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Uzbekistan’s electricity demand forecasting: an outlook until 2035

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**PolicY STUDY**

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Executive summary

This study models **electricity demand in Uzbekistan up to 2035**, evaluating the potential impact of various economic and policy assumptions on the country’s electricity needs. Uzbekistan is experiencing rapid population growth and a transitioning economy, with electricity consumption patterns expected to evolve due to factors such as increasing industrialization, the electrification of transportation, and the implementation of energy efficiency measures.

The demand forecasts in this study are based on the **Prophet forecasting framework**, employing a long-term top-down modelling approach. To explore the range of possible future electricity demand scenarios, three distinct model variants are presented in this study. These variants differ in the external variables they incorporate, such as GDP growth, sector-specific consumption, and the potential impact of tariff reforms. By adjusting these variables, the model variants provide insights into how different factors could influence electricity demand in Uzbekistan over the coming years.

The model results show that Uzbekistan’s electricity demand is **expected to increase significantly** by 2030 and 2035. The forecasts range between **109-123 TWh** in **2030** and **131-151 TWh** in **2035**, representing a 35-52% and 62-87% increase from 2023, respectively. External factors such as GDP growth expectations, sectoral shifts, and tariff changes were found to significantly influence the projections. These findings highlight the importance of making informed decisions based on evidence-driven projections to avoid both underestimating and overestimating future demand.

To meet future electricity demand while supporting economic growth, this study emphasizes several **key policy recommendations**. First, the establishment of **in-house forecasting capabilities** will enable Uzbekistan to produce precise demand projections tailored to its unique economic and sectoral dynamics. **Robust generation capacity planning** is also essential, incorporating a **capacity reserve margin** to address variability in renewable energy sources and ensure system reliability. Additionally, the continuation of **tariff reforms**, coupled with strengthened social support mechanisms, will promote cost-reflective pricing without overburdening vulnerable households. Finally, strengthening **demand-side management (DSM)** through digital tools and real-time analytics can optimize grid performance and balance growing energy needs, particularly as electric vehicle adoption rises.

This study provides a valuable foundation for policymakers in Uzbekistan, offering insights into the complexities of energy demand forecasting and the potential implications for future energy policy and infrastructure development. The findings emphasize the need for flexibility in planning, as well as a multi-scenario approach to address the uncertainties that inevitably accompany long-term energy planning.

Introduction

Uzbekistan is experiencing **significant transformations in its energy sector**, driven by economic and population growth and pressing challenges related to energy security. The country’s reliance on diminishing domestic natural gas reserves, combined with rising demand and increasing import reliance, has placed substantial pressure on its energy infrastructure. The energy crisis of 2022/2023, which saw blackouts and supply shortfalls, underscored the urgency of addressing these issues. Apart from the mentioned growth factors, the country’s electricity demand is also expected to rise substantially due to industrial expansion over the next decade. Conversely, improvements in energy efficiency have a dampening effect on consumption. In light of these dynamics, forecasting Uzbekistan's electricity demand over the coming years is essential to make the right investment choices to meet the electricity demand in the most cost-efficient way without endangering energy security.

This study aims to **forecast Uzbekistan's electricity demand for 2030 and 2035**. By evaluating multiple scenarios, the study seeks to provide insights into potential future electricity consumption patterns, assess the implications of different growth trajectories, and inform policymakers about the strategic planning necessary to meet anticipated demand without incurring excessive costs. Understanding these dynamics is crucial for ensuring that Uzbekistan's energy infrastructure can support economic growth while also transitioning to a more sustainable energy model.

This policy study is structured as follows. Chapter 2 delves into the current economic landscape and electricity sector in Uzbekistan. Chapter 3 offers an overview of long-term forecasting methods, details the methodology employed, and outlines the various model variants developed. Chapter 4 presents and analyses the results of the models. Finally, Chapter 5 discusses potential implications for policymaking, and Chapter 6 concludes.

# Country context

This section provides an overview of the key factors driving electricity demand in Uzbekistan and the challenges the energy sector faces in meeting these needs, as well as the ongoing reforms designed to modernise the sector and ensure it can support the country’s future growth.

## Electricity sector development and challenges

Uzbekistan's economy has grown consistently over the past two decades, with GDP in constant 2020 UZS rising from UZS 175 trillion in 2000 to UZS 728 trillion in 2023 and is projected to reach UZS 1,055 trillion by 2030.[[1]](#footnote-2),[[2]](#footnote-3) Annual growth rates fluctuated, peaking at 9.5% in 2007 and remaining high during the late 2000s. However, it should be noted that statistical figures prior to 2017 are not considered particularly reliable. After a slowdown to 4.4% in 2017, the economy rebounded in subsequent years, despite a dip to 2% in 2020 due to the COVID-19 pandemic. Between 2021 and 2023, real GDP growth reached around 6% p.a., reflecting a stable recovery. Such growth spurs greater energy consumption across industries and households. In tandem with economic growth, the living standards of Uzbekistan’s citizens have been rising, resulting in increased use of electricity-intensive appliances and equipment.

Figure 1: GDP in constant prices and its real growth rate, 2000-2023

*Source: International Monetary Fund, World Economic Outlook, April 2024. Note: GDP at constant 2020 UZS.*

Uzbekistan’s population has grown steadily since 2000, with an annual growth rate rising from around 1.2% in the early 2000s to 2.05% in 2023. This growth is expected to continue, with the population projected to reach 43 million by 2030. Combined with a trend toward urbanisation, this development will amplify the demand for reliable electricity services across the country.

Figure 2: Population and its growth rate, 2000-2022

*Source: United Nations, World Populations Prospects 2024*

Uzbekistan’s energy system is under mounting pressure as rising **economic growth, industrialisation, and urbanisation** fuel unprecedented demand for electricity. This increasing demand places strain on infrastructure, revealing **critical gaps in supply** and challenges in regional transmission. Currently, highly subsidised electricity tariffs provide little incentives to save energy for consumers, are not attractive for energy system investors and create (quasi-)fiscal deficits for the government. Despite recent tariff reforms, the electricity prices are still not cost-covering. These gaps in supply, along with inefficiencies across sectors, highlight the urgent need for **comprehensive reforms**.

While substantial reforms have been underway since 2016 to liberalise Uzbekistan’s economy, the electricity sector remains constrained by legacy regulatory structures and operational inefficiencies. These limitations hinder its scalability to meet future demands effectively. Reform is essential not only to **accommodate rising demand** but, more fundamentally, to **address systemic inefficiencies** and enable the energy sector to evolve into a resilient and sustainable foundation for Uzbekistan’s ongoing development.

