

Methodology for China Simulated Hourly Electricity Load Profiles

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Overview

We developed scripts to generate **simulated hourly electricity load profiles** (24 hours × days in month) for one or more Chinese provinces/prefecture cities, given:

- a **target monthly total electricity consumption** (province-level or prefecture level, per month),
- a province's typical **workday** (工作日 / **gongzuori**) **24-hour shape**,
- **daily maximum / minimum** constraints derived from historical “全年日 / quannianri” data (scaled to the target year),
- and a small amount of **calendar handling** (month length + Lunar New Year shifting for Jan/Feb).

The core step is a **quadratic optimization (Gurobi)** that finds hourly loads that:

- 1) match the daily shape as closely as possible,
- 2) respect daily max/min bounds, and
- 3) match the monthly total.

Please check the latest version of the simulation code in the [china-load-simulation](#) repository under Power Transformation Lab.

Data Format

Dataset: cn_prov_simulated_hourly_load_profiles_2022

The dataset is provided in **CSV format**. It was generated using the latest version of the simulation code. Each row represents **the simulated hourly electricity load for a province**.

Field	Description
province	Province name

Field	Description
year	Simulation year
month	Simulation month
day	Simulation day
hour	Simulation hour
load_mw	Simulated electricity load in megawatts (MW)

Dataset: cn_east_grid_hourly_load_2030

The dataset is provided in **CSV format**. It was generated using an earlier version of the simulation code. Each row represents **the simulated hourly electricity load for a province in the east grid of China**.

Field	Description
datetime	Timestamp (hourly)
Shanghai, Jiangsu, Zhejiang, Anhui, Fujian	Simulated electricity load in megawatts (MW) for each province

Note: It includes two datasets, L1 and L2. L1 assumes an annual electricity load growth rate of 6%. L2 assumes the same growth rate, but distributes 72% of the incremental demand evenly across all hours, while the remaining 28% is concentrated in summer peak hours (16:00–20:00, June–September).

Dataset: cn_south_grid_hourly_load_2030_2060

The dataset is provided in **CSV format**. It was generated using an earlier version of the simulation code. Each row represents **the simulated hourly electricity load for a province in the south grid of China**.

Field	Description
datetime	Timestamp (hourly)

Field	Description
Guangdong, Guangxi, Guizhou, Hainan, Yunnan	Simulated electricity load in megawatts (MW) for each province

Dataset: cn_gd_prefecture_hourly_load_2030_2060

The dataset is provided in **CSV format**. It was generated using an earlier version of the simulation code. Each row represents **the simulated hourly electricity load for a prefecture city in Guangdong province**.

Field	Description
datetime	Timestamp (hourly)
Chaozhou, Dongguan, Foshan, Guangzhou, Heyuan, Huizhou, Jiangmen, Jieyang, Maoming, Meizhou, Qingyuan, Shaoguan, Shantou, Shanwei, Shenzhen, Yangjiang, Yunfu, Zhongshan, Zhuhai, Zhaoqing, Zhanjiang	Simulated electricity load in megawatts (MW) for each prefecture city

Workflow for Generating Provincial-Level Load Profiles

For each province and each year–month combination, historical daily load envelopes are transformed into hourly electricity load profiles that are consistent with official monthly electricity statistics while preserving realistic intra-day and intra-month dynamics. The procedure consists of four stages: (1) monthly rescaling of historical profiles, (2) construction of month-specific constraints, (3) hourly optimization, and (4) batch generation across provinces and time periods.

Step 1: Rescale historical daily profiles to official monthly totals

To ensure consistency with official energy statistics, historical daily load profiles are first rescaled at the monthly level.

The reference dataset provides upper and lower bounds for daily load in 2018. For each day, a representative load level is defined as the average of these bounds. These daily values are aggregated into a raw monthly energy estimate by assuming 24 hours per day.

