

# SYSTEM MODELLING OF THE ELECTRIC POWER SYSTEM OF THE KYRGYZ REPUBLIC:

## A Scenario Tool for Planning and Assessing Development Pathways

Country Modelling Unit:

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- **Objective 1: Understand the factors shaping the load** on the power system: sectoral demand, seasonality, peak loads, and losses.
- **Objective 2: Assess how specific measures affect the system balance and peak load:** generation expansion, energy efficiency, loss reduction, and tariff adjustments.
- **Objective 3: Compare alternative development scenarios** on a consistent quantitative basis: which options work faster, more cost-effectively, and more sustainably for the system.

## 1. Model Type

- Quantitative system balance model
- Links electricity demand, generation, and key system parameters
- Designed for scenario analysis and decision support

## 2. Time Representation

- Annual electricity balance (2023–2040)
- Monthly load distribution
- Intraday load profiles and peak hours

## 3. System Coverage

- National-level electricity system
- Demand by main economic sectors
- Generation by major technology types
- Measures on both demand and supply sides

## 4. Key Features

- Transparent and adjustable parameters
- Explicit treatment of seasonality and peak demand
- Direct comparison of alternative scenarios

## Demand Side:

- Electricity consumption by main economic sectors
- Demand drivers:
  - Economic growth
  - Population growth
  - **Consumer response to tariff changes**
- Measures included (**any measure can be modelled**):
  - Building insulation (M1)
  - Energy-efficient household appliances and lighting (M2)
- Explicit representation of seasonal and intraday load profiles

## Power System Side:

- Network losses and loss reduction (M3)
- Commissioning of new generation capacity:
  - Solar and wind power (M4)
  - Hydropower modernisation and new HPPs (M5)

The number of scenarios is **not limited and is defined by the analytical task.**

For each scenario, the following parameters can be configured:

- Economic growth rates
- Population growth rates
- Sector-specific demand growth speeds
- Commissioning pace of new generation capacity
- Energy efficiency and loss reduction measures
- Household demand response to tariff changes

**Scenarios presented in this deck:**

**Baseline scenario:** current demand growth trajectory with no additional measures

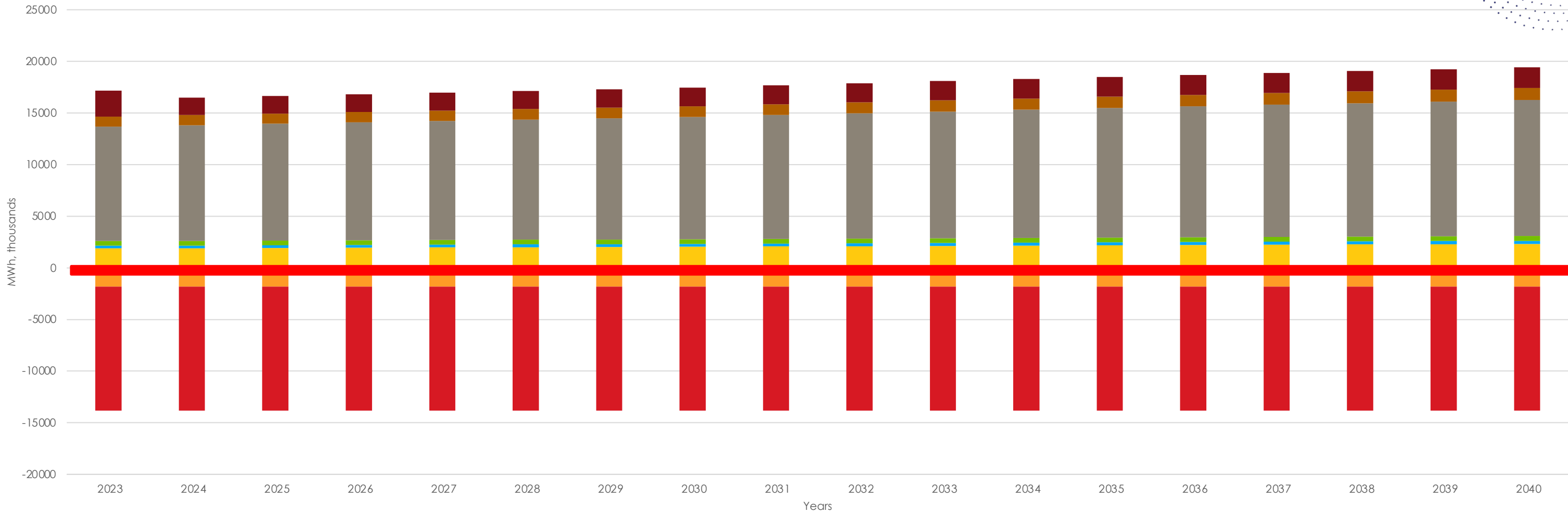
**Scenario with accelerated RES deployment and full package of measures:**

energy efficiency + accelerated solar, wind, and hydropower deployment + electricity tariff increase

(Any other scenario can be defined within the tool.)

# Default Scenario (annual load)

Electricity balance - Projection (annual)



Domestic generation-Fossil  
Irrigation and pumps  
Other heavy activities

Domestic generation-Hydro  
Public Sector  
Losses (T&NT)