Figure 3: Electricity consumption, 2014-2023

*Source: CDC Energiya*

## Sector reforms and future needs

To address these challenges, Uzbekistan has introduced several policy changes and tariff adjustments aimed at fostering greater efficiency and financial sustainability in the energy sector. In 2024, the government implemented a tiered electricity tariff system that imposes higher rates on households with larger consumption levels. This approach encourages efficient energy use while easing the financial burden on low-consumption households. Additional tariff increases are scheduled for 2025 as part of the government's broader strategy to reduce subsidies and promote cost recovery within the sector.[[3]](#footnote-4)

Moreover, Uzbekistan established the Agency for Development and Regulation of the Energy Market to oversee sector liberalisation. Since 1 July 2024, centralised electricity trading is managed by Uzenergosotish JSC, fostering competition and attracting private investment.[[4]](#footnote-5) This shift is crucial for modernising infrastructure and ensuring a reliable power supply amid rising demand, aligning with the government’s vision for a more resilient and sustainable energy framework.

In light of this, a reliable electricity demand forecast is essential for supporting these reforms, making informed decisions, and planning for future infrastructure needs to meet the country's evolving energy demands. Estimates from the Ministry of Energy suggest a demand of 120.8 TWh by 2030, while a study conducted by the China Electric Power Planning and Engineering Institute (EPPEI) at the Ministry’s request projects a range from 118.2 TWh (conservative) to 137.3 TWh (accelerating growth). Given recent developments in Uzbekistan’s economic and energy landscape – including tariff adjustments and expanding electric vehicle adoption – an updated forecast that employs a flexible, adaptive model is useful for capturing these evolving dynamics using the most recent data available through 2023.

Figure 4: 2030 consumption and its peak load forecasts from different sources

*Source: Ministry of Energy, EPPEI “Power System Planning Study in Uzbekistan, 2024”.*

# Model

In the following sub-chapters, we first provide an overview of various methodologies and models commonly used for electricity demand forecasting, presenting the different approaches that could be applied. We then focus on the methodology selected for this study, explaining de advantages of the chosen model in detail. Finally, we describe the input data and how it shapes the three distinct model variants developed to capture different potential future scenarios.

## Methodology

**Overview of electricity demand forecasting models**

Load forecasting serves various purposes depending on its time frame. In the short term, it is typically used for dispatch planning, requiring precise and detailed predictions over a period of hours or days. For long-term forecasting, the focus shifts to assessing generation adequacy and supporting investment decisions that span months or years. Forecasts play a crucial role at both the distribution and transmission grid levels, and they are often categorised into regional or national forecasts based on the scope of the analysis. **The focus of this analysis is long-term forecasting on the national level.**

Long-term forecasting methods include **bottom-up** and **top-down** approaches. **Bottom-up approach models** generate forecasts at the customer level. The data of individual consumers is aggregated to predict total demand. These models excel at capturing the impact of technological advancements and specific consumer behaviours, as they rely on detailed data about the use of specific devices and processes, e.g. industrial machinery or household appliances.[[5]](#footnote-6) The **main limitation** of this approach **is the data intensity** required to maintain accuracy over long periods. Bottom-up models need extensive data on appliance use, consumer behaviour, and technological characteristics, which is often unavailable. Furthermore, such models may overlook broader macroeconomic trends that influence electricity demand on a national level. A common tool used for this is the LEAP (Low Emissions Analysis Platform) model, which offers flexibility in modelling different scenarios, from energy demand to CO2 emissions.[[6]](#footnote-7) However, while LEAP is comprehensive in addressing energy demand at granular levels, it requires precise data inputs, limiting its application where such data is scarce. Given the **lack of openly available granular data** in Uzbekistan, we conclude that the **bottom-up approach for electricity demand forecasting is not feasible**.

**Top-down models** use broader economic indicators like GDP, population growth, and weather data to forecast demand at the macro level. Such models perform better in macroeconomic analysis, providing insights into how large-scale factors drive electricity demand. For long-term forecasting, top-down models are particularly effective in data-scarce environments, where the detailed data required for bottom-up approaches may be unavailable. In countries with rapidly growing economies, such as Uzbekistan, this approach helps capture the impact of industrialisation and population growth on electricity demand. It can also produce accurate forecasts by utilising historical demand data alongside macroeconomic variables.

Table 1: Comparison table between common forecasting approaches

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Technique | Description | Strengths | Limitation | Application |
| Regression analysis | Uses statistical methods to model the relationship between demand and variables like GDP and population | Straightforward; interpretable; well-suited for capturing linear relationships | Assumes linear relationships, which may not capture complex dynamics | Effective for environments where demand drivers are primarily economic |
| Time-series forecasting | Analyses historical demand data to identify trends and seasonal patterns | Good for identifying trends and seasonality, particularly when extensive historical data is available | Limited by its reliance on internal data patterns as it is challenging to include external variables | Suitable for stable environments with consistent historical data |
| AI-based | Utilises machine learning models to capture non-linear relationships in large datasets | Handles complex, non-linear relationships; adaptable to high-dimensional data | Often lacks interpretability; can be data-intensive and computationally demanding | Useful in data-rich environments with complex demand dynamics; applicable in fast-evolving markets |
| Additive models | Incorporates both linear and non-linear components; can include external variables like weather and GDP | Handles seasonality well; robust to missing data; allows inclusion of external regressors; interpretable | May require careful tuning; does not inherently capture highly complex non-linearities as well as AI models | Well-suited for seasonal-driven demand, where external factors have significant impact; applicable for data-scarce environments |

*Source: Mir et al. (2020)[[7]](#footnote-8), Steinbuks et al. (2017)[[8]](#footnote-9), Das, Dey (2021)[[9]](#footnote-10)*

**Model chosen: Prophet**

*Hybrid model combining* ***time-series forecasting*** *and* ***additive modelling***

Given the outlined options for electricity demand forecasting, the **Prophet model** developed by Meta (formerly Facebook) was selected for this study. Prophet is a robust, flexible tool designed for forecasting time series data that demonstrates patterns of seasonality, trends, and occasional irregularities. It combines the strengths of time-series analysis and additive modelling, providing reliable forecasts even when missing data or unusual trends are present. The model has been widely adopted in peer-reviewed research[[10]](#footnote-11),[[11]](#footnote-12) and is frequently used for demand forecasting, as it is well-suited for datasets involving **recurrent seasonal patterns and trend shifts**.

