Danish Energy Agency

EMBASSY OF DENMARK

MOIT

EREA Electricity & Renewable Energy Authority

Demand Flexibility Report

Background report to Viet Nam Energy Outlook Report 2021

2021

Demand Flexibility Report

Background report to Viet Nam Energy Outlook Report 2021

2021

Published by:

Ea Energy Analyses
Copenhagen
Denmark
Web: www.eaea.dk

Contents

1 Introduction and summary 4

2 Definition of new demand types 6

3 References 12

1 Introduction and summary

This note is a deliverable for the project "Data foundation and model development – part 1" which aims to continue the developments of the Vietnamese TIMES and Balmorel models as well as improve the interaction between both models. The project is part of the Energy Partnership Programme between Vietnam and Denmark and supports the objective of providing support and capacity building and improving the data and modelling foundation for long-term energy planning at the Vietnamese Electricity and Renewable Energy Authority (EREA).

The Vietnam Energy Outlook Report 2021 will be published as a reference for stakeholders and policymakers and will support the sustainable development of Vietnam's energy system through implementation of cost-optimized policy and planning. Two suites will support the modelling activities: Balmorel and TIMES. The first is used for in-depth analyses of the evolution of the power sector, while the second will provide a broader overview of all energy transformation and end-use sectors. A thorough linking of the two models is pivotal to ensure reliable and consistent results from the modelling activities.

This note describes the implementation of new electricity demand types into Vietnamese Balmorel model. Previously, the Vietnamese Balmorel model's electricity demand was the aggregation of all end-use sectors. This update expands the model to cover electricity consumption for both the transformation sector (alternative fuels) and end-use sectors. These include:

- Direct demand for electricity in the residential, commercial and industrial sectors
- The new electricity consumption related to the spread of electric vehicles (EVs) in the transport sector
- Electricity demand in for Power-to-X production.

An overview is provided in (Table 1). The modelling setup is characterized by demand prognoses for each sector (*demand definition*) and *flexibility* options, which allow for a load/demand re-shaping to further optimize the electricity supply.

This update has implemented functionality to allow for representation of the above-mentioned demand types and flexibility options. At this stage, annual demand projections for the different demand sectors are based on estimates.

In future projects, updated projections will be derived from soft-linking the Balmorel model with the TIMES model (Ea Energy Analyses and Energy Modelling Lab, 2020). The TIMES model optimizes all energy sectors and is therefore well-suited to provide input on power demand from various sectors.

Assumptions on the degree of demand flexibility are also based on rough estimates at this stage. The current implementation is expected to be updated based on documented sources with the help of local consultants in future projects.

Table 1. Overview of model changes

Demand type	Previous model setup		New model setup	
	Demand definition	Flexibility	Demand definition	Flexibility
"Classic" electricity demand	Aggregated demand representing electricity consumption of residential, industrial and commercial sectors	No flexibility, except for endogenous investments in energy storage	Direct electricity demand split into • Residential sector • Commercial sector • Industrial sector	Demand flexibility added to the model by sector
EV demand	Not present		New demand type by macro-region	Demand flexibility to deviate from natural charging pattern
Power-to-X	Not present		New demand type by macro-region	Hydrogen storage Geographical flexibility

2 Definition of new demand types

Demand definition and projections

This model update introduces a fine-grain modelling setup for the electricity demand, used either directly or indirectly for conversion into other energy carriers. The final electricity demand is defined for four end-use sectors (residential, industry, commercial and transport); Power-to-X is also added and encapsulates the electricity demand needed to produce e-fuels. The final demand for e-fuels is modelled as one carrier, which includes hydrogen and other alternative liquid and gaseous fuels ("hydrogen" in the following for simplicity). The model can invest in electrolysers to satisfy the final demand for e-fuels.

The TIMES model represents the production of each alternative fuel with a specific production pathway. The final mix of e-fuels resulting from TIMES will define the average electricity-to-e-fuel efficiency characterizing the electrolysers in Balmorel. Presently, the efficiency is set at 57-60% depending on the investment year.

The projected electricity demand until 2050 and the relative distribution among end-use sectors and regions in Vietnam are shown in Figure 1. The distribution of the different demand types over the Vietnamese regions is based on the work carried out during the EOR19 framework. Industry is assumed to hold ~ 55% of the gross electricity consumption in 2050, for the most part located in the North and South regions. The projected power demand split as shares by end-use are derived from the work carried out in (Danish Energy Agency and Ea Energy Analyses, 2019).