Industrial and Commercial  
Residential  
Domestic generation-Solar&Wind

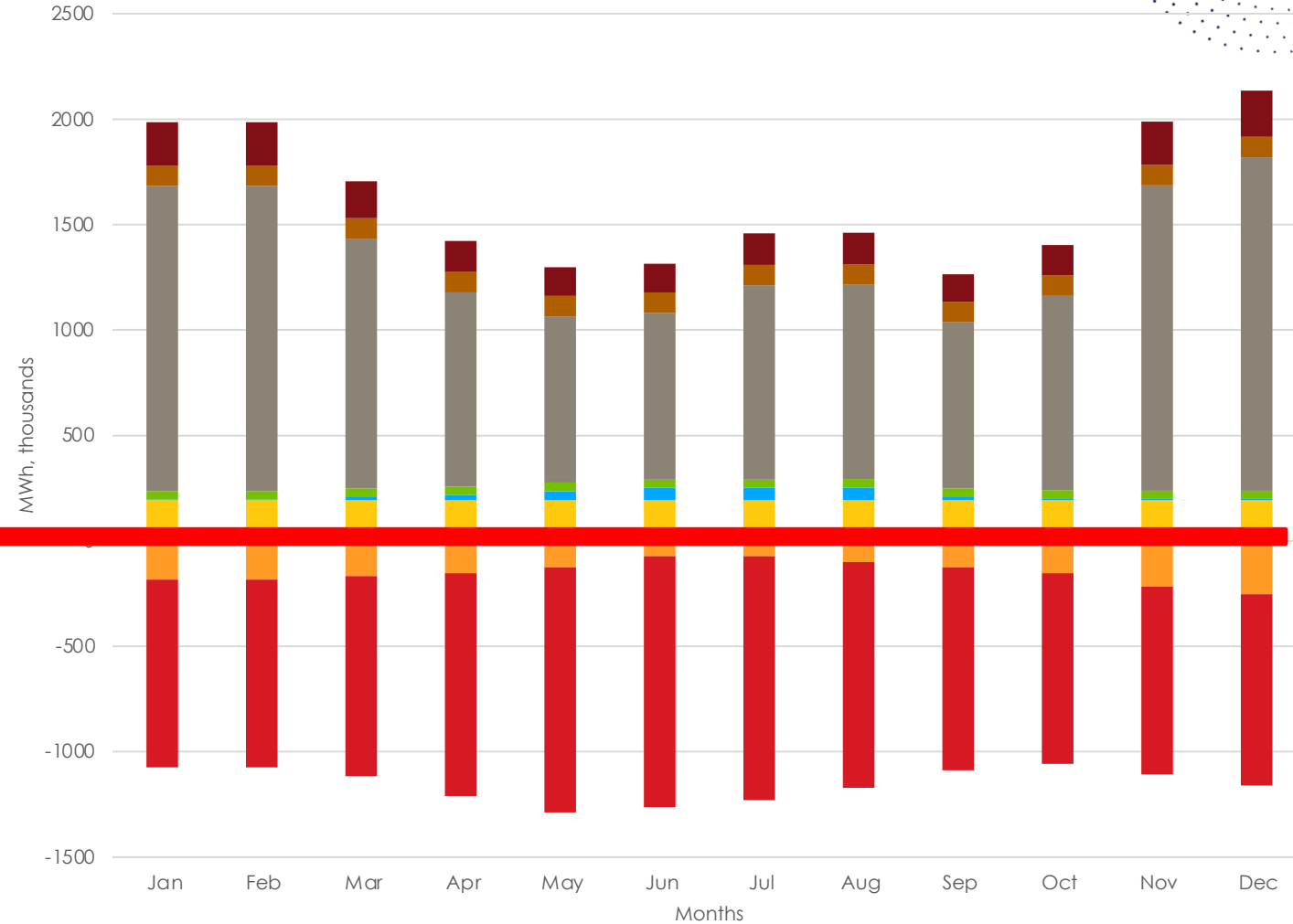
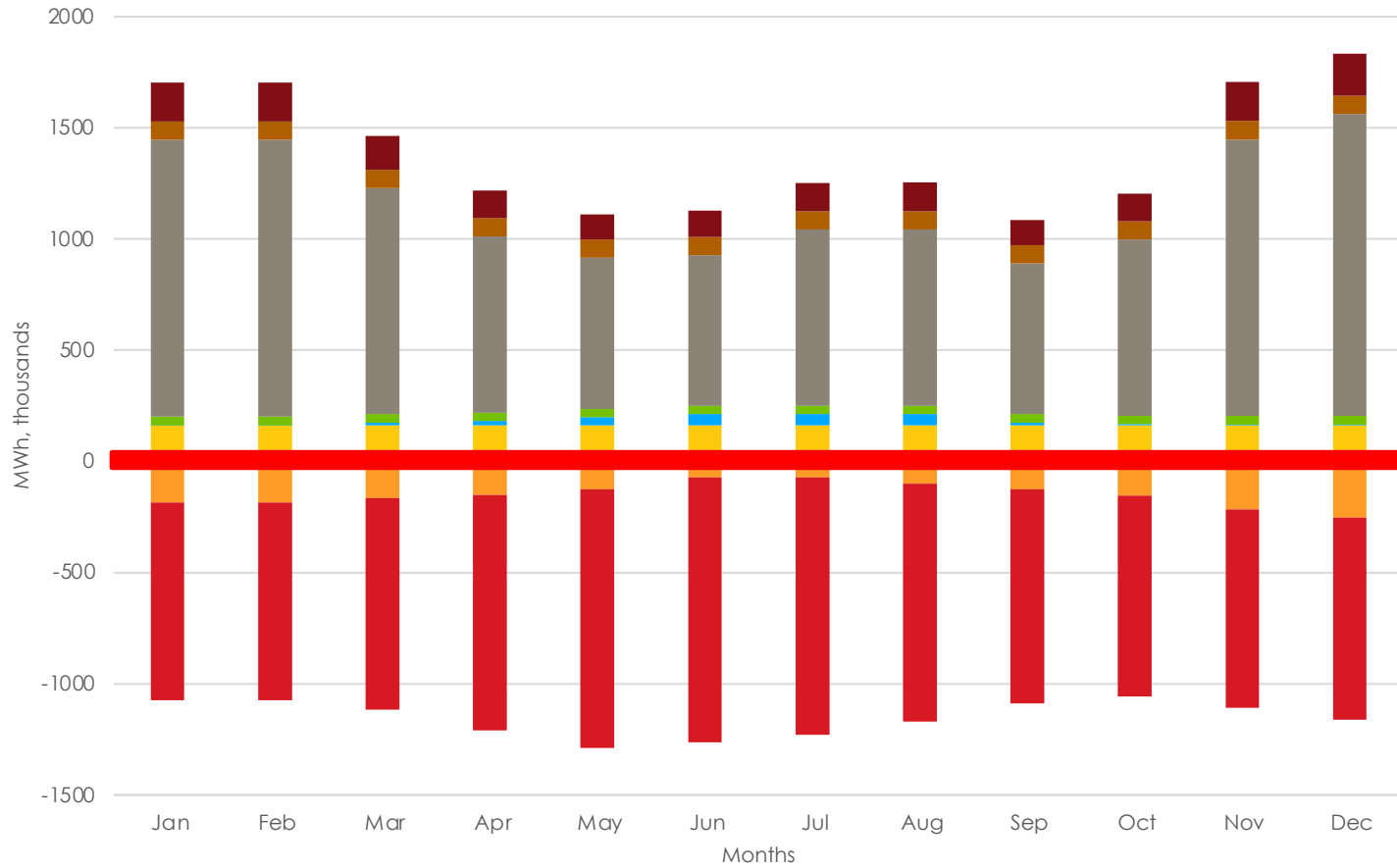
# Default Scenario (monthly load)