Prophet was selected for its notable advantages in addressing the complexities of Uzbekistan’s electricity demand forecasting:

* **Seasonality and trend** handling: Prophet is adept at capturing seasonal variations and long-term trends crucial for accurate forecasting in Uzbekistan's dynamic economy. It can effectively manage **multiple seasonalities**, capturing variations on daily, weekly, and yearly levels – essential for modelling electricity demand accurately.
* Integration of **external regressors**: Prophet allows for the inclusion of external variables (e.g., GDP or sectoral data), enhancing its predictive capability.
* **Usability and interpretability**: Prophet generally handles raw data effectively without requiring extensive transformations (such as logarithmic or differencing), which enhances usability and preserves data integrity. This flexibility simplifies data preparation and contributes to the interpretability of the model's outputs, facilitating data-driven decision-making.
* **Open-source transparency**: As an open-source model, Prophet fosters transparency and facilitates reproducibility. This enhances the model's credibility, allowing researchers and practitioners to verify results and build upon existing work more easily.

Overall, the Prophet model is well-suited for top-down, long-term electricity demand forecasting in Uzbekistan. Its capacity to incorporate external factors, manage seasonality, and work with raw data makes it a valuable tool for understanding and projecting the complex dynamics of electricity demand.[[12]](#footnote-13)

To test the accuracy of our forecasting model, we implemented a train-test split of the data, using historical data from 2014 to 2019 for training the model, while reserving data from 2020 to 2023 for testing purposes. This approach allows us to evaluate the model's predictive performance on more recent, potentially volatile data, which is essential for understanding the evolving dynamics of electricity demand in Uzbekistan. To evaluate forecast accuracy, we utilise the Mean Absolute Percentage Error (MAPE) metric, which is particularly valuable as it provides a percentage-based assessment of forecast accuracy. This characteristic allows for easier interpretation of the model's performance in relation to the scale of the actual data and facilitates comparisons across different forecasts.

As the Prophet model extrapolates from historical data, it tends to smooth out irregular spikes that often cause peak loads. This approach produces a forecast with narrower and more uniform daily fluctuations. To account for the potentially underestimated peak loads, we use a robustness check that scales the 2023 hourly demand profile to match the projected 2030 annual demand across the variants. This adjustment suggests peak load estimates that are 11–16% higher than those generated directly by the model. Accordingly, when presenting the results we report peak loads increased by 16%.

## Data and model variants

This section outlines the input data and assumptions that form the four distinct model variants, designed to capture a range of possible future developments in Uzbekistan's electricity demand. Detailed descriptive statistics of all input variables are presented in the Annex.

The forecast variable is **hourly national electricity demand** (measured in MW), from 2014 to 2023, sourced from *CDC Energiya*. This data includes technical losses in the grid and own consumption by power plants. We do not estimate this separately from actual consumption. However, if losses are reduced in the future, our presented model might overestimate electricity demand. The hourly resolution of the forecast allows us to derive not only the annual electricity demand in TWh (aggregated across all hourly values) but also provides a generic demand path across daily, weekly, and yearly levels, capturing the regular seasonal patterns that drive electricity consumption over time.

Figure 5: External explanatory variables included in each model variant

*Source: Own illustration.*

**“Steady growth” model variant**

The first model variant incorporates **GDP** as an external regressor, recognising that economic growth tends to drive increased electricity demand as higher levels of activity usually lead to more energy consumption. The relationship between GDP and electricity demand, however, may not be strictly linear. While rising incomes can increase demand through greater appliance use or sectoral electrification, they can also lead to efficiency improvements that may reduce consumption. Observing this co-movement over time through our rich data set helps provide more accurate demand forecasting. Moreover, including GDP enhances historical consumption trends by integrating assumptions about future economic developments. Factoring GDP growth into the demand forecast helps to avoid a scenario where limiting power supply could inadvertently constrain economic growth, a key concern in system adequacy planning.

The yearly data is measured in constant 2020 Uzbek Som (UZS) to abstract from inflation and exchange rate variations. Historical data and forecasts up to 2029 have been obtained from the International Monetary Fund (IMF)[[13]](#footnote-14), while projections from 2030 to 2035 assume a stable growth rate of 5.5%. This yields a GDP of 2020-UZS 1,055 tn in 2030 and 2020-UZS 1,379 tn in 2035 – an increase of 45% or 90% compared to 2023, respectively. A key challenge in using Uzbekistan’s GDP figures is the reported overstatement of economic growth rates over the years.[[14]](#footnote-15) To account for this, GDP growth rates were adjusted downwards by 4 percentage points prior to 2017.[[15]](#footnote-16)

The Ministry of Energy has reported that an estimated 10% of Uzbekistan’s electricity demand goes unmet due to capacity constraints.[[16]](#footnote-17) We assume that, through capacity expansion efforts, Uzbekistan will fully meet this previously unmet demand by 2030. To account for this potential underestimation of actual demand, the electricity consumption projection for 2030 and after is increased by 10%, with values for the years 2024 to 2029 adjusted linearly to reflect the gradual resolution of these supply limitations. This adjustment will equally be done to the following model variants.

**“Sectoral expansion” model variant**

The “Sectoral expansion” model variant extends the baseline model by incorporating **additional sector-specific electricity consumption** data. This adjustment addresses the limitations of relying solely on GDP trends by accounting for the distinct drivers of electricity demand within various sectors and reflecting **Uzbekistan’s evolving economic landscape**.

In this variant, annual electricity consumption from the industrial, transport, and residential sectors is used as external regressors, each contributing specific growth dynamics to the forecast. The data on sectoral electricity consumption, sourced from the International Energy Agency (IEA)[[17]](#footnote-18), covers the period from 2000 to 2022. For the years 2023 to 2035, assumptions are made based on historical trends and relevant sector-specific indicators:[[18]](#footnote-19)

* **Industrial electricity consumption**: Industrial demand is tied to industrial production (IP) growth. Given Uzbekistan's ambitious industrial expansion plans, incorporating this variable allows the model to better capture electricity demand from this key sector.
* **Transport electricity consumption**: Transport demand grows with population and the increasing share of electric vehicles (EVs). As EV adoption accelerates in Uzbekistan, particularly in line with global trends, transport electricity consumption is expected to become a more significant driver of demand.
* **Residential electricity consumption**: Residential demand is influenced by population growth and GDP per capita. These factors reflect demographic shifts and rising living standards, both of which are essential to understanding electricity consumption in this sector.

By expanding the model to include sector-specific data, the “Sectoral expansion” variant captures a more granular picture of electricity demand, offering a broader understanding of how sectoral shifts influence the overall national consumption.