A monthly scaling factor is then computed as the ratio between official monthly electricity consumption and the raw estimated energy. This factor is applied uniformly to all daily values within the month, preserving the original intra-month shape while ensuring consistency with official totals.

For January and February, a combined treatment is applied when necessary to avoid artificial discontinuities. In this case, both months share a single scaling factor derived from their joint energy and joint official total.

Step 2: Construct month-specific daily load constraints

For each province, year, and target month, daily load constraints are constructed based on the 2018 reference profiles.

To preserve holiday-related demand patterns, the temporal structure of the reference year is aligned with the target year when necessary, particularly for the Chinese New Year period. This ensures that holiday-driven load variations occur on correct calendar dates.

The reference daily profiles are then filtered to the target month and scaled according to the corresponding monthly electricity consumption. If official data is available, it is used directly; otherwise, future values are extrapolated using a compound annual growth assumption.

A reconciliation step is applied to ensure internal consistency between daily bounds and the monthly target. Specifically, a constant adjustment is added to both upper and lower bounds so that the implied monthly total exactly matches the target while preserving the daily load range.

When multiple months are optimized jointly (e.g., January–February), the monthly target is proportionally allocated based on the number of days in each month, and reconciliation is performed independently for each month.

Step 3: Perform hourly load optimization

Given the constructed daily constraints, hourly load profiles are generated by solving a constrained optimization problem.

Hourly variables are fitted to a typical daily load shape while respecting daily upper and lower bounds. The optimization enforces consistency with official monthly electricity consumption through a strong equality constraint.

To ensure realism, the objective includes penalties for excessive variation in daily average load across consecutive days, promoting smooth intra-month dynamics. Additionally, continuity

constraints are introduced across month boundaries to avoid artificial discontinuities in long time series.

The relative importance of each objective component is controlled through a set of weighting parameters, allowing flexible balancing between profile fidelity, smoothness, and statistical consistency.

Step 4: Batch execution across provinces, years, and months

The full pipeline is executed across multiple provinces, years, and months in a sequential manner.

Within each year, months are processed in chronological order. When applicable, adjacent months such as January and February are treated jointly to ensure consistent seasonal transitions.

After each optimization period, the final day's load level is passed forward as a boundary condition for the next period, ensuring temporal continuity across the entire time series.

The final outputs are stored as separate files for each province–year–month combination.

Workflow for Generating Prefecture-Level Load Profiles

For each target year and optional set of provinces, historical province-level monthly electricity data is downsampled and transformed into prefecture-level hourly load profiles. The resulting data preserves both inter-prefecture allocation patterns and intraday load shapes, while allowing for future growth projections.

The workflow consists of three main steps: (1) province-to-prefecture mapping, (2) construction of baseline prefecture-level hourly profiles, and (3) projection to future years.

Step 1: Province-to-prefecture mapping

To ensure consistency in naming conventions, Chinese province names are first standardized and mapped to their English equivalents.

This mapping defines the set of provinces to be processed. If no specific province subset is provided, all available provinces are included in the simulation.

Step 2: Construction of baseline prefecture-level hourly profiles

Baseline prefecture-level hourly electricity demand is constructed from historical province-level monthly data (year 2022).

For each province, hourly load profiles are first derived at the province level using historical load structures. These province-level profiles are then disaggregated to the prefecture level using prefecture-level monthly electricity consumption shares.

This step ensures that:

- The sum of all prefectures within a province matches the province-level total
- The intra-day hourly structure is preserved from the province-level load shape
- Prefecture-level heterogeneity is reflected through monthly share distributions

The result is a consistent 2022 baseline of prefecture-level hourly electricity usage.

Step 3: Projection to future years

To generate data beyond the baseline year, a compound annual growth assumption is applied.

For each target year after 2022, prefecture-level hourly loads are uniformly scaled using a specified annual growth rate. This preserves both the spatial distribution across prefectures and the temporal hourly pattern within each day.

When no specific province subset is provided, the projection is applied across all provinces and their corresponding prefectures.