2025

2040

Electricity balance - Monthly

Electricity balance - Monthly



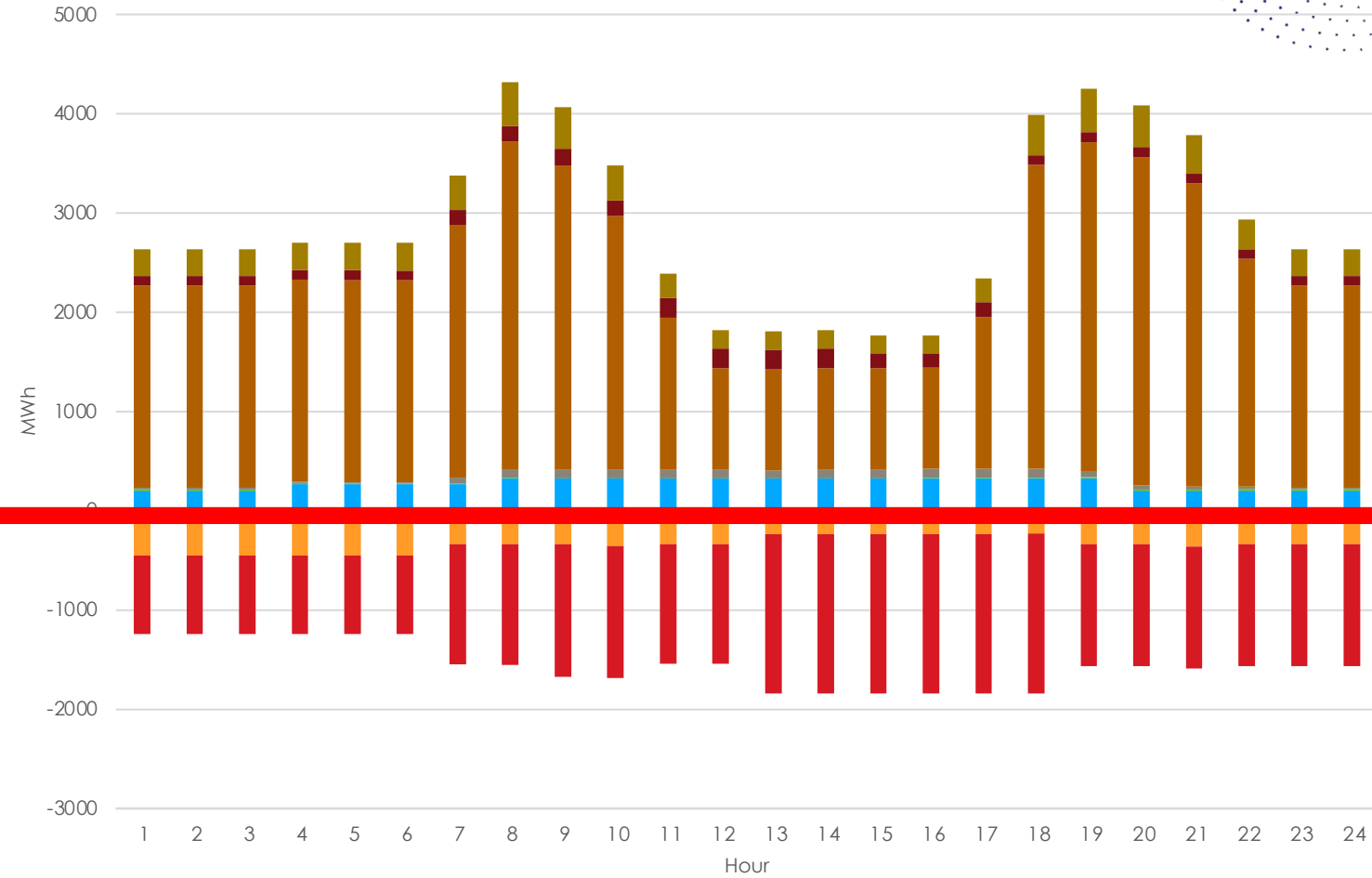
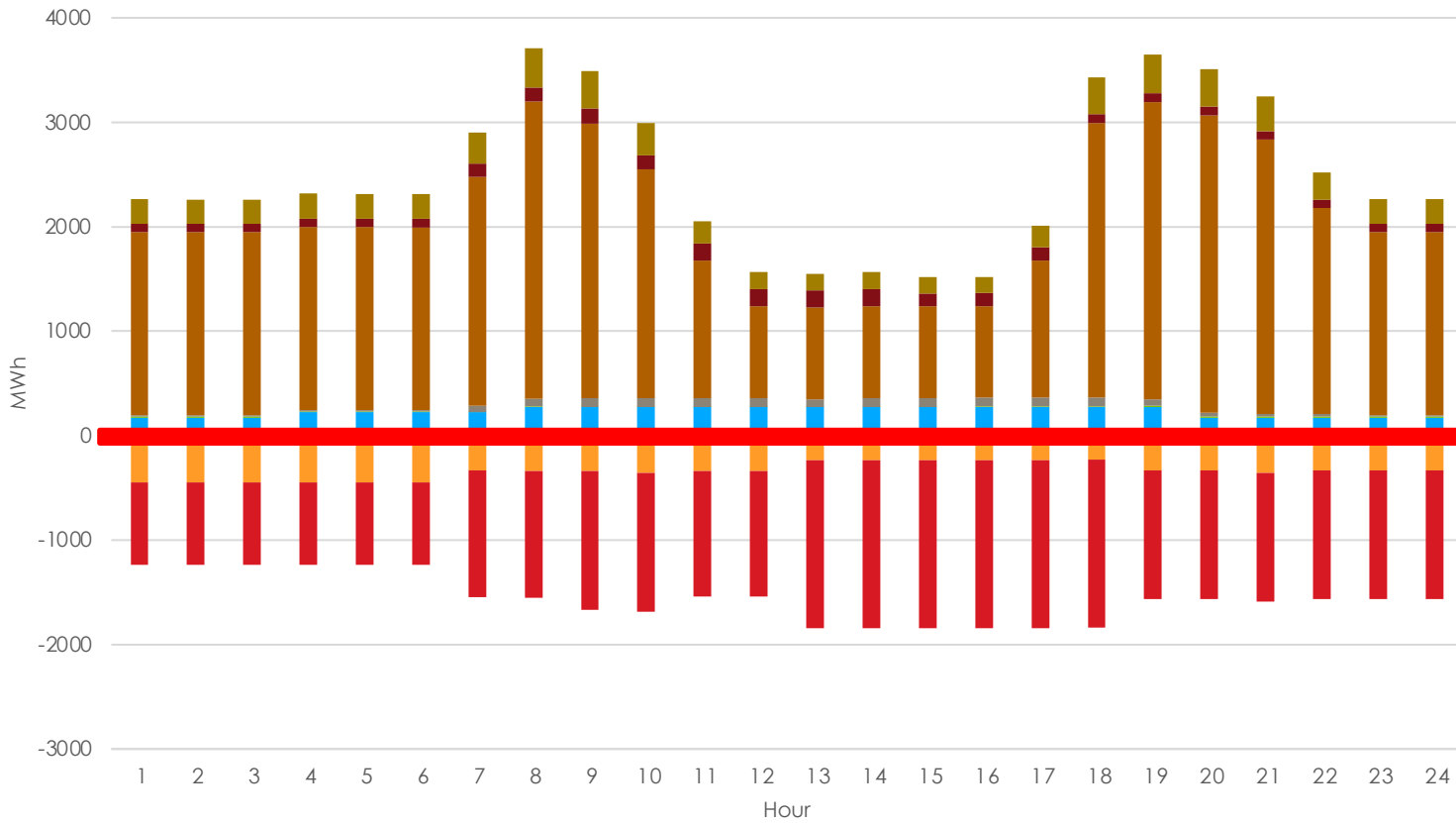
- Domestic generation-Fossil
- Domestic generation-Hydro
- Industrial and Commercial
- Irrigation and pumps
- Public Sector
- Residential
- Other heavy activities
- Losses (T&NT)
- Domestic generation-Solar&Wind