**“Tariff impact” model variant**

Finally, this variant incorporates the **influence of electricity prices on demand**, recognising that price changes play a crucial role in shaping consumer behaviour. Not accounting for tariffs would miss an important aspect of demand forecasting. Although demand forecasts often face challenges when incorporating price variables – since prices can respond to supply-demand dynamics – in Uzbekistan, the government centrally controls electricity tariffs, so prices do not adjust directly to changes in demand. This allows for more stable modelling assumptions. Instead of including tariffs as a direct input, we rely on established elasticities from existing literature.[[19]](#footnote-20)

In May 2024, Uzbekistan implemented its first significant electricity tariff increase for households since 2019, as part of broader reforms aimed at reducing subsidies, improving energy efficiency, and achieving cost recovery. Further price adjustments are planned for 2025. For this model variant we account for the tariff adjustments that have already taken place in 2023 and 2024, and those that are planned for 2025. To isolate the effects of the current round of increases, we assume that real tariffs (i.e., net of inflation) remain unchanged from 2026 to 2035.[[20]](#footnote-21) This assumption is not meant to imply that constant real tariffs are a likely scenario, but rather serves as a necessary assumption due to the uncertainty around future tariff adjustments and their timing. Should further real tariff increases be necessary beyond 2025 to achieve cost recovery, it is likely that these would exert additional dampening effects on demand.

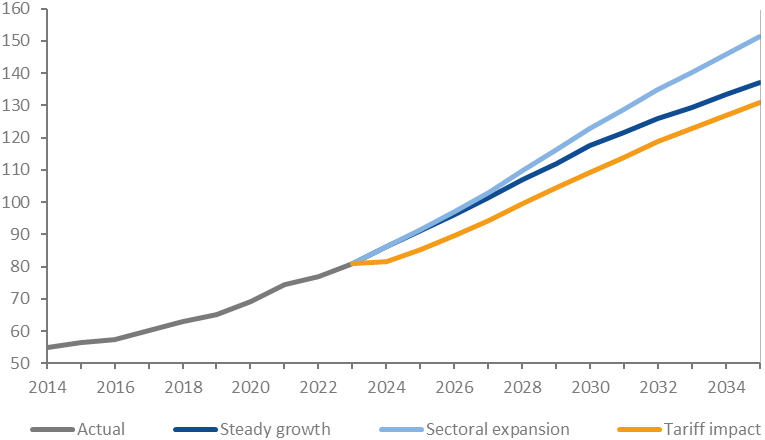
# Model results

This section presents the findings from the three model variants, starting with an overview of the projected electricity demand under each variant, followed by a detailed discussion of the forecast accuracy and comparisons with external forecasts.

## Demand forecast results

Figure **6** shows the different model variants’ forecasts in relation to historic demand development, and Table **2** displays the annual consumption and peak load in 2023 together with forecasts for 2030 and 2035. These results offer a range of electricity demand projections, helping to illustrate how different economic drivers and sectoral trends may shape Uzbekistan’s energy needs through 2035.

Figure 6: Annual electricity demand projection under the three model variants



**122.7117.5109.3**

**151.5137.2130.9**

TWh

**81.0**

*Source: CDC Energiya (2014-2023 data); own calculations (projected data).*

**“Steady growth”**

The "Steady growth" model projects Uzbekistan's annual electricity demand to reach **117.5 TWh by 2030** and **137.2 TWh by 2035** – a growth rate of 45% and 69% from the 2023 level of 81.0 TWh, respectively. Peak load is projected to increase from **12.4 GW in 2023** to **18.6 GW in 2030**, and **21.2 GW by 2035**. As shown in Figure **6**, this forecast exhibits a noticeably higher growth rate leading up to 2030. This pattern reflects the assumed catch-up effect, where demand grows more strongly as supply constraints are alleviated by capacity expansion.

These projections are anchored in historical consumption trends and the established relationship between GDP growth and electricity demand. This projection provides a benchmark scenario, where overall economic expansion primarily drives rising demand, absent major changes in consumption behaviour or policy interventions.

Table 2: Electricity demand projection under the three model variants

|  |  |  |  |
| --- | --- | --- | --- |
|  | Annual consumption (TWh) | | |
| 2023 | 81.0 | | |
|  | Steady growth | Sectoral expansion | Tariff impact |
| 2030 | 117.5 | 122.7 | 109.3 |
| 2035 | 137.2 | 151.5 | 130.9 |
|  |  |  |  |
|  | **Peak demand (GW)** | | |
| 2023 | 12.4 | | |
|  | Steady growth | Sectoral expansion | Tariff impact |
| 2030 | 18.6 | 19.2 | 17.4 |
| 2035 | 21.2 | 23.0 | 20.3 |

*Source: CDC Energiya (2023 data); own calculations (projected data). Note: Annual results for all remaining years are provided in the annex.*

**“Sectoral expansion”**

While the baseline model offers a conservative forecast based on historical patterns and GDP growth, it does not fully capture potential structural shifts in the economy. Historical data and GDP trends alone cannot account for significant changes in Uzbekistan's sectoral composition. As sectors like industry and transport electrify, the relationship between GDP growth and electricity demand will evolve, leading to upward pressure on consumption beyond what historical patterns would suggest. Moreover, if the sectoral composition of GDP changes – such as a potential rise in the share stemming from industry – this could increase the electricity intensity (electricity use per unit of GDP). Thus, incorporating sector-specific developments is essential for a more nuanced and comprehensive projection.

In Uzbekistan, industrial production is projected to nearly double between 2022 and 2030, and the share of electric vehicles is expected to triple, reflecting significant electrification within the transport sector. Additionally, GDP per capita is assumed to grow by 28% over the same period, contributing to increased electricity consumption across sectors.

Taking these sectoral assumptions into account in the “Sectoral expansion” variant, demand is projected to reach **122.7 TWh by 2030** (+52%) and **151.5 TWh by 2035** (+87%), with a **peak load of 19.2 GW and 23.0 GW**. By accounting for these sectoral dynamics, it offers a more detailed view of future demand trends, addressing structural breaks and sectoral shifts.

**“Tariff impact”**

The "Tariff impact" model introduces the influence of electricity prices on demand, recognising that price reforms play a critical role in shaping consumer behaviour. By incorporating tariff elasticity estimates, this model adds another dimension to the previous projections, acknowledging that Uzbekistan’s recent and planned price hikes will likely moderate demand growth.

Following the 2023-2025 tariff increases, the model assumes that electricity prices will start to reflect real costs – including generation, transmission, and distribution – thereby contributing to more efficient electricity use across sectors. Under this scenario, demand is projected to reach **109.3 TWh by 2030** (+35%) and **130.9 TWh by 2035** (+62%), a moderation compared to the "Steady growth" and "Sectoral expansion" variants. Similarly, also peak loads are more moderated at **17.4 GW and 20.3 GW**. This illustrates how reforms aimed at reducing subsidies and ensuring cost-recovery in the energy sector will likely temper overall demand growth.

