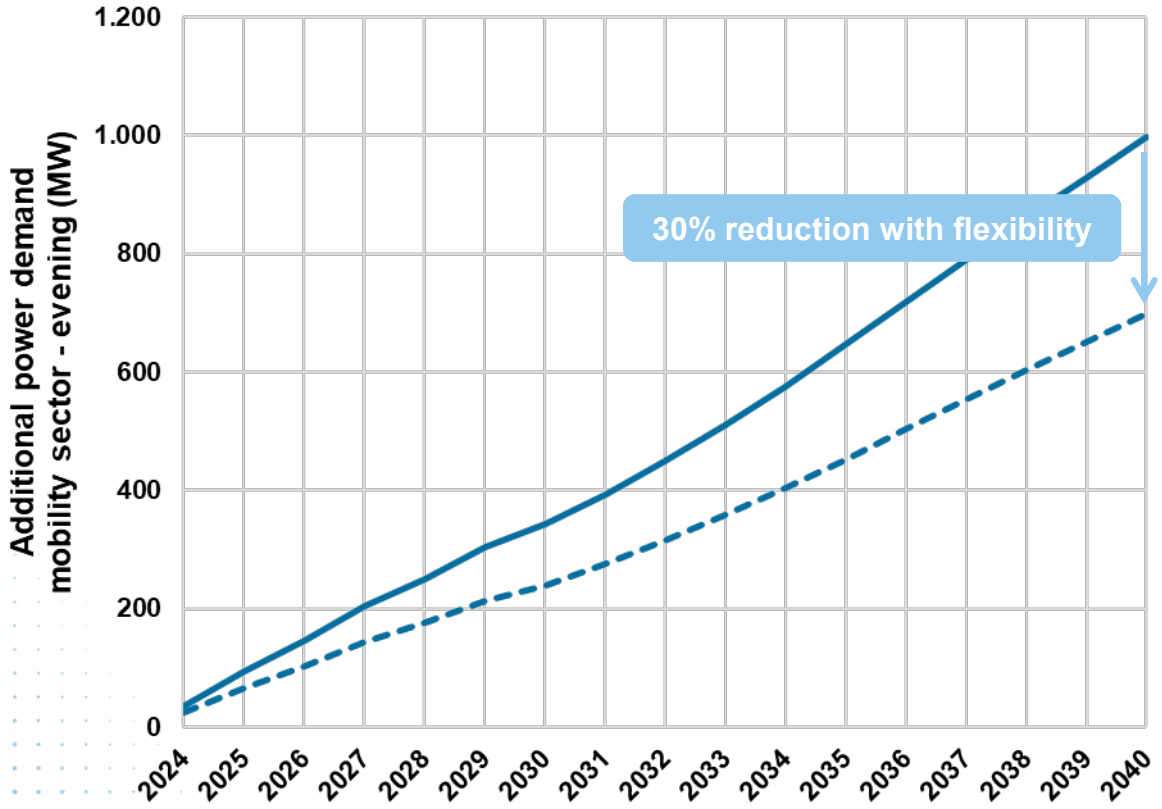
~ 650 MW from more than 500k electric cars and vans

~ 55 MW from around 3,000 electric buses

~ 270 MW from over 8,500 electric trucks

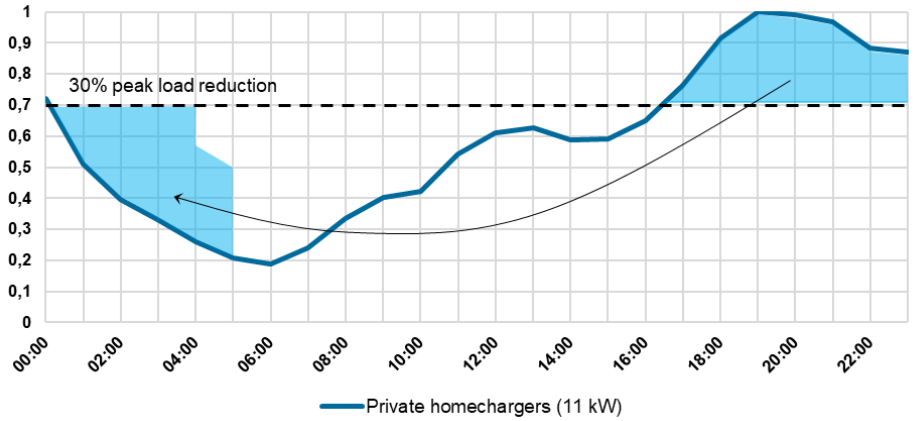
~ 20 MW from rail and tram network expansion