# Default Scenario (intraday load)

2025 2040

Electricity balance - Projection (winter peak day/hourly)

Electricity balance - Projection (winter peak day/hourly)



- Domestic generation-Fossil
- Industrial and Commercial
- Residential
- Domestic generation-Solar&Wind
- Domestic generation-Hydro
- Irrigation and pumps
- Other heavy activities
- Export
- Public Sector
- Losses (T&NT)

- Domestic generation-Fossil
- Industrial and Commercial
- Residential
- Domestic generation-Solar&Wind
- Domestic generation-Hydro
- Irrigation and pumps
- Other heavy activities
- Export
- Public Sector
- Losses (T&NT)

## 1. Demand growth is structural and persistent; households are the main driver

- Household consumption grows from ~11.1 TWh in 2023 to ~13.2 TWh in 2040 (+2.1 TWh driven purely by demographics and economic growth)
- Industrial and commercial consumption increases from ~1.9 to ~2.3 TWh
- Total annual system imbalance increases from ~3.3 TWh (2023) to ~5.6 TWh (2040)
- [!] Even without electrification or new loads, **pressure on the system increases automatically.**

## 2. Seasonal imbalance intensifies: winter defines system reliability

By 2040, winter months account for the core deficit:

- January: ~0.9 TWh
- February: ~0.9 TWh
- December: ~1.0 TWh

For comparison, in 2026:

- January: ~0.65 TWh
- February: ~0.65 TWh

Growth of winter deficit (2026–2040):  
+250–350 GWh per month

[!] The system challenge is **not the annual balance, but winter concentration** of demand.

## 3. Peak hours are the key point of systemic risk

Intraday profile:

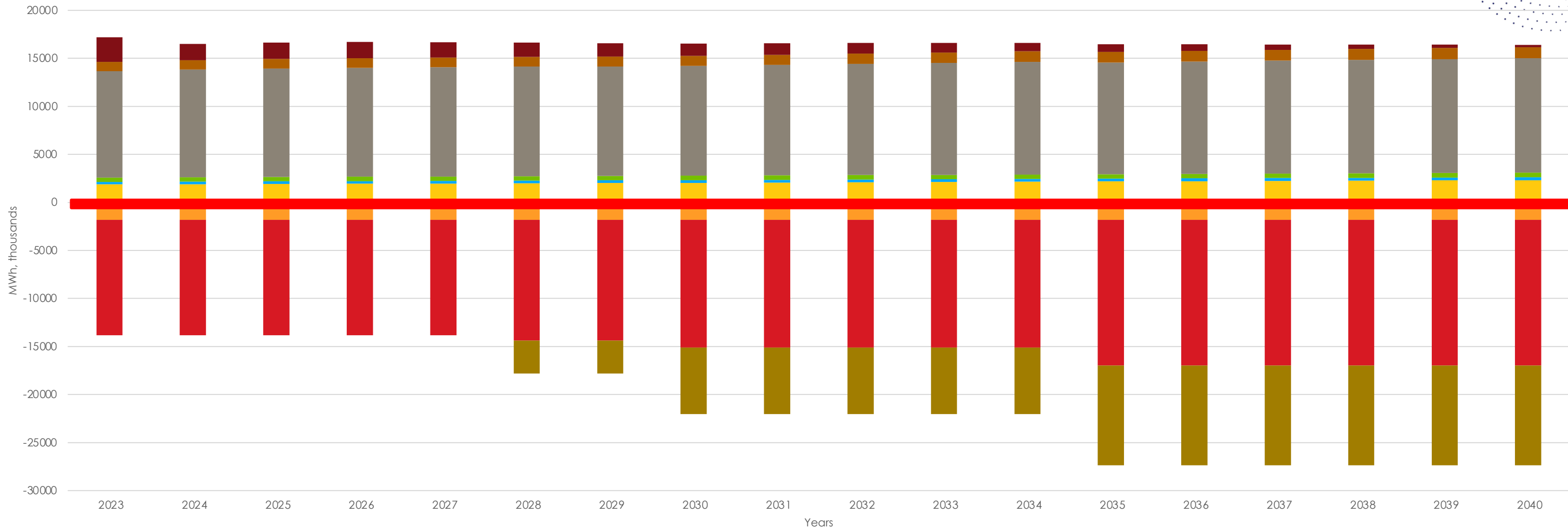
- 2026: evening peak ~2.1–2.2 GW
- 2040: evening peak ~2.6–2.7 GW

Growth in peak gap: ~+500 MW over 14 years

[!] Even with moderate economic growth, **the system fails at peak hours.**

# Measures Scenario (annual load)

Electricity balance - Projection (annual)



Domestic generation-Fossil

Domestic generation-Hydro

Industrial and Commercial

Irrigation and pumps

Public Sector

Residential

Other heavy activities

Losses (T&NT)