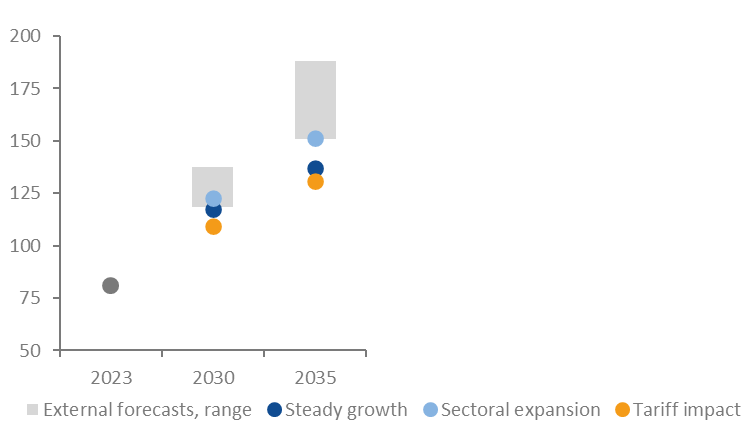
## Discussion of results

The projections from the different model variants present a range of growth patterns based on assumptions about sectoral and technological shifts. The first two variantsshow continuous growth in electricity demand, driven by economic advancements, assumptions that Uzbekistan will increase its power generation capacity enough to meet rising demand, and the latter also driven by the inclusion of sectoral expansions (particularly industrial and transport electrification). The "Tariff impact" model presents a distinct pattern, with demand growth flattening initially. This reflects the assumed response to real electricity tariff increases. After this initial adjustment, the model assumes that if no further tariff increases occur in real terms, demand will resume growing at a similar rate as the "Sectoral expansion" variant, though starting from a lower base.

Each of the three model variants demonstrates strong predictive accuracy when tested on hourly data from 2020 to 2023, each achieving a **Mean Absolute Percentage Error (MAPE)** of **around 5.5%**. Given the volatility in global economic growth during this period – alongside the energy-crisis influencing energy and electricity usage in Uzbekistan – these results enhance confidence in the model’s ability to forecast demand effectively under evolving future scenarios.

The **comparison with external forecasts,** visualised inFigure 7 reveals that both the "Steady growth" and "Sectoral expansion" models align closely with 2030 projections from the Ministry of Energy (120.8 TWh) and the conservative EPPEI scenario (118.2 TWh). The “Tariff impact” variant, however, based on Uzbekistan's tariff reform – announced and implemented after the two external forecasts were produced – projects a more conservative demand estimate, reflecting moderating effects from assumed real electricity tariff increases.

Figure 7: Forecast comparison for annual consumption and peak load



TWh

GW

Peak load

Annual consumption

*Source: CDC Energiya (2023 data); Ministry of Energy, EPPEI “Power System Planning Study in Uzbekistan, 2024” (external forecast range); own calculations (2030 and 2035 projections). Note: The range includes external forecasts from the Ministry of Energy and EPPEI.*

Looking further to 2035, only the "Sectoral expansion" variant remains aligned with EPPEI’s most conservative projections. This highlights the influence of differing assumptions on long-term electricity demand, particularly regarding GDP growth, electricity intensity, and sectoral electrification. On electricity intensity, for example, EPPEI’s “accelerating” scenario anticipates that electricity demand will outpace GDP growth until 2035. In contrast, both the "Steady growth" and "Sectoral expansion" variants predict an initial phase of rapid electricity demand growth that surpasses GDP for several years, followed by a slower rate of increase relative to GDP growth. This trend mirrors the expected development path of middle-income countries, where initial industrialisation and sectoral electrification – especially in heavy industry and transport – temporarily increase electricity intensity. However, as modernisation progresses and efficiency improvements are realised, electricity intensity typically stabilises or declines.

The diverse trajectories of electricity demand forecasts for Uzbekistan underscores the uncertainty inherent in long-term forecasting. Much of this variability arises from different choices regarding which external factors to include, assumptions about their future trajectories, and the degree to which these factors reliably impact consumption. Moreover, long-term models cannot account for unforeseen developments, highlighting the limitations in establishing a fully predictable demand pathway.

# Implications for policy-making

From these insights, several implications and recommendations for policy-making can be derived to promote efficient and equitable access to electricity in Uzbekistan. While some of the following recommendations stem directly from our analysis of demand projections, others represent best practices from international experience in energy sector reform and modernization. Together, these findings have broader implications for economic growth, competitiveness, and the overall resilience of the energy sector, which are critical for sustainable development in the region.

Build in-house forecasting capabilities for enhanced energy planning

Our study highlights the need for data-driven demand projections specific to Uzbekistan’s unique sectoral dynamics. To improve energy planning, reduce dependency on external models, and support informed policy-making, **Uzbekistan should establish a dedicated in-house forecasting unit within the Ministry of Energy or a regulatory body**. This unit would have direct access to critical data on consumption, pricing, and sectoral trends, enabling the generation of accurate demand projections and the ability to model evolving energy patterns. It would also allow for more precise calculation of tariff elasticities using local data, rather than relying on estimates from existing literature. Investing in domestic forecasting capacity will empower Uzbekistan to better anticipate demand shifts, such as those driven by electric vehicle adoption, and adapt to sectoral changes. By building this capacity, Uzbekistan can develop a more resilient and competitive energy sector capable of integrating renewables.

Examples of such units include forecasting divisions in energy regulatory authorities in the EU, the U.S. Energy Information Administration (EIA), and dedicated units within ministries in countries with ambitious energy transition goals, like Germany and Denmark. These units help governments remain proactive, especially as energy systems grow more complex and interdependent with other sectors.

Generation capacity planning

Given the projected demand growth outlined in this study, a robust generation capacity planning strategy is essential to ensure that electricity supply aligns with forecasted demand. A **preliminary assessment based on current expansion plans** indicates a generation capacity capable of supplying around 138 TWh by 2030.[[21]](#footnote-22) Due to the preliminary nature of this capacity estimate[[22]](#footnote-23), it is advisable to anticipate that **the planned capacity may fall short of meeting projected demand**. This estimate assumes average capacity factors for renewable sources, which do not account for seasonal or daily variability, nor the potential for extended low-generation periods. Additionally, technical degradation from wear and tear on infrastructure, coupled with potential maintenance downtimes, are not factored into this assessment, further tightening the actual supply margins. Furthermore, while generation has garnered substantial investor attention, transmission and distribution infrastructure require significant development to prevent supply constraints, especially as the share of renewable energy sources (RES) increases. Transmission bottlenecks could limit the delivery of electricity to high-demand regions, reducing effective capacity during peak periods.