Flexibility Could Reduce Electric Mobility Peak Load by 30%

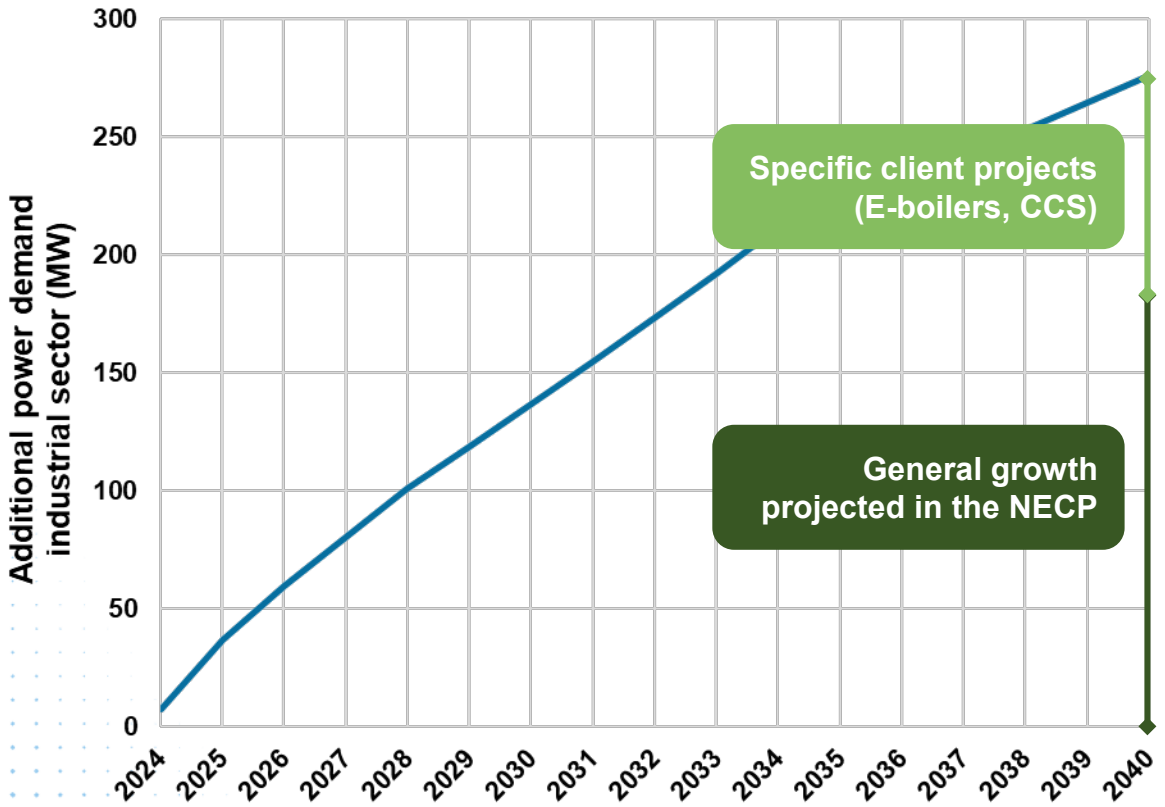


Based on the load profiles of different user groups, a **30% reduction in peak load** from electric mobility appears achievable – through smart charging, depot load management, adapted grid tariffs, connection agreements, and other flexibility mechanisms.

This could reduce the 2040 **evening peak** by nearly 300 MW — from 1,000 MW to around **700 MW.**



Industry Sector: Electrification Drives 280 MW in New Demand

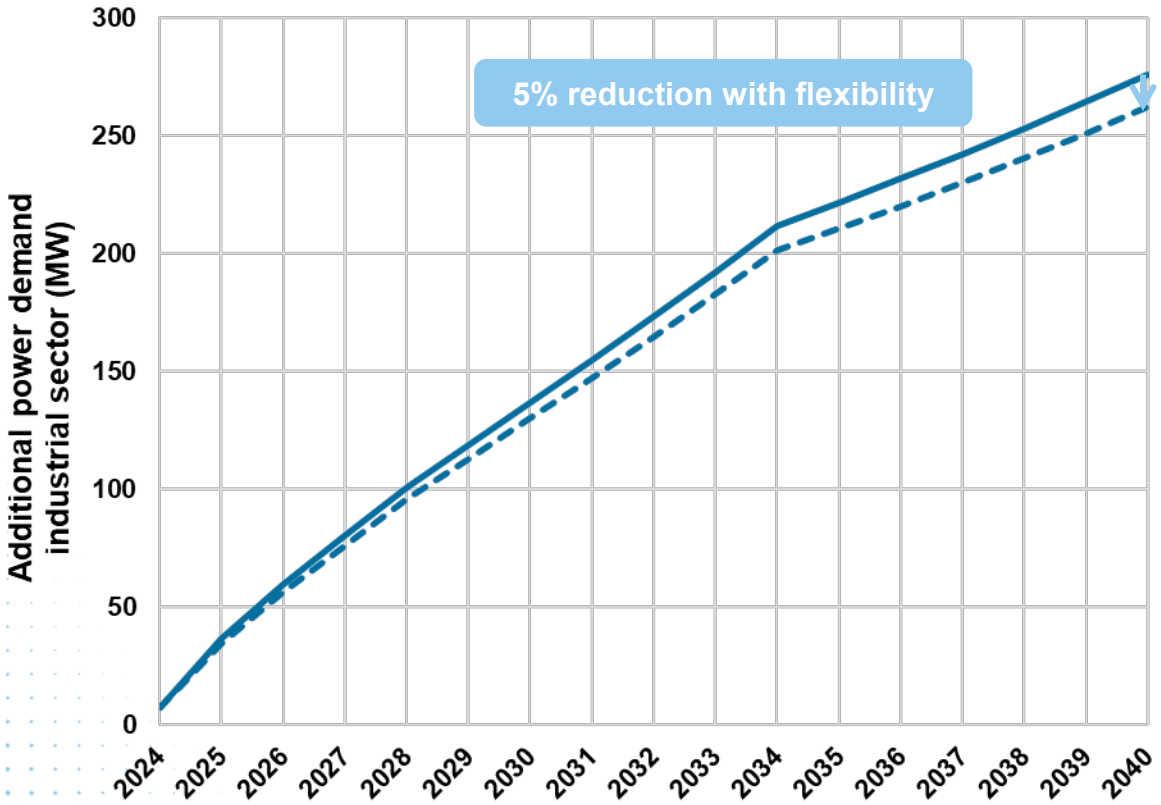


The additional power demand in the **industry sector** on the Creos grid has been determined based on:

- **General growth in energy consumption** in the non-ETS industry sector, as projected in the NECP, resulting in an additional **180 MW**
- **Specific client projects**, including the installation of e-boilers and carbon capture and storage systems, accounting for another **100 MW**

Together, these trends result in up to **280 MW of additional peak evening load by 2040**.

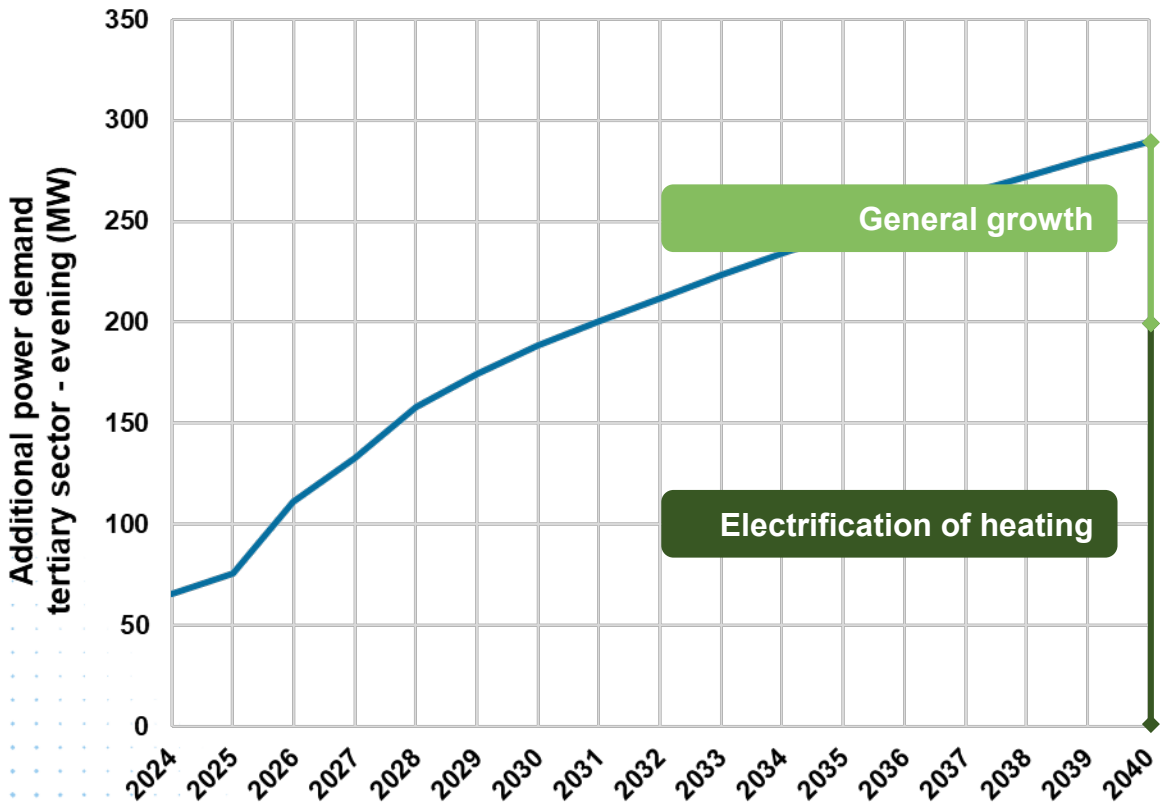
Flexibility in Industry: Potential Exists, but Clients Are Reluctant