Domestic generation-Solar&Wind

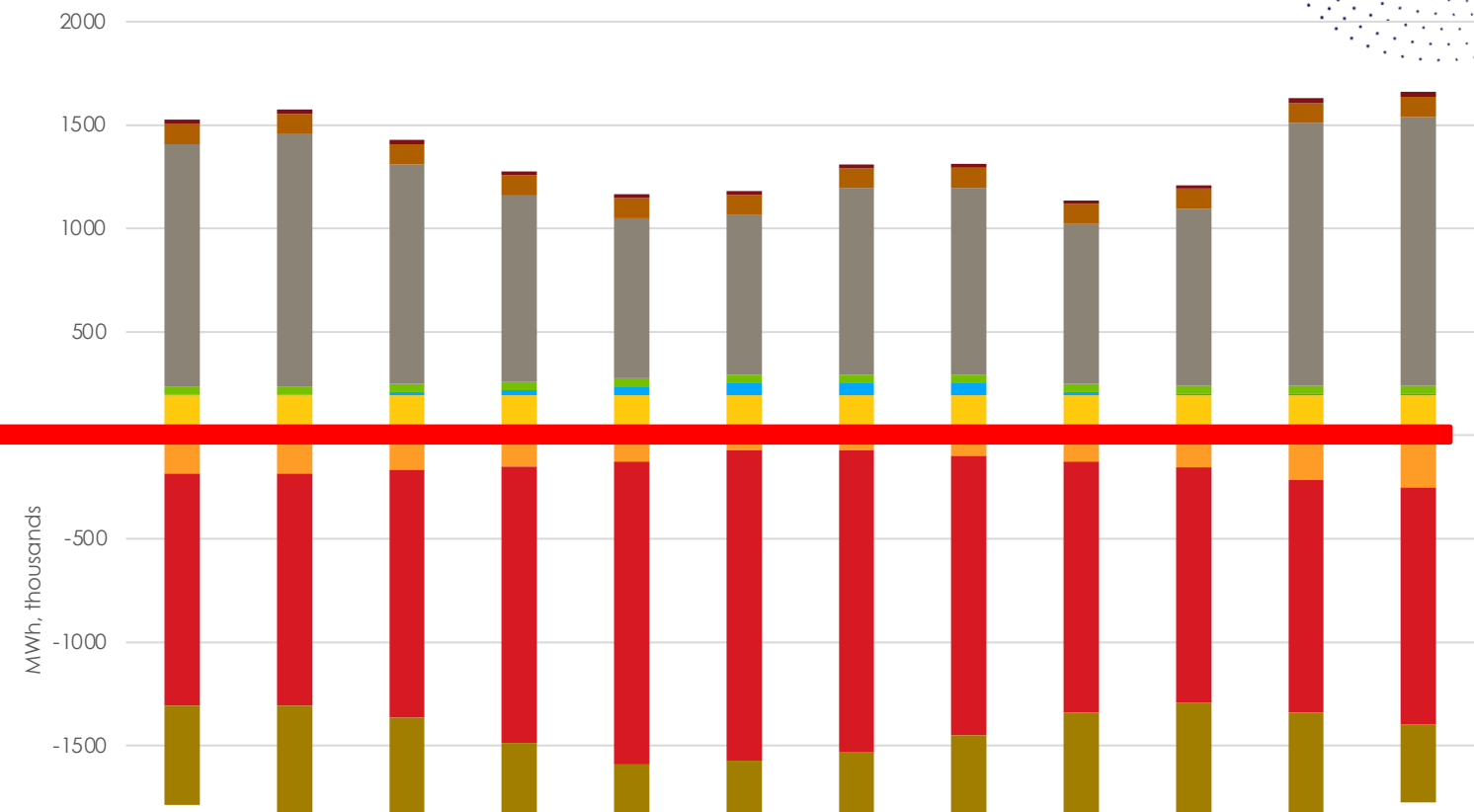
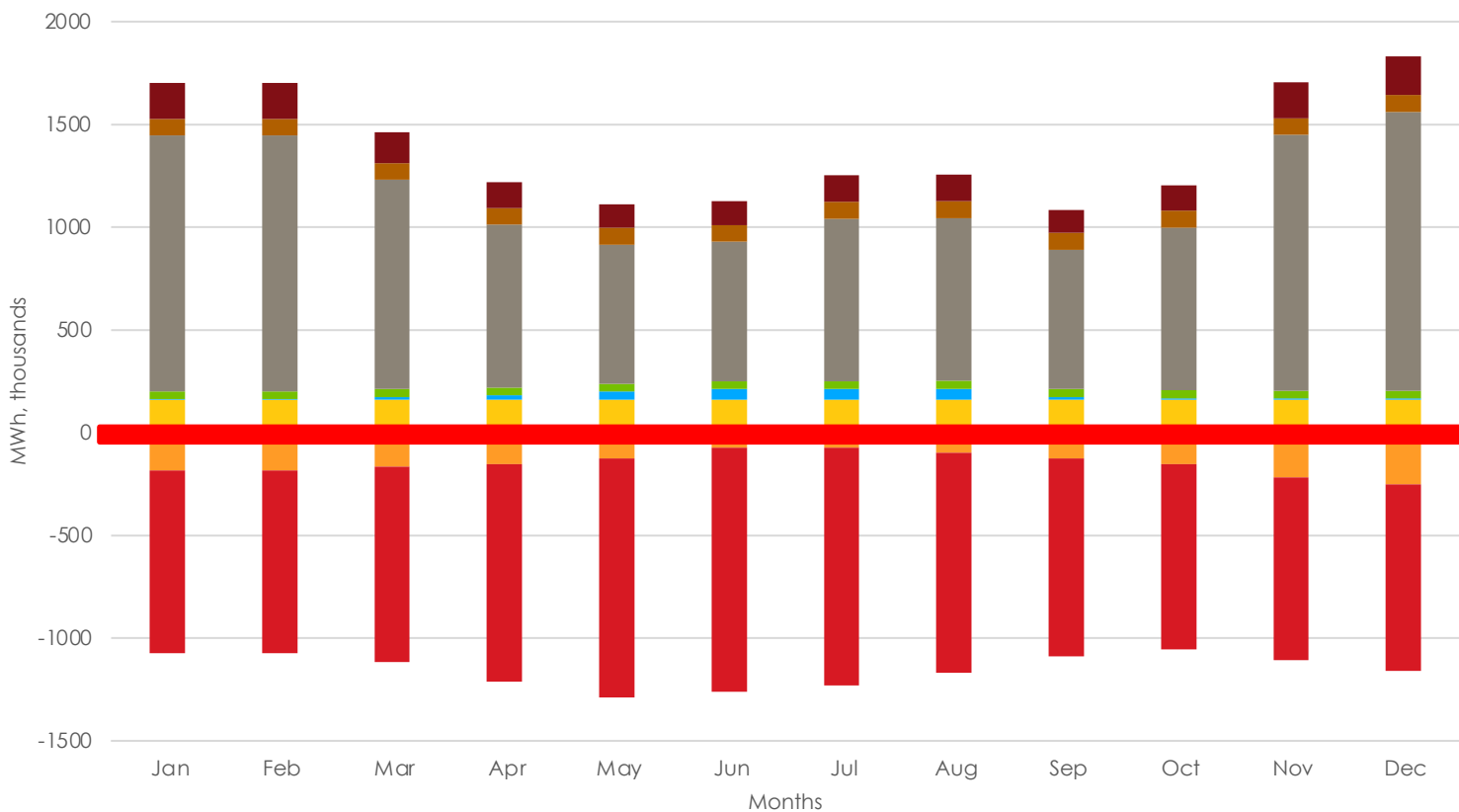
# Measures Scenario (monthly load)