To address these technical uncertainties, incorporating a capacity reserve margin (15% to 20% given planned share of renewables) is crucial, especially since Uzbekistan’s current system balancing is heavily dependent on Russia. If Kazakhstan disconnect from the Central Asian power network – a possibility that would isolate Uzbekistan from this broader balancing system – the need for internal flexibility would become even more urgent. Investment in transmission and distribution, alongside battery storage solutions, could provide the necessary flexibility to balance peak loads and manage renewable intermittency within the grid.

Regular reviews and adjustments to capacity projections, guided by real-world operational data and infrastructure assessments, will help the country to build a resilient energy supply that can adapt to evolving demand patterns.

Continue implementing cost-reflective tariffs

Cost-reflective tariffs that fully cover the costs of generation, transmission, and distribution are recommended to sustain investment while managing demand. This would ensure financial sustainability for utilities and send accurate price signals that encourage efficient energy use. Additionally, market liberalisation and a shift toward cost-covering tariffs could relieve the financial burden of take-or-pay Power Purchase Agreements (PPAs), fostering a more sustainable investment climate and encouraging efficiency in supply. As the market liberalises, it is vital to **strengthen the regulatory role of the Agency for Development and Regulation of the Energy Market to ensure transparent pricing practices, investor protection, and consumer rights**.

At the same time, it is crucial to **calibrate and monitor existing social support measures** to shield low-income households from the effects of tariff changes. The government’s lifeline tariff and seasonal financial aid for essential energy use are essential for balancing affordability with cost recovery. To maintain effective support, regular evaluations should include data collection on consumption patterns, impact assessments of current measures, and adjustments to eligibility criteria as needed. This approach will ensure targeted support remains responsive to evolving needs while preserving financial sustainability in the sector. By implementing these measures, Uzbekistan can create a balanced energy landscape that attracts investment, promotes efficiency, and safeguards vulnerable consumers.

Strengthen demand-side management (DSM)

With Uzbekistan’s economic and sectoral growth accelerating, such as EV adoption and increase of household energy needs, **digitalising demand-side management (DSM) strategies will be essential for balancing grid performance and optimising energy use.** Digital tools, such as advanced metering infrastructure (AMI), smart home devices, and real-time data analytics, can enable more precise control over demand patterns. By digitalising DSM, Uzbekistan can not only incentivise off-peak EV charging and introduce time-of-use pricing but also provide consumers with real-time data on their energy consumption, empowering them to make informed decisions and actively participate in demand management.

For grid operators, digitalised DSM offers greater visibility into usage patterns across sectors, allowing for efficient load balancing and reducing the need for costly capacity expansions. With the integration of renewable energy sources, digital tools become even more valuable by aligning demand with variable supply from sources like solar and wind. Digitalising DSM can thus reduce operational costs, enhance grid resilience, and promote energy efficiency while fostering a more competitive and adaptive energy landscape. By investing in digital DSM infrastructure, Uzbekistan positions itself to better manage demand in an increasingly complex energy ecosystem.

# Conclusion

**Uzbekistan’s population and economy are set to grow considerably**, which will likely lead to **shifts in electricity consumption patterns and levels**. Key developments, such as the anticipated growth of the industrial sector’s share of GDP and the increasing adoption of electric vehicles, will place upward pressure on electricity demand. Conversely, improvements in energy efficiency are expected to moderate consumption to some extent. Uzbekistan faces a persistent supply shortage in recent years, highlighting the urgent need to **align supply expansion with projected demand growth**. While insufficient supply could stifle economic development, an overestimation could lead to excessive investment, potentially straining resources. Accurately planning for generation and transmission capacity is therefore essential to meet these evolving needs.

The model results show that Uzbekistan’s electricity demand is **expected to increase significantly** by 2030 and 2035. The forecasts range from **109 to 123 TWh in 2030** and **131 to 151 TWh in 2035**, representing a 35-52% and 62-87% increase from 2023, respectively. External factors such as GDP growth expectations, sectoral shifts, and tariff changes were found to significantly influence the projections. This nuanced perspective underscores the **importance of a balanced approach in planning Uzbekistan’s energy future**, taking into account multiple growth scenarios to align capacity expansion with realistic demand projections.

**Policy recommendations** that can be derived from the findings include several strategic measures: building in-house forecasting capabilities to improve energy planning and informed policy-making, enhancing generation capacity planning to meet projected demand and mitigate supply risks, continuing tariff reform with targeted social protections to balance cost recovery and consumer affordability and strengthening demand-side management through digital tools to optimise usage across sectors as demand grows. These steps collectively aim to **promote efficient, equitable access to electricity and strengthen Uzbekistan's energy security, while supporting economic growth**.

# Annex

## Descriptive statistics of input data

Hourly electricity consumption data

The unusually low load of less than 2,000 MW on January 25, 2022, resulted from a large-scale power outage that affected Uzbekistan, Kazakhstan, and Kyrgyzstan. In Uzbekistan, the outage began around 11:00 a.m., leading to widespread power loss across major cities. According to the Ministry of Energy, it took approximately 53 hours to fully restore electricity supply across the country, with typical consumption patterns only resuming on January 28. Consequently, January 25 to 27, 2022, are marked as outliers in the Prophet model.

Figure 8: Electricity demand over time, training and testing data

A blue and white sound wave

Description automatically generated

*Source: CDC Energiya*

Figure 9: Boxplot - Hourly and monthly electricity consumption patterns, 2014-2023 data

|  |  |
| --- | --- |
| A graph of a graph showing a number of objects  Description automatically generated with medium confidence | A graph of a graph with blue squares  Description automatically generated with medium confidence |

*Source: CDC Energiya. Note: These boxplots show the distribution of our electricity consumption data. The blue boxes represent the range of hourly consumption in which 50% of data points lie for the given hour/month (25th to 75th percentile), with the line inside each box marking the median. The "whiskers" extend to show the range of most data points, while dots indicate outliers (values significantly higher or lower than the rest). These charts therefore show us the typical daily and yearly seasonalities over the whole dataset.*

Figure 10: Hourly electricity consumption patterns by weekday, 2014-2023 data

A graph with blue and orange lines

Description automatically generated

*Source: CDC Energiya. Note: This chart shows the average hourly electricity consumption patterns for each weekday, based on data from 2014 to 2023. Each line represents a different day of the week, highlighting variations in electricity demand throughout the day and across weekdays versus weekends.*