As part of the **FlexBeAn** (Flexibility Potential and User Behaviour Analysis) study, conducted with the Luxembourg Institute of Science and Technology (**LIST**) and the Interdisciplinary Centre for Security, Reliability and Trust (**SnT**) of the University of Luxembourg, the **flexibility potential in the industrial sector** was assessed through literature research and **client surveys**.

Results indicate that industrial clients in Luxembourg take a more **cautious stance toward flexibility**, leading to an estimated **peak load reduction of only 5%** in this sector to **260 MW**.

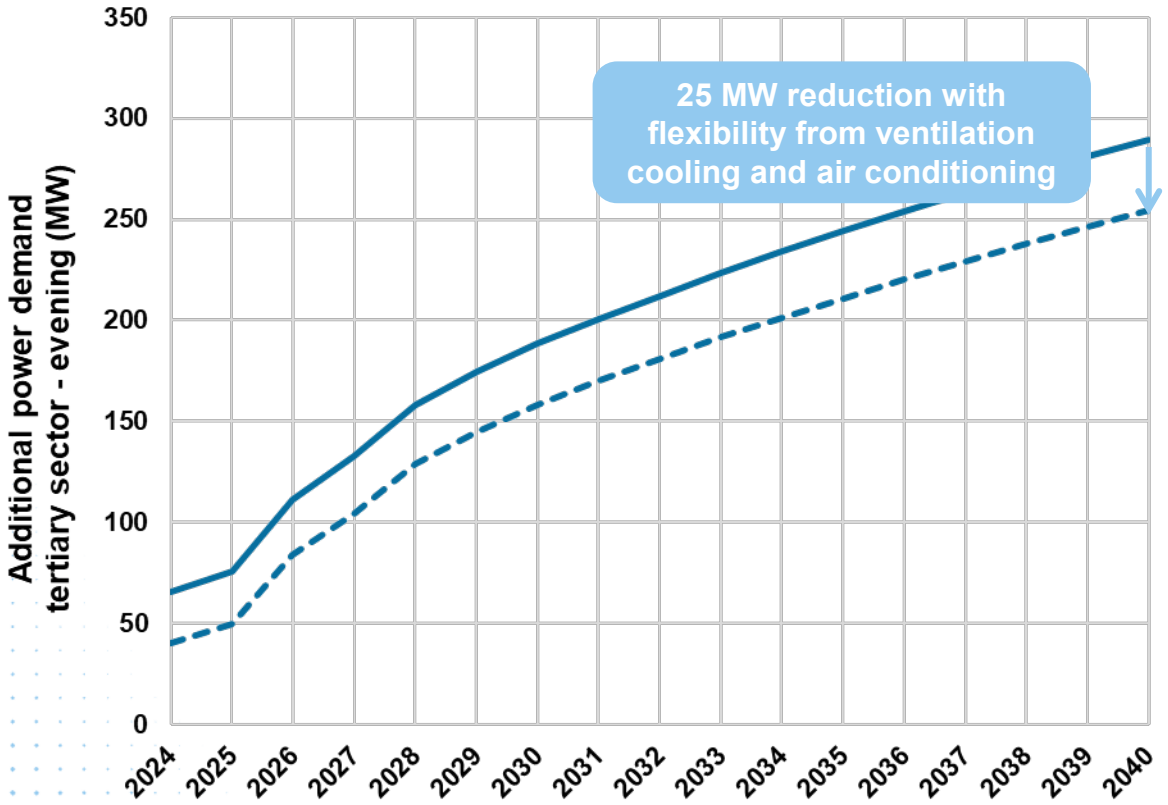
Tertiary Sector: Electrification of Heating Drives Peak Load



According to the NECP, demand growth in the **tertiary sector** will be primarily driven by the **electrification of heating**, contributing around **200 MW** by 2040.

An additional **90 MW** is expected from **general growth** in services, offices, retail, and public buildings.

