Case Guidelines

🤔 1. Who We Are

NOX Energy is a software platform that bridges the gap between **energy utilities** and the **electrical assets of their residential customers.**

We help utilities become more competitive by **optimizing consumption** across assets like **heat pumps, solar panels, EV chargers, and batteries**, reducing energy bills and improving sustainability.

To achieve this, we build **digital twins** of these assets, allowing **real-time control and participation in energy markets** — such as balancing and trading — all while maintaining user comfort and system efficiency.

📑 2. Case Introduction

💡 The Challenge

Balance Responsible Parties – BRPs (≈ Energy suppliers) must ensure that their **electricity portfolio is balanced** — meaning that the **total supply** they inject into the grid matches their customers' **total consumption**.

When a BRP's actual supply and demand differ, it creates an **imbalance**. The BRP must then **pay (or receive)** the corresponding **imbalance costs -** penalties that directly affect profitability and customer prices.

In a market like **Belgium**, where renewables and consumer behaviour are highly variable, these imbalances are frequent and costly.

Your mission:

> 🧠 Develop a model that predicts the imbalance for the next quarter hour, updated every minute throughout the day.

This model will help NOX Energy and energy suppliers **anticipate deviations**, **reduce imbalance penalties**, and **improve trading strategies**.

🧩 Expected Final Product

Participants are expected to build a **working prototype or proof of concept** that:

- Predicts **the imbalance value for the next quarter hour (15-min period)**.
- Updates every minute using real-time and historical signals.
- Demonstrates **strong feature engineering** and **novel data extraction** — think creatively!

Examples of innovative features:

- Derived weather variables (temperature gradients, solar proxies, etc.)
- Calendar or behavioral patterns (e.g., workdays, holidays)
- Market relationships (day-ahead vs. real-time signals, system imbalance forecast)

💡 Out-of-the-box ideas are strongly encouraged — use any public data that can improve prediction accuracy!

👥 End Users and Stakeholders

- **End User:** NOX Energy operational & data teams
- **Stakeholders:** Energy suppliers, flexibility aggregators, and system operators (e.g., **Elia**)
- **Goal:** Help utilities predict imbalance and make smarter real-time trading decisions

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🔍 3. Further Information

To **train** and **test** your model, NOX Energy provides you with curated datasets containing **Belgian market and system signals** relevant to imbalance prediction.

These datasets replicate what energy utilities and aggregators use in real operations — including **day-ahead prices**, **real-time imbalance costs**, and **Elia's imbalance forecasts**.

However, to generate **live predictions**, your solution should interact with **real-time APIs** (see below).

🧠 Prediction Task

Starting from 18:29, each team must:

- Generate a **prediction for the imbalance** of the **next quarter hour**.
- This prediction must be made **no later than 1 minute before the beginning of the next quarter hour**, using only data available up to that moment.
- Meaning predictions of
  - 18:30-18:45 must be sent the latest 18:29
  - 18:45-19:00 must be sent the latest 18:44
  - 19:15-19:30 must be sent the latest 18:59
  - 19:30–19:45 must be sent the latest 19:29
- **Submit your predicted imbalance value every 15 minutes to the jury through the email gdgkul@nox.energy with your team number/name and the quarter hour of the prediction.**

⛔ **No post-hoc calculations —** predictions must be made in real time using the same conditions you would face in production.

Your prediction will be evaluated against Elia's published imbalance data for the same period using the **Mean Absolute Error (MAE)** metric.

📊 4. Data Provided & APIs

⚡ Dataset Overview

You are provided with **three core market datasets**, all synchronized to **UTC timestamps** and formatted as **CSV**.

Each file contains consistent columns for easy merging and feature engineering.

File Name	Resolution	Source	Columns
`dam_prices.csv`	15 min	ENTSO-E Transparency Platform	`datetime_utc` – exact UTC timestamp of record `date` – calendar date (YYYY-MM-DD) `hour` – hour of day (0–23) `minute` – minute of record `price_eur_mwh` – price in €/MWh
`imbalance_actual.csv`	15 min	Elia Open Data (**ODS134**)	`datetime_utc` – exact UTC timestamp of record `date` – calendar date (YYYY-MM-DD) `hour` – hour of day (0–23) `minute` – minute of record `price_eur_mwh` – imbalance price in €/MWh
`imbalance_forecast.csv`	1 min	Elia Open Data (**ODS161**, historical data pre-saved by NOX)	`datetime_utc` – exact UTC timestamp of forecast `date` – calendar date (YYYY-MM-DD) `hour` – hour of day (0–23) `minute` – minute of record (1-min resolution) `price_eur_mwh` – predicted imbalance price in €/MWh

🏦 Data Descriptions & Relevance

1. Day-Ahead Market (DAM) Prices

- The **wholesale electricity price** set one day in advance by the **ENTSO-E market**.
- Every day, market participants submit buy/sell bids for each **15-minute delivery period** of the next day.
- The market clears when supply meets demand, setting a **uniform clearing price (€/MWh)** per interval.

- **Be aware**: the data is expanded to 15-minute because prices went from hourly to quarter-hourly on the 1st of October 2025.

Relevance to NOX:

These prices define the *reference schedule* energy suppliers commit to. Deviations from these day-ahead commitments result in **imbalances**. Comparing day-ahead and real-time imbalance prices helps NOX and suppliers evaluate **flexibility opportunities** and **trading efficiency**.