Input data for external regressors

Table 3: Descriptive statistics of input data

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Variable** | **Unit** | **Historical data** | | **Source** |
| **Coverage** | **Mean – Min – Max** |
| GDP | Constant 2020 UZS | 2014-2023 | 584 – 482 – 728 (tn) (growth rates prior to 2017 decreased by 4pp) | IMF, WEO 2024 |
| Sectoral final electricity consumption | TWh | 2000-2022 | Industry: 15.8 – 13.8 – 22.4; Transport: 1.3 – 1.1 – 2.1; Residential: 10.0 – 4.0 – 17.5 | International Energy Agency (IEA) |
| Population | Units | 2000-2023 | 20.2 – 30 – 35.3 (m) | UN, World Population Prospects 2024 |
| Industrial Production | Constant 2020 UZS | 2010-2022 | 248 – 122 – 448 (tn) | Statistics Agency Uzbekistan |
| CPI | %-change | 2010-2023 | 12.2 – 8.1 – 17.5 | World Bank, World Development Indicators |
| Electric vehicles | Stock share in % | 2016-2023 | 4.5 – 0.7 – 8 | Statista Market Insights |

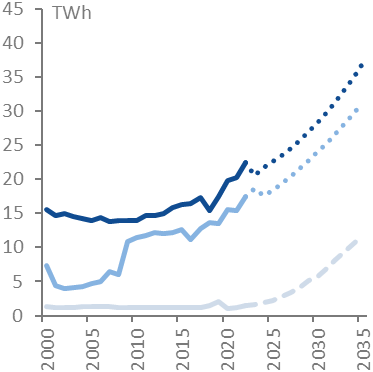
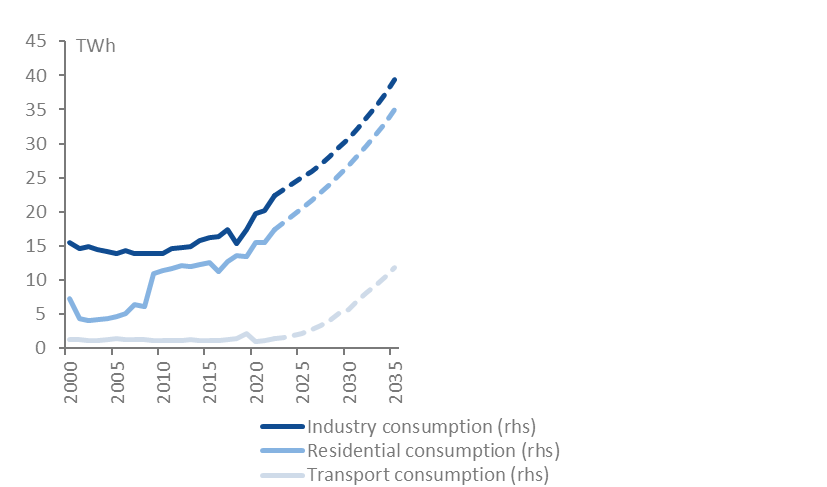
*Sources: International Monetary Fund World Economic Outlook 2024, International Energy Agency, United Nations World Population Prospects 2024, Statistics Agency Uzbekistan, World Bank World Development Indicators, Statista Market Insights.*

## Prophet model specifications

The Prophet model was configured with daily, weekly, and yearly seasonalities, using Uzbekistan-specific holidays and treating January 25–27, 2022, as an outlier due to a major power outage (see also chapter 7.1). To better capture recent trends, the number of changepoints was increased from 25 to 50, allowing the model to respond more effectively to shifts in electricity demand.

## Detailed assumptions of model variants

Figure 11: Sectoral electricity consumption as external variables



Sectoral expansion variant

Tariff impact variant

*Sources: International Energy Agency (historical data), own calculations (projection of final electricity consumption by sector; see below for details).*

“Sectoral expansion” model variant

This section outlines the detailed assumptions for industrial, transport, and residential electricity consumption used in the “Sectoral expansion” model variant. These are depicted by **long-dashed lines in the left panel** of Figure **11**.

* Industrial electricity consumption: Assumptions about future industrial electricity demand are tied to industrial production (IP), with a coefficient derived from a linear regression using 2010–2022 data. The IP growth rate assumption is based on the Uzbek government’s goal to increase IP by 1.4 times between 2022 and 2026.[[23]](#footnote-24) Growth rates after 2026 are computed using a five-year moving average.
* Transport electricity consumption: Firstly, transport electricity demand is expected to grow in line with population growth, using a coefficient derived from a linear regression using 2000–2019 data. The rising share of electric vehicles (EVs) also plays a role, using a coefficient derived from a linear regression using 2016–2019 data. Historical data and projections on the EV stock share in Uzbekistan 2016-2029 is sourced from Statista[[24]](#footnote-25). For the years 2030 to 2035, forecasts follow the IEA’s projected world growth rates.[[25]](#footnote-26)
* Residential electricity consumption: Residential electricity demand is modelled based on population growth and GDP per capita, with elasticities of 1 for both drivers. Population data and projections come from the UN.[[26]](#footnote-27)

“Tariff impact” model variant

This section outlines the specific assumptions regarding tariff changes and price elasticities in the "Tariff impact" model variant. The resulting industry and residential electricity consumptions are depicted as dotted lines in the right panel of Figure 11.

Electricity tariff reforms:

Until 2017, electricity tariffs for households and industrial consumers were set at the same level. From 2017 to 2022, tariffs for commercial consumers were approximately 50–60% higher than household tariffs, effectively cross-subsidising households. However, even with these increases, tariffs remained below cost-recovery levels, preventing full financial sustainability in the electricity sector.

In the primary phase of tariff reforms (2023–2025), industrial tariffs saw a significant rise in 2023, reaching 900 UZS/kWh. In 2024, a block tariff system for households was introduced, with rates varying based on consumption across five blocks. Since detailed data on consumer distribution across blocks is unavailable, we assume that the majority (around 80%) fall into Block I and Block II, which cover households using less than 1,000 kWh per year. For modelling purposes, we use an average of the tariffs from these two blocks. In 2024, Block I and II tariffs are set at 450 UZS/kWh and 900 UZS/kWh, respectively. We further assume that the planned tariff increases for 2025 will take effect, raising tariffs in these blocks to 600 UZS/kWh and 1,000 UZS/kWh. After 2025, we assume tariffs to increase in line with inflation, keeping real tariffs stable over time.

Price elasticity assumptions:

Both industrial and residential electricity demand are modelled to respond to real tariff changes, rather than nominal ones. Industrial demand has a price elasticity of -0.15, meaning a 10% increase in tariffs results in a 1.5% reduction in demand. Residential demand is slightly less elastic, with an elasticity of -0.1, implying a 1% reduction in consumption for every 10% increase in tariffs. These elasticity values are derived from established studies and reflect **the lower end of** typical consumer behaviour in response to price changes in comparable markets.[[27]](#footnote-28)Futureforecast updates would greatly benefit from a calculation of tariff elasticities using local data, rather than relying on estimates from existing literature, as Uzbekistan’s tariff reforms progress.