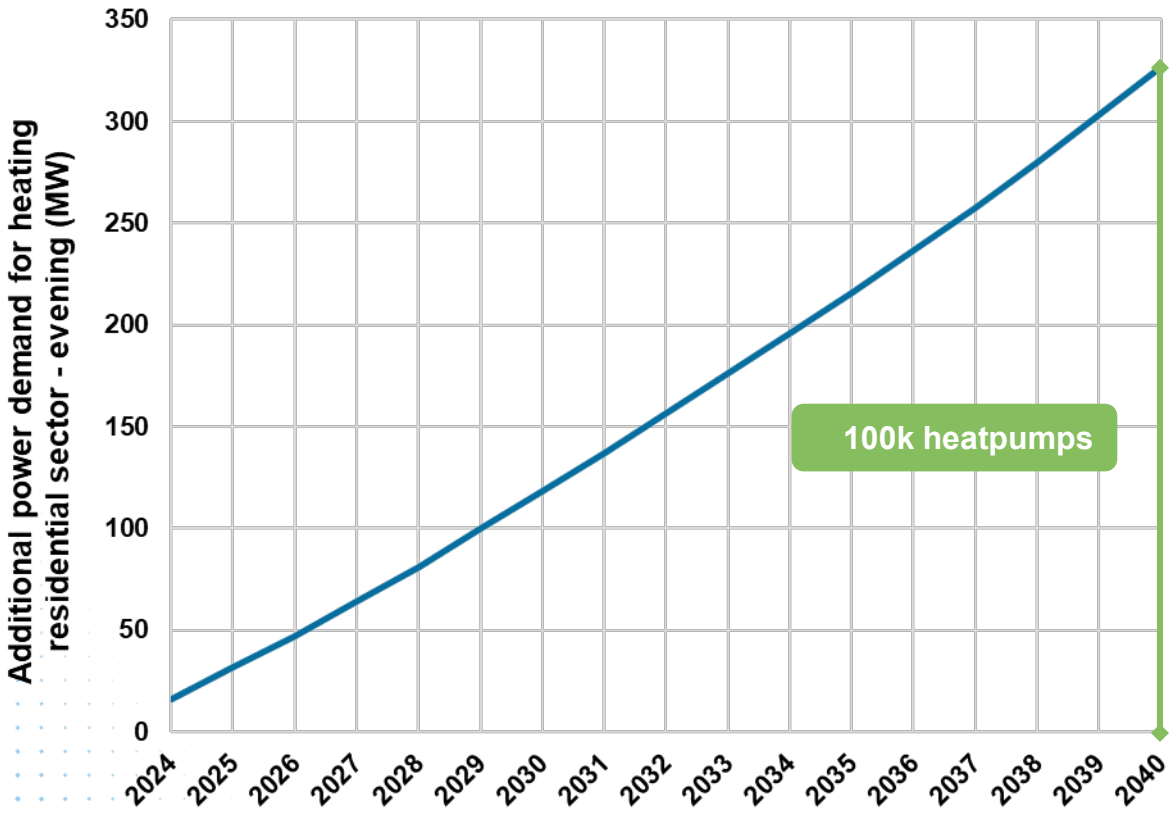
Tertiary Flexibility: Limited Winter Potential



The **FlexBeAn** study also assessed **flexibility** potential in the **tertiary sector**, identifying opportunities primarily **in ventilation, cooling, and air-conditioning** systems.

For the **winter months**, when heating dominates, the achievable peak load reduction is estimated at **25 MW**.

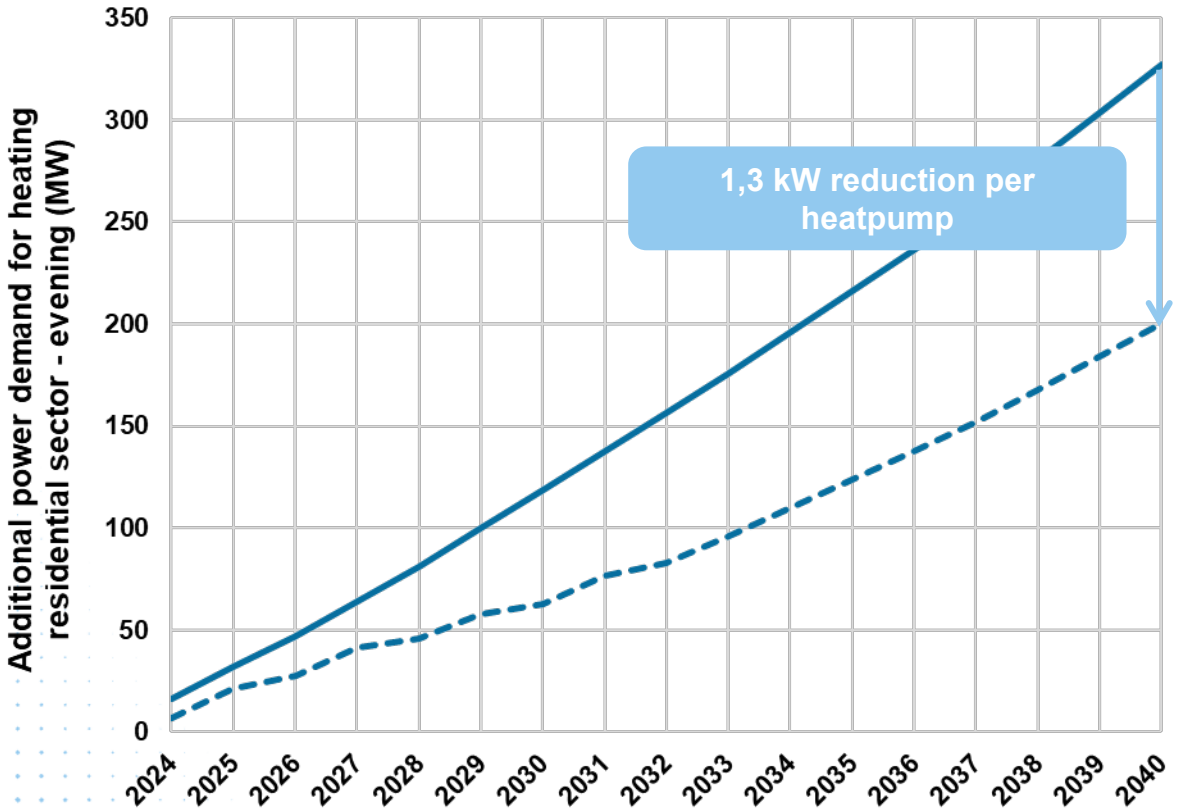
Residential Sector: Heat Pumps Add 320 MW to Evening Load



In the **residential sector**, demand growth is driven entirely by the **replacement of fossil-based heating systems with heat pumps**.

According to the NECP, nearly **100,000 heat pumps** could be installed by **2040**, resulting in an estimated additional evening load of **320 MW**.