🧩 **API Access:**

ENTSO-E Transparency Platform (Belgium Zone)

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2. Actual Imbalance Prices

- Represents the **real-time financial penalty or reward** (€/MWh) imposed by **Elia**, the Belgian Transmission System Operator.
- Whenever total generation and consumption in Belgium
- diverge, Elia must activate reserves — at a cost that is passed through the **imbalance price**.
- If generation < demand, the imbalance price increases (expensive upward balancing).

  If generation > demand, it decreases (cheap downward balancing).

Relevance to NOX:

This is the *true real-time cost signal*. Predicting or responding to imbalance prices allows NOX to **control distributed assets (e.g., heat pumps, EVs, batteries)** to either avoid penalties or capture revenue by supporting grid balance.

🧩 **API Access:**

Elia Open Data – Actual Imbalance Price (ODS134)

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3. Forecasted Imbalance Prices

https://www.elia.be/en/grid-data/balancing/imbalance-prices-forecasts

- Published by **Elia** as dataset **ODS161**, these are **short-term imbalance price predictions** updated **every minute**.

- The forecasts estimate the **upcoming imbalance price** for the *current* 15-minute period, using real-time system measurements (production, consumption, reserves, renewables, etc.).

How It Works:

- At each minute, Elia updates its forecast for the **current quarter hour**.
- As time progresses and more real data is collected within a given quarter-hour, the forecast becomes **more accurate**.
- For example, the forecast made at 19:18 for the 19:15–19:30 quarter will generally be less accurate than the forecast made at 19:25 for the same quarter, since system deviations become clearer near the end of the interval.
- At the end of each quarter-hour, the forecast is “reset” for the new quarter-hour estimation.
- Your key challenge here is to **predict the upcoming quarter-hour imbalance** just before it begins — i.e., when uncertainty is highest.

Relevance to NOX:

If your model can **outperform or complement** Elia’s real-time forecasts, it becomes a valuable decision-support tool for NOX’s flexibility control system — allowing more efficient energy dispatch and reduced imbalance penalties.

🧩 **API Access (live-only, no history):**

Elia Open Data – Imbalance Price Forecast (ODS161)

> ⚠️ Note: Elia’s API only provides forecasts for the current day — it does not offer historical records.
>
> Therefore, NOX provides **historical forecasts starting from 2025-07-24 13:52:00** to enable proper model training and evaluation.

📅 Data Availability

You are provided with:

- **Historical data (up to 28 October 2025) of 2024-2025** for:
    - `dam_prices.csv`

    - `imbalance_actual.csv` (from 2024-05-21 onward)
    - `imbalance_forecast.csv` (from 2025-07-24 onward)
- **Real-time access** via APIs for:
    - Day-Ahead Market (ENTSO-E)
    - Actual Imbalance (Elia ODS134)
    - Forecasted Imbalance (Elia ODS161 — current day only)

💻 Example: Fetching Latest Imbalance Forecast (Pseudo-code)

```
function get_latest_imbalance_forecast():
    url = "https://opendata.elia.be/api/explore/v2.1/catalog/datasets/ods161/records"
    params = {
        "limit": 1,
        "order_by": "datetime DESC"
    }
    response = HTTP_GET(url, params)
    if response.ok:
        record = response.json()["results"][0]
        return {
            "timestamp": record["datetime"],
            "quarterhour": record["quarterhour"],
            "imbalance_price": record["imbalanceprice"]
        }
    else:
        return None
```

🌦️ Weather Data (Open-Meteo)

You are encouraged to include **meteorological features** — weather strongly affects renewable production and consumption, which in turn drive imbalances.

Purpose	Endpoint	Use Case
Forecast / Real-time	`/v1/forecast`	Get current and near-future conditions (temperature, wind, solar irradiance, etc.)
Historical	`/v1/archive`	Retrieve past weather data for model training
Reanalysis	`/v1/historical-forecast`	Use historical forecasts to simulate real operational conditions

🔗 Open-Meteo Documentation

Recommended Variables:

Temperature, wind speed, solar irradiance, cloud cover, precipitation, humidity, surface pressure, etc.

You can enhance them with **derived features** — e.g., temperature gradients, rolling averages, or forecast errors.

🌍 Additional Data Suggestions

To boost accuracy, consider adding:

- **Renewable generation forecasts** (solar/wind from Elia or ENTSO-E)
- **Public consumption data**
- **Calendar effects** (weekday/weekend, holidays)
- **Market signals** (EPEX SPOT, reserve prices, etc.)
- **Behavioral or temporal patterns** (rush hours, workdays, temperature lags)

🧮 5. Judging Criteria

Primary Evaluation: Mean Absolute Error (MAE) on the next-quarter-hour imbalance prediction.

Criteria	Weight	Guiding Questions
Technical Accuracy	50%	How accurate is your model's forecast?
Innovation & Creativity	30%	Did you introduce unique features or creative data sources?

Criteria	Weight	Guiding Questions
User Experience & Presentation	15%	Is your solution well explained, clear, and visually engaging?
Impact & Relevance	5%	Does it provide real value to NOX Energy or the wider grid ecosystem?

💡 *Bonus points for interpretability, visual dashboards, or creative model visualization.*

📞 6. Technical Contact Points

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