Electricity balance - Monthly

2025

2040

Electricity balance - Monthly



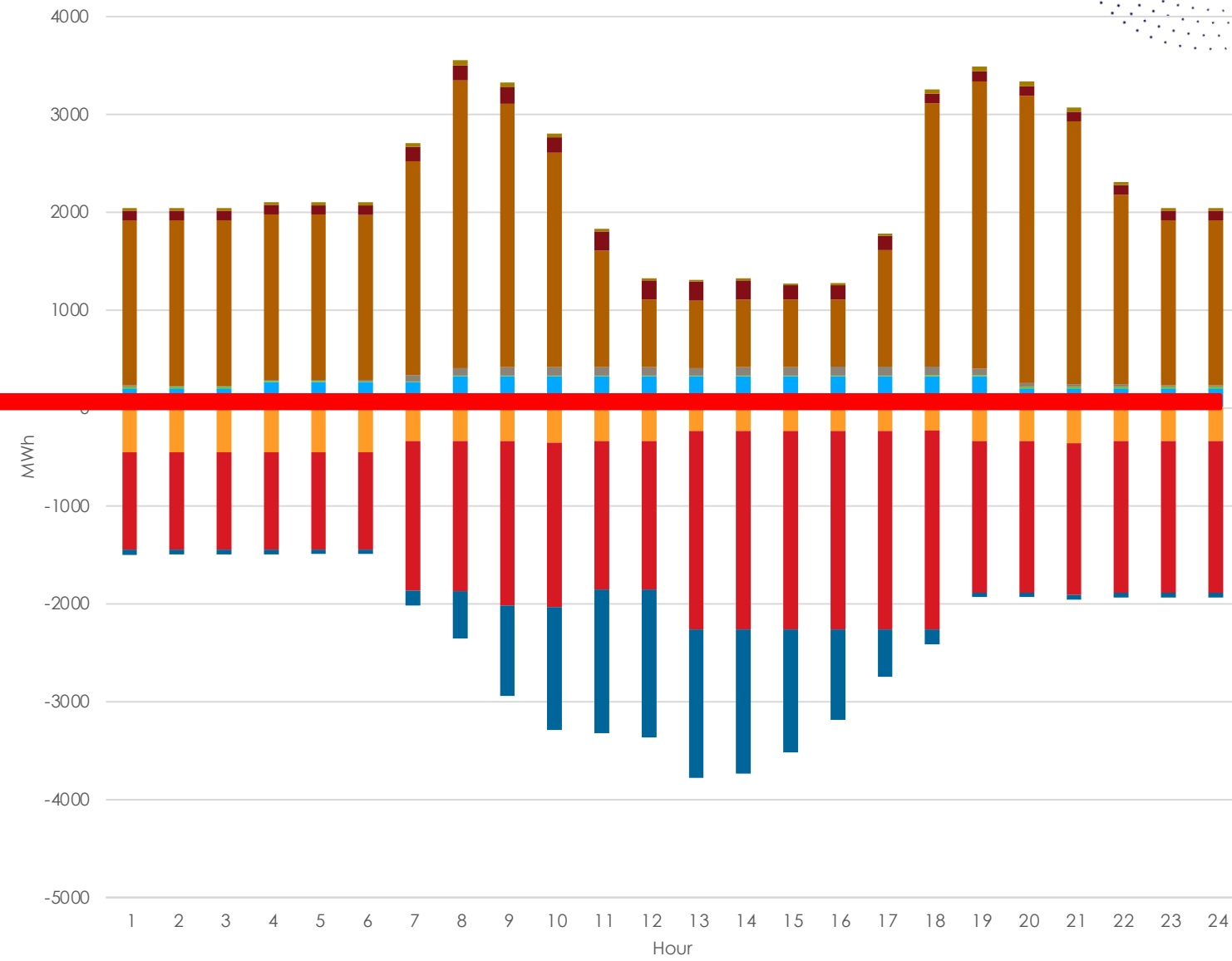
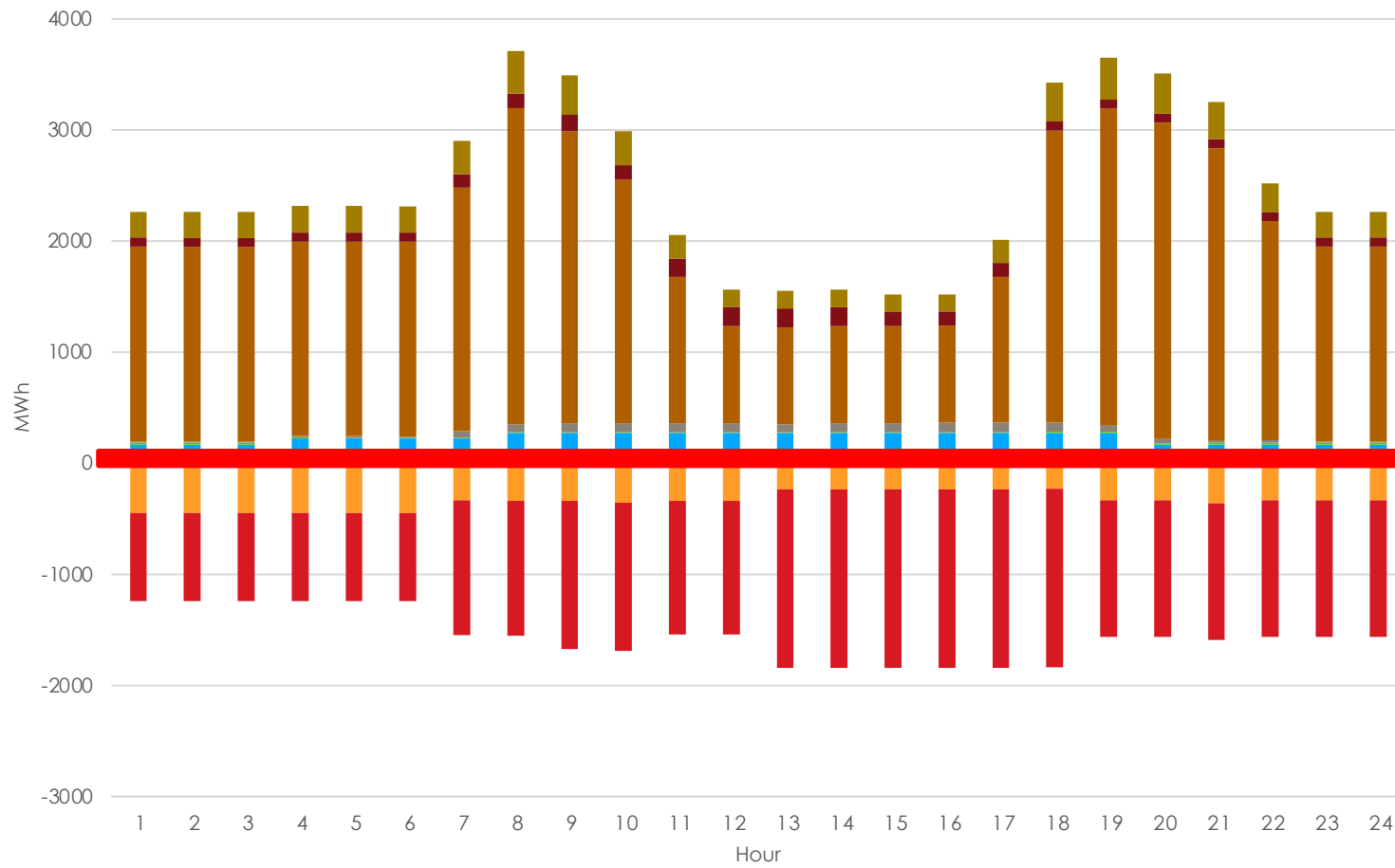
- Domestic generation-Fossil
- Industrial and Commercial
- Public Sector
- Other heavy activities
- Domestic generation-Solar&Wind
- Domestic generation-Hydro
- Irrigation and pumps
- Residential
- Losses (T&NT)