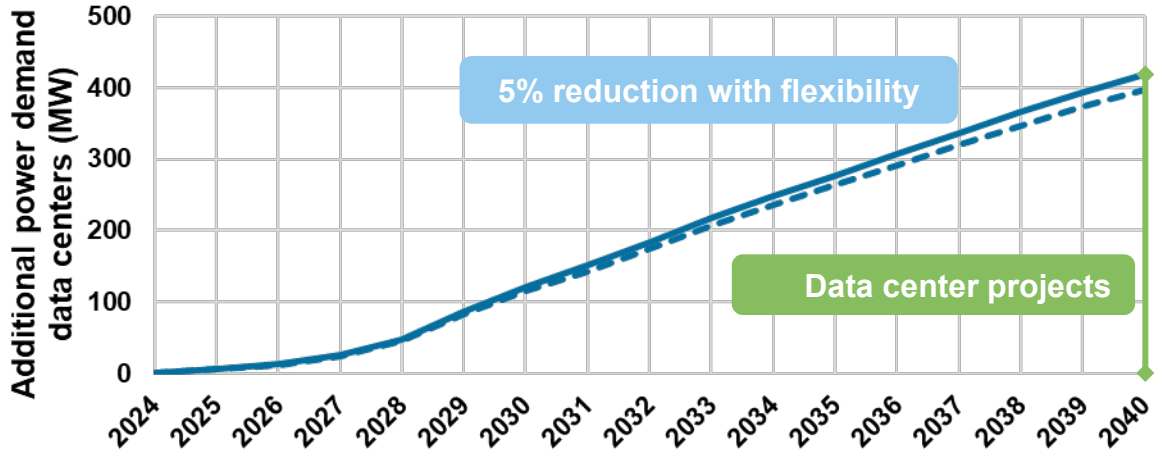
Residential Flexibility: High Potential from Heat Pump Control

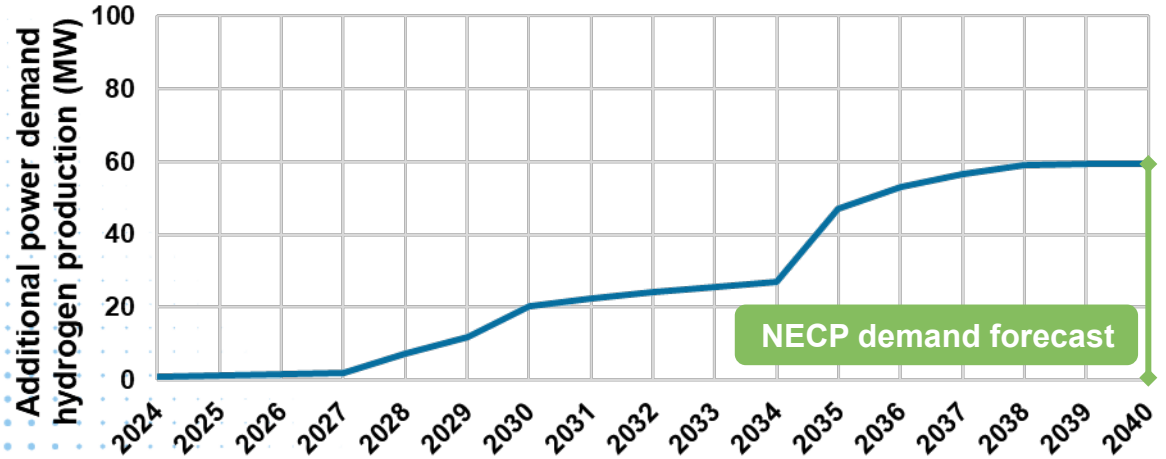


The **FlexBeAn** study also assessed the **residential sector**, identifying a **high flexibility potential** due to heat pump usage.

On average, **each unit offers about 1.3 kW of shiftable load**, which could lead to a peak reduction of up to **130 MW** by 2040.

Additional loads: Data Centers & Hydrogen Production





Future **data center load** has been estimated based on client projects and inquiries, **exceeding 400 MW by 2040**.

Due to their **steady 24-hour load profile**, a **limited flexibility potential of 5%** has been applied.

For **hydrogen**, the NECP projects a scenario with **entirely local production** for industrial and transport use **until 2030**, after which a hydrogen transport infrastructure is expected.

Due to uncertainty around implementation and operation, no flexibility potential has been assumed for this load.

5

PROJECTED PEAK GENERATION

creos

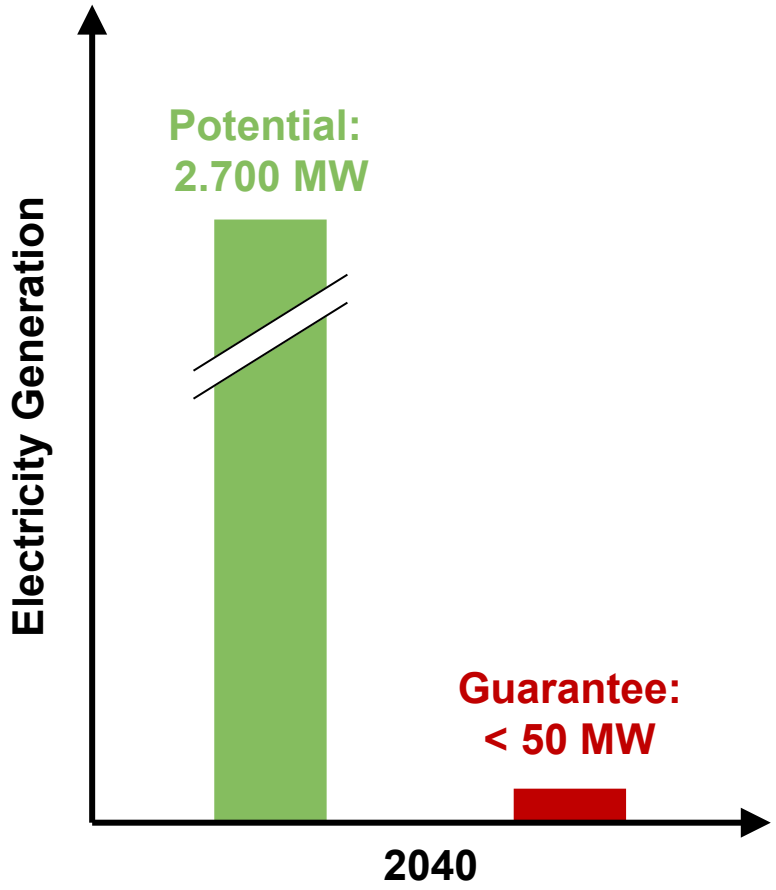
Projected Peak Generation Until 2040

This section presents the **projected peak generation** from all major technologies in Luxembourg, under both **high and low estimate scenarios**. Unlike installed capacity, this reflects the actual injection into the grid.