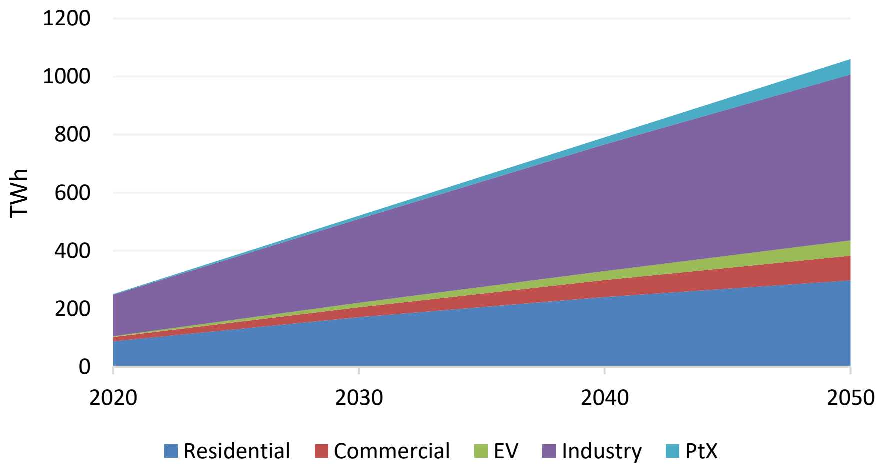

Figure 1. Electricity demand projection by final use until 2050.

Demand profiles

Demand profiles are defined on an hourly basis for each demand type.

Direct, classic demand

The hourly profiles for the industry, commercial and residential demands are displayed in Figure 2. Profiles for the commercial and industrial sector are based on typical patterns, but do not rely on Vietnamese sources; these can be updated in future activities, should data be available. The residential demand has the same profile as the former aggregate demand.

The residential and industrial sectors have a flatter profile shape during the day with respect to the commercial sector. Industry and residential show a two-peak daily load curve, in the late morning and afternoon. The commercial sector has a rather low night demand to keep essential appliances on; the demand steps up during daytime. The residential demand varies across seasons (higher in summer than in winter), while the industry and commercial profiles are characterized only by daily patterns. Each of the six Vietnamese macro regions has its own electricity profile.

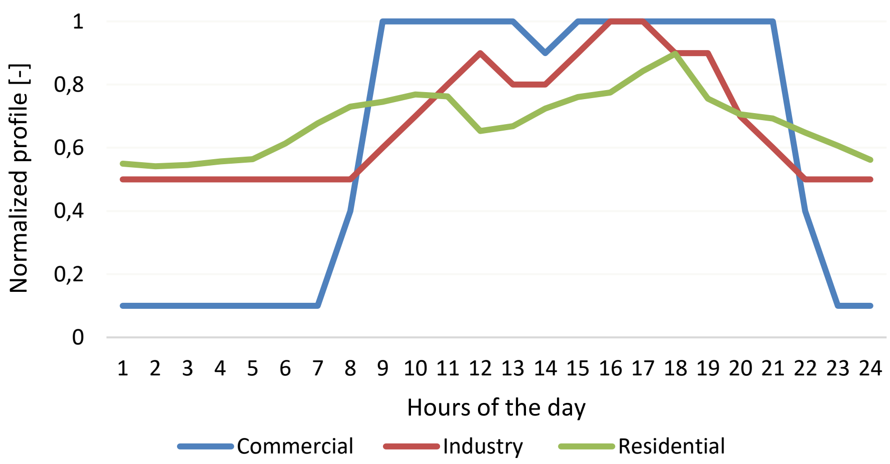

Figure 2. Normalized hourly profiles for commercial, industry and residential sectors (one week example).

Electric vehicles

The EV hourly profiles reflect typical Norwegian charging patterns. The weekly profile is divided into working days and the weekend. Working days display a morning, local peak at 9 a.m. and a daily peak at 6 p.m., which reproduce hours when most cars charge. Saturday and Sunday's profiles are characterized by only a daily peak, occurring in the late afternoon (Figure 3, *Natural charging pattern*).

Power-to-X

The demand profile for e-fuels is constant throughout the year. The lack of variation in the profile definition is overcome with flexibility options (see Section below).

Demand flexibility

Each demand type is given flexibility to adjust the load profiles. Flexibility options realistically reflect the opportunities that different consumers have to shift consumption when more convenient (demand-side response). This option is implemented differently depending on the demand type:

- Demand flexibility applies