# Measures Scenario (intraday load)

Electricity balance - Projection (winter peak day/hourly)

2025 2040

Electricity balance - Projection (winter peak day/hourly)



- Domestic generation-Fossil
- Domestic generation-Hydro
- Export
- Industrial and Commercial
- Irrigation and pumps
- Public Sector
- Residential
- Other heavy activities
- Losses (T&NT)
- Domestic generation-Solar&Wind

## 1. Measures shift the system from deficit to a stable **annual surplus**

Until 2027, the system remains close to balance with a **small deficit**:

- 2026: -2.86 TWh
- 2027: -2.84 TWh

From 2028 onwards, following solar and wind deployment, the balance shifts **sharply into surplus**:

- 2028: +1.17 TWh
- 2030: +5.5 TWh
- 2040: +11.0 TWh

Main sources of impact:

- Solar and wind deployment: up to ~10.4 TWh by 2040
- Loss reduction: from ~2.5 to ~0.23 TWh

## 2. Winter remains a bottleneck despite annual surplus

Even with a large annual surplus, **winter months remain deficit-driven**.

2040 (with measures):

- January: -0.26 TWh
- February: -0.30 TWh
- March: -0.68 TWh

## 3. Intraday profile changes fundamentally: surplus during the day, deficit in the evening

2026:

- Evening peak: ~2.1–2.2 GW
- Night hours: moderate deficit

2040 (with solar and wind):

- Daytime: **deep surplus** (up to 2.0–2.5 GW)
- Evening peak (18:00–20:00): **deficit** up to ~1.4–1.5 GW