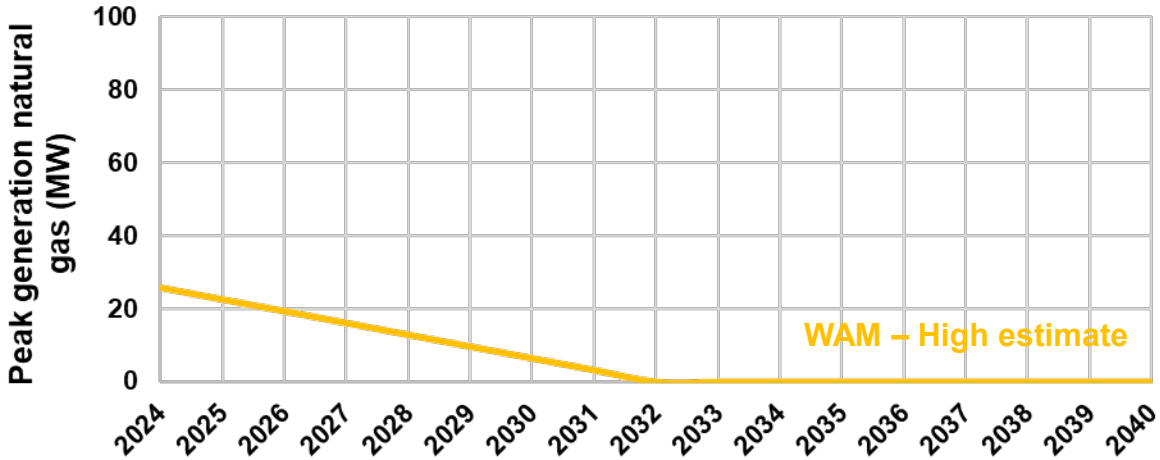
The projections are **based on** generation volumes from the **NECP WEM and WAM scenarios**, using historical full-load hours for each technology. As in the previous section, we will focus here on the ambitious WAM scenario.

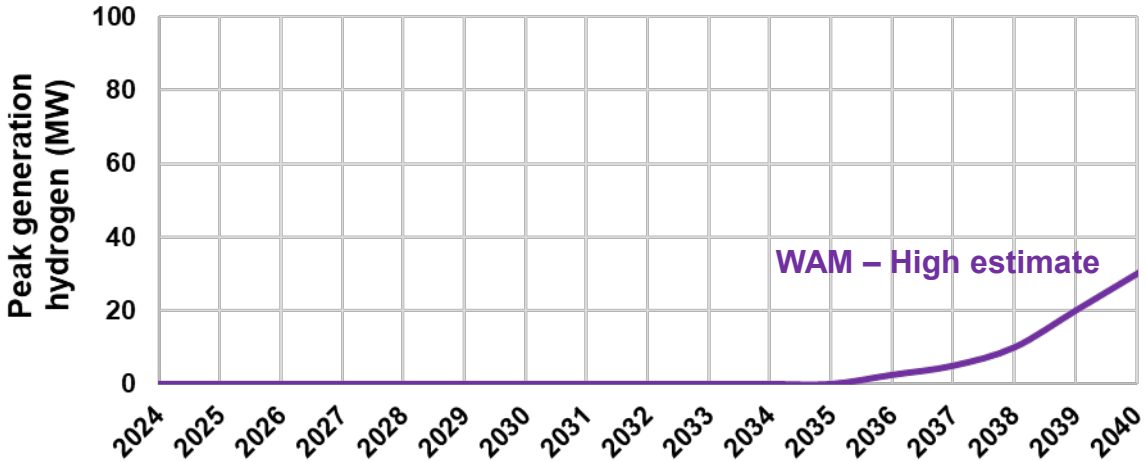
While installed capacity is expected to grow significantly, **not all sources contribute reliably to peak demand.**

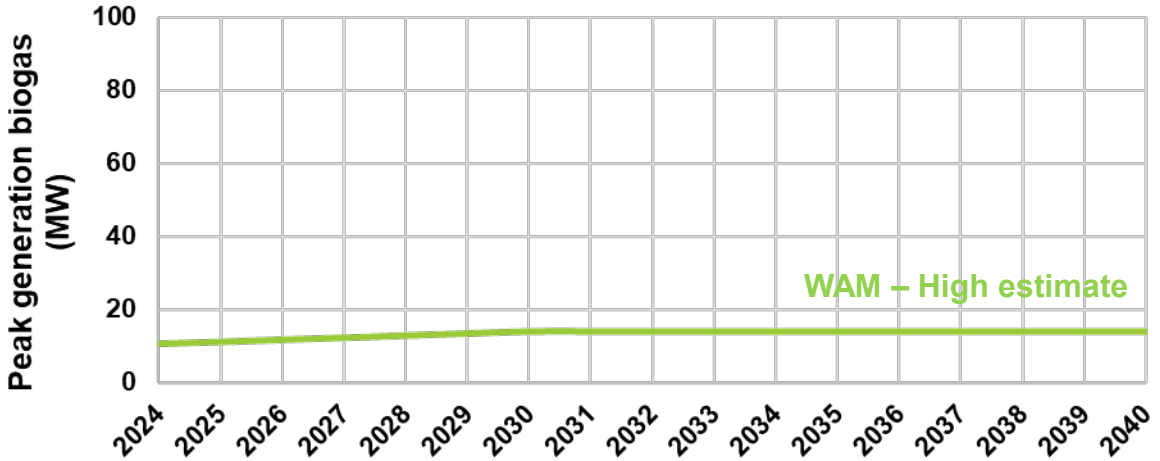
By **2040, peak generation could theoretically reach up to 2,700 MW** — but in a **worst-case scenario**, analysis of the last six years suggests **less than 50 MW can be considered guaranteed** during peak events.