Figure 12: Electricity tariffs at current prices as assumed in the model

*Source: Cabinet of Ministers of Uzbekistan (2014-2025 data); own calculations (projections). Notes: Household tariffs in 2024 and 2025 are an average of the (announced) nominal tariffs for Block I and Block II users. Nominal tariffs after 2025 are assumed to grow in line with projected inflation, such that real tariffs remain constant.*

## Model results – complete annual figures

Table 4: Complete electricity demand projection under the four model variants

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Annual consumption (TWh) | | | | |
| 2014 | 54.9 | | | | |
| 2015 | 56.3 | | | | |
| 2016 | 57.3 | | | | |
| 2017 | 60.0 | | | | |
| 2018 | 62.9 | | | | |
| 2019 | 65.1 | | | | |
| 2020 | 69.0 | | | | |
| 2021 | 74.3 | | | | |
| 2022 | 77.1 | | | | |
| 2023 | 81.0 | | | | |
|  | Steady growth | Sectoral expansion | Tariff impact | | |
| 2024 | 86.2 | 86.3 | | 81.7 |
| 2025 | 91.0 | 91.4 | | 85.3 |
| 2026 | 96.2 | 97.1 | | 89.6 |
| 2027 | 101.4 | 103.1 | | 94.2 |
| 2028 | 107.0 | 109.8 | | 99.4 |
| 2029 | 112.1 | 116.4 | | 104.6 |
| 2030 | 117.5 | 122.7 | | 109.3 |
| 2031 | 121.5 | 128.6 | | 113.9 |
| 2032 | 125.8 | 134.9 | | 118.8 |
| 2033 | 129.4 | 140.2 | | 122.7 |
| 2034 | 133.3 | 145.9 | | 126.9 |
| 2035 | 137.2 | 151.4 | | 130.9 |

*Source: CDC Energiya (2014-2023 data); own calculations (projected data).*

1. IMF, World Economic Outlook (April 2024). – *Gross domestic product, constant 2020 prices, national currency.* [↑](#footnote-ref-2)
2. Equivalent to USD 17.5 bn in 2000, USD 72.7 bn in 2023 and USD 105.4 bn in 2030 (constant 2020-USD). [↑](#footnote-ref-3)
3. Cabinet of Ministers of the Republic of Uzbekistan. (15 September 2023). [On additional measures to introduce market mechanisms in the fuel and energy sector (Resolution No. 475).](https://lex.uz/ru/pdfs/6609144) National Legal Information Center "Adolat". [↑](#footnote-ref-4)
4. President of the Republic of Uzbekistan. (28 September 2023). [On measures to implement the next stage of reforms in the energy sector (Decree No. PF-166).](https://lex.uz/uz/docs/6624455) National Legal Information Center "Adolat". [↑](#footnote-ref-5)
5. Mir, A. A., Alghassab, M., Ullah, K., Khan, Z. A., Lu, Y., & Imran, M. (2020). A review of electricity demand forecasting in low and middle income countries: The demand determinants and horizons. *Sustainability*, *12*(15), 5931. [↑](#footnote-ref-6)
6. [Low-Emission Analysis Platform (LEAP)](https://www.sei.org/tools/leap-long-range-energy-alternatives-planning-system/) [↑](#footnote-ref-7)
7. Mir et al. (2020). A review of electricity demand forecasting in low- and middle-income countries: The demand determinants and horizons. *Sustainability*, 12(15), 5931. [↑](#footnote-ref-8)
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10. Chaturvedi et al. (2022). A comparative assessment of SARIMA, LSTM RNN and Fb Prophet models to forecast total and peak monthly energy demand for India. *Energy Policy*, 168, 113097. [↑](#footnote-ref-11)
11. Maleki et al. (2024). Future energy insights: Time-series and deep learning models for city load forecasting. *Applied Energy*, 374, 124067. [↑](#footnote-ref-12)
12. Detailed Prophet model specifications are provided in the annex. [↑](#footnote-ref-13)
13. IMF, World Economic Outlook (April 2024). – *Gross domestic product, constant prices, national currency.* [↑](#footnote-ref-14)
14. Reuters (2017). Uzbek president says economic data was 'fiction' for years. Retrieved on 10 October 2024 from <https://www.reuters.com/article/us-uzbekistan-economy-idUSKBN1EG24T/>. [↑](#footnote-ref-15)
15. Results are robust to this adjustment: forecasts remain closely aligned when using unadjusted GDP data or when reducing growth rates by 3% or 5% prior to 2017. [↑](#footnote-ref-16)
16. Ministry of Energy of Uzbekistan (2020). Concept note for ensuring electricity supply in Uzbekistan in 2020-2030. [↑](#footnote-ref-17)
17. International Energy Agency (IEA). Evolution of electricity final consumption by sector in Uzbekistan since 2000. Retrieved on 10 October 2024 from <https://www.iea.org/countries/uzbekistan/electricity> [↑](#footnote-ref-18)
18. Detailed assumptions for these sector-specific drivers are provided in the Annex. [↑](#footnote-ref-19)
19. Detailed assumptions on price elasticities are provided in the Annex. [↑](#footnote-ref-20)
20. Detailed assumptions on electricity tariffs are presented in the Annex. [↑](#footnote-ref-21)
21. Assuming a loss factor of 15% based on the [Strategy for the Development of Electricity Distribution Networks in the Republic of Uzbekistan until 2025](https://het.uz/uploads/e2dff98e-6eb9-2c89-3ff6-2bc23943bbe7_media_.pdf) [↑](#footnote-ref-22)
22. The estimation is based on the information available as of June-July 2024 and does not include the plans for construction of SMRs given that the feasibility of completion by 2030 is unclear. [↑](#footnote-ref-23)
23. Development Strategy of Uzbekistan for 2022-2026. [↑](#footnote-ref-24)
24. Statista Market Insights. Fuel or Drive-type Share. Retrieved on 10 October 2024 from https://www.statista.com/outlook/mmo/passenger-cars/uzbekistan#technical-specifications [↑](#footnote-ref-25)
25. IEA, Global EV Outlook 2024. – *World* *EV stock share in Stated Policies Scenario (STEPS)*. [↑](#footnote-ref-26)
26. UN, World Population Prospects 2024. – *Population, projection 2024-2050 using medium fertility variant.* [↑](#footnote-ref-27)
27. Zhu et al. (2018). A meta-analysis on the price elasticity and income elasticity of residential electricity demand. *Journal of Cleaner Production*, 201, 169-177. [↑](#footnote-ref-28)