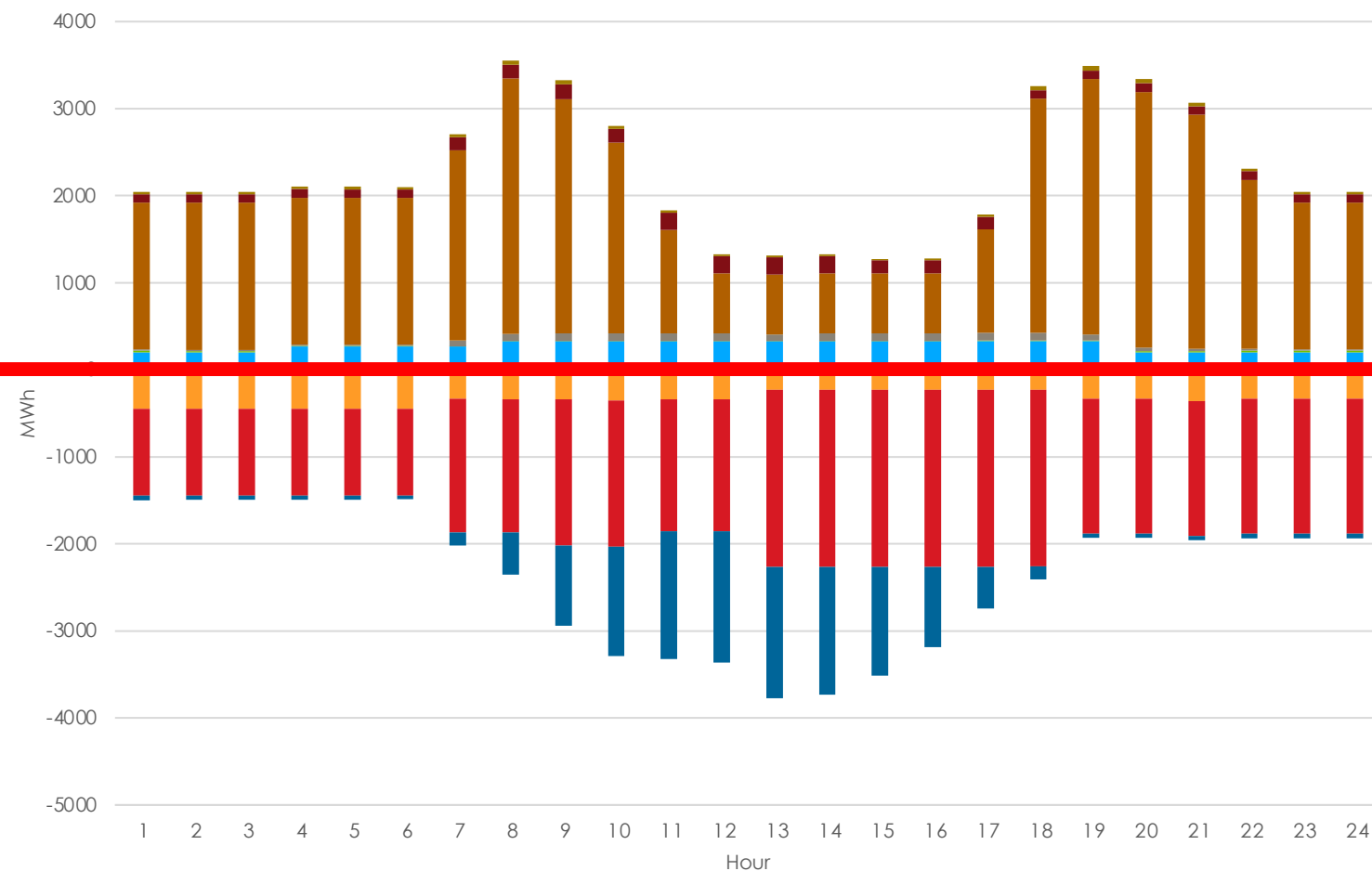
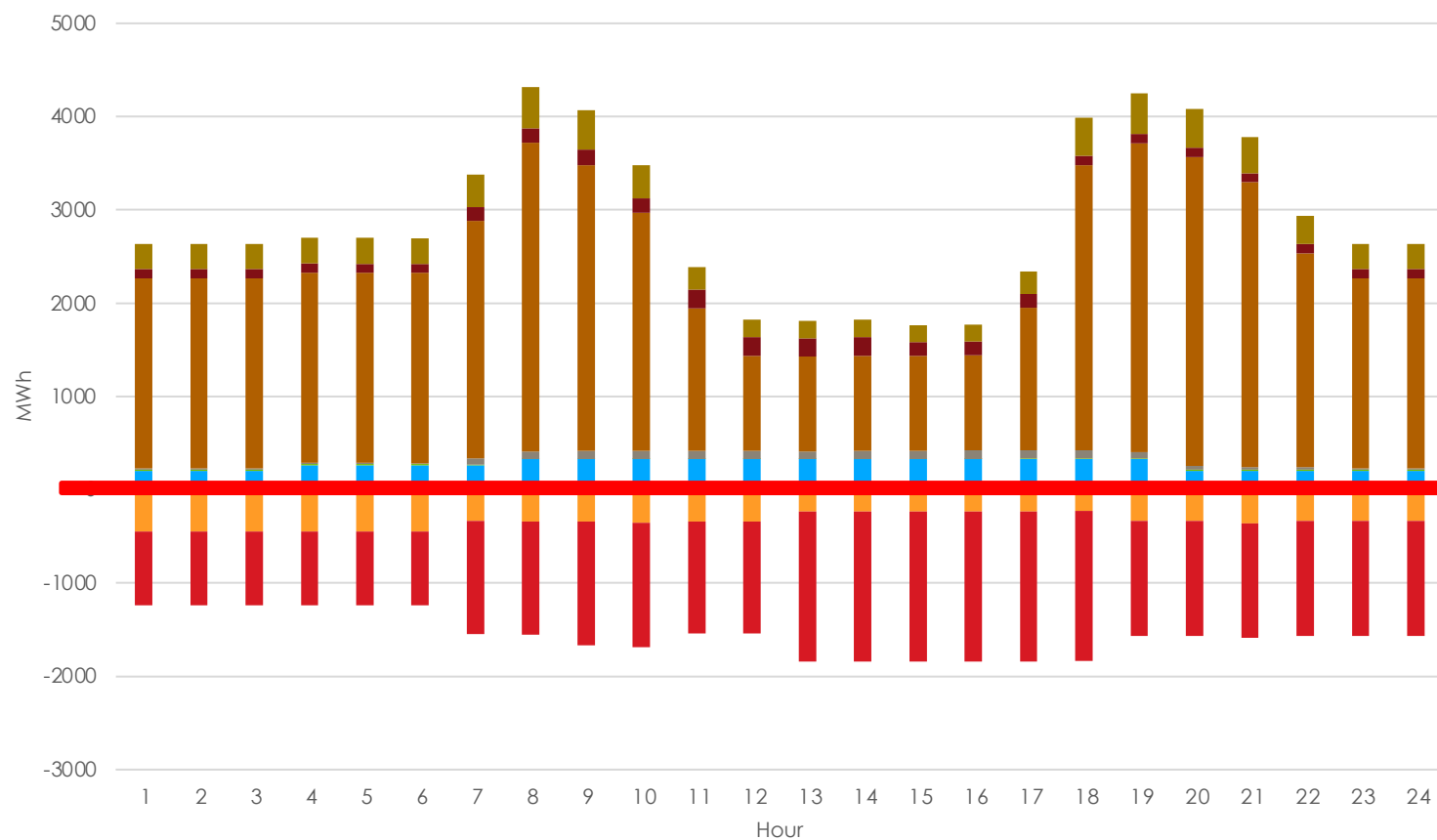
# Scenario Comparison (2040)

Electricity balance - Projection (winter peak day/hourly)

**DEFAULT**

**MEASURES**

Electricity balance - Projection (winter peak day/hourly)



- Domestic generation-Fossil
- Industrial and Commercial
- Residential
- Domestic generation-Solar&Wind
- Domestic generation-Hydro
- Irrigation and pumps
- Other heavy activities
- Export
- Public Sector
- Losses (T&NT)

## 1. Reliability is assessed over time, not “on an annual average”

The model simultaneously evaluates:

- Annual load
- Seasonal load
- Intraday peaks

This allows early identification of critical hours and months of system risk.

Decisions are based on **stress periods, not averages.**

## 2. Measures are evaluated by system impact, not in isolation

Each measure is assessed through its impact on:

- Peak coverage
- Winter reliability
- Supply–demand balance

The model shows **which measures improve annual statistics but fail to resolve reliability risks.**

## 3. Built-in sensitivity and scenario testing

The tool allows testing of:

- Sector-specific demand growth
- Price elasticity of consumption
- Acceleration or delay of capacity commissioning

Results are immediately visible in:

- Winter load
- Evening peaks

## 4. Reduction of fiscal and investment risks

The model identifies:

- When exactly deficits occur
- Where emergency and costly solutions will be required

It enables comparison of measures by system-level effect, supporting decisions on:

- Sequencing of measures
- Optimal timing of investments

The focus shifts from **“what to build”** to **“when and why to spend public money.”**

## 1. Key Takeaways

Scenario modelling enables **comparison of solutions before implementation**, not ex post

Time-based assessment (**annual, seasonal, intraday**) provides a more complete picture of system adequacy

The tool supports decision-making under uncertainty rather than fixed forecasts

## 2. Practical value:

A single **analytical foundation** for discussions across:

- energy,
- tariffs,
- environment, and
- public finance

Ability to test within one tool:

- alternative development paths
- policy packages, and
- decision timing

## 3. Next Steps

Calibration of model parameters using national data

Expansion of scenarios for concrete policy tasks:

- tariff decisions
- capacity commissioning
- energy efficiency measures

Gradual development of the tool:

- integration of CO<sub>2</sub> emissions and climate targets,
- linkage with investment and financial assessments