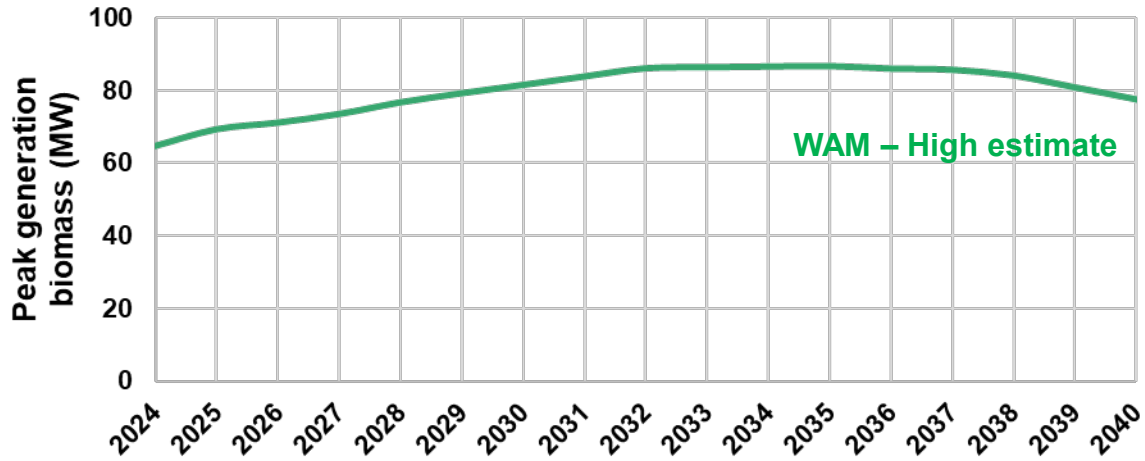


Natural gas, hydrogen, biogas and biomass



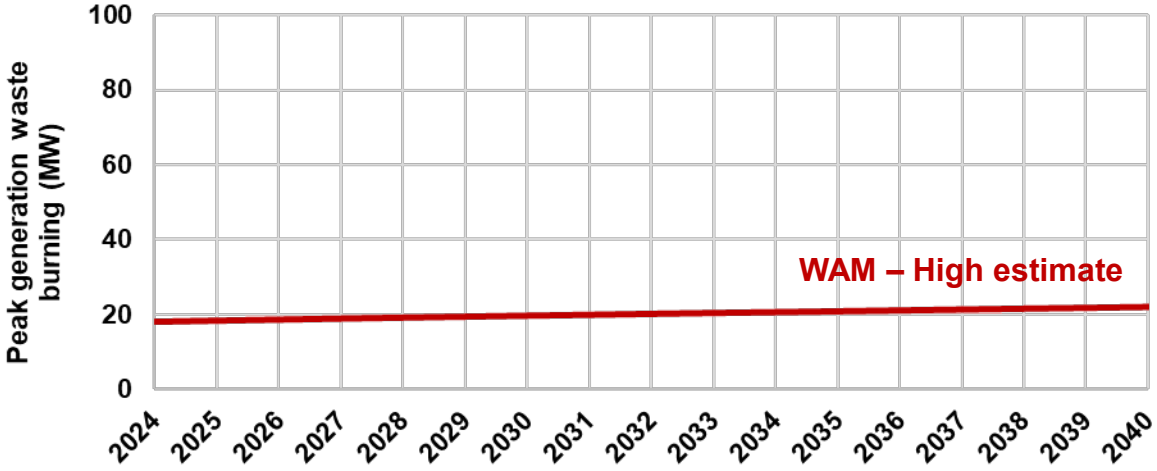


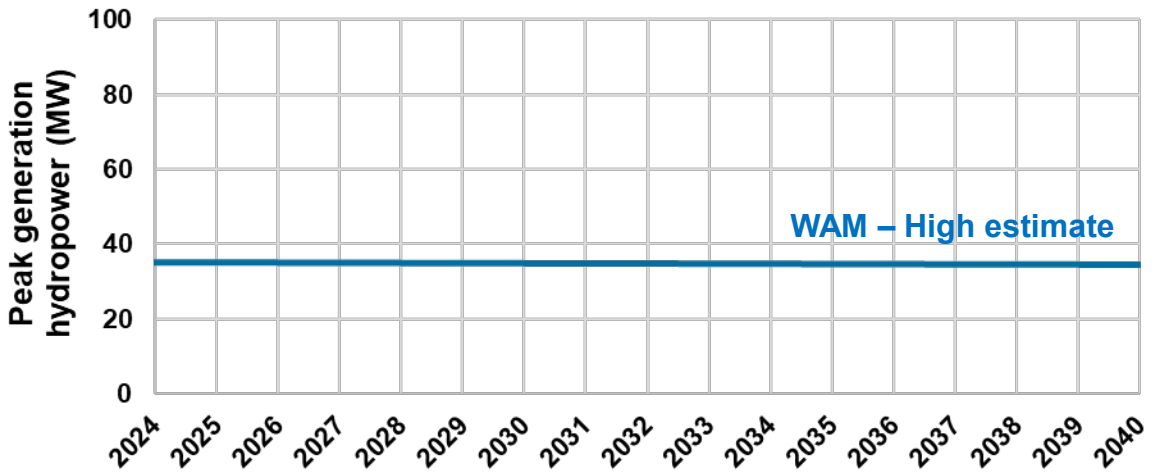


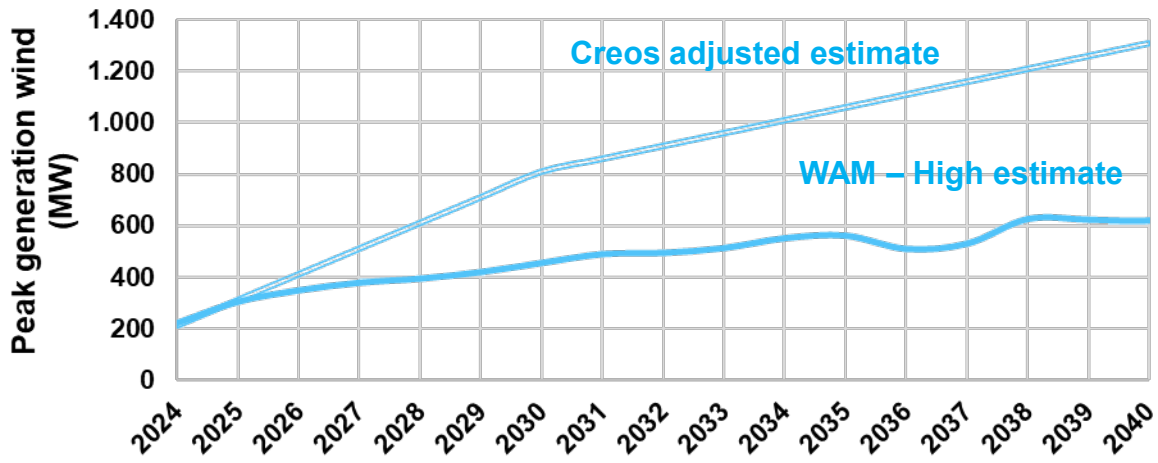


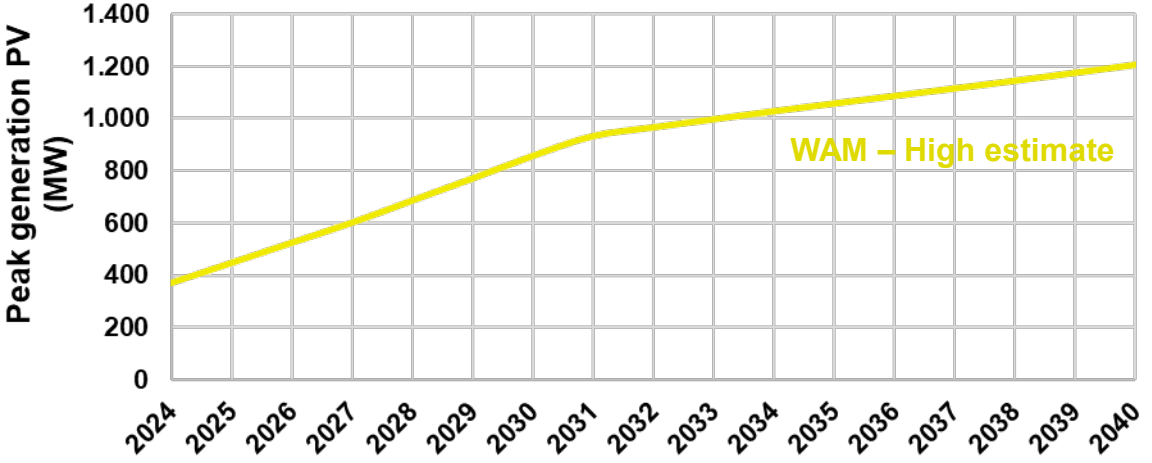
Guaranteed peak generation remains limited, as the most reliable are either phasing out or growing only moderately.

Waste burning, hydropower, wind and photovoltaics









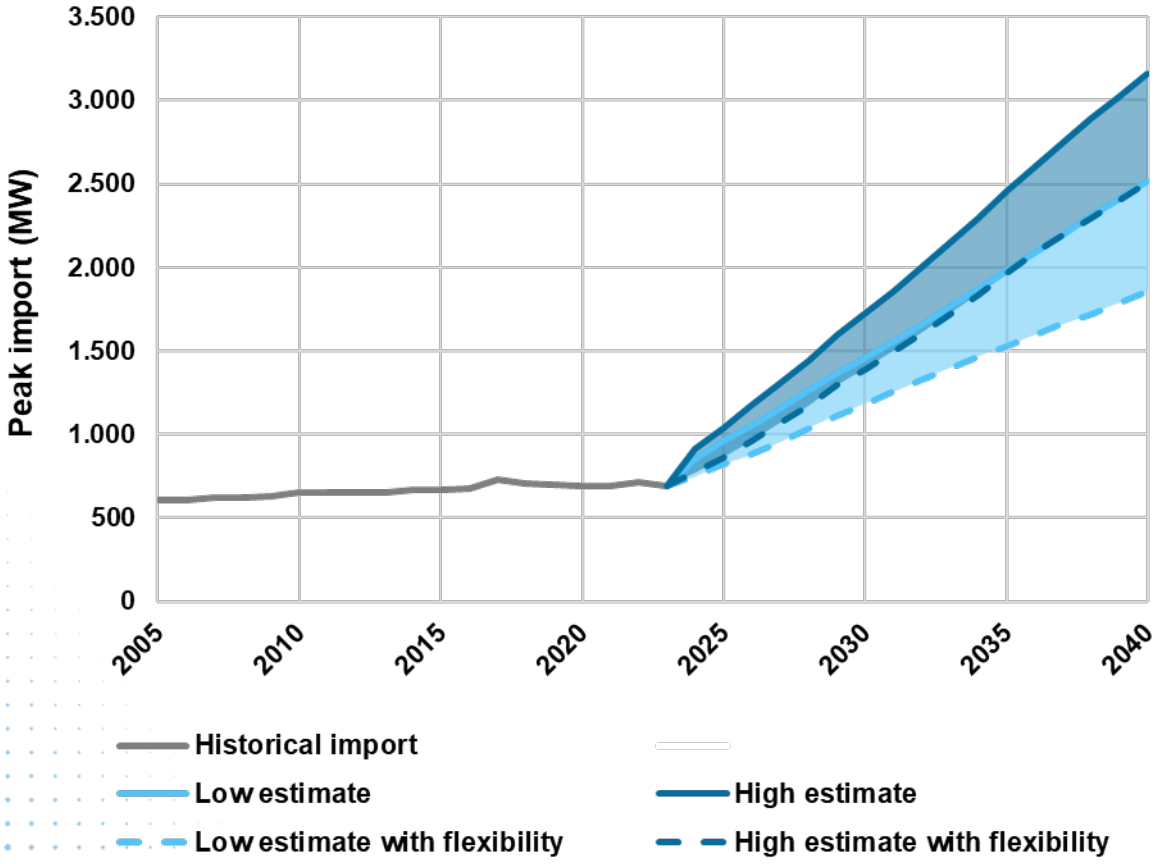
Wind and PV drive most of the projected increase in peak generation — but seasonal and weather-dependent availability remains a key limitation.

6

PROJECTED PEAK IMPORT

creos

High Import Reliance Persists — Even With Flexibility



Peak import is calculated as **total load minus guaranteed generation**. The total load used in this analysis is the sum of sectoral peak loads presented in section 4.

While the previous sections showed only the high estimate, this slide presents the **full range of calculations**, including:

- **High and low estimate scenarios**
- **With and without flexibility measures**

By 2040, the import need could range from 1,850 MW to 3,150 MW.

For long-term grid planning in the **Network Development Plan**, the **high estimate with flexibility** will be used.

Measures will be triggered by **power or voltage thresholds**, enabling targeted follow-up and review.

7

DISTRIBUTION NETWORK DEVELOPMENT PLAN (DNDP)

creos

Turning Forecasts into the Network Development Plans

1) Assess current grid state of each voltage level

Grid Modelling
Replicate the grid topology in the grid planning tools

→

Apply Measurements
Gather, verifiy and apply measurements at the different voltage levels

→

Load flow analysis
Perform load flow analysis to determine bottlenecks and critical elements

→

Contingency simulations
Perform N-1 analyses to determine bottlenecks in a derogated state

2) Distribute projections for demand and generation to assess future grid state per voltage level and region

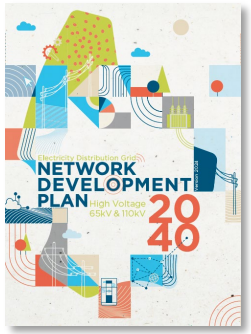
Per voltage level

Per grid region

Demand and generation distribution

3) Determine necessary measures and perform Cost-Benefit-Analyses to compare traditional grid reinforcement to smart grid or flexibility options

4) Document results in Network Development Plan



THANK YOU FOR YOUR ATTENTION

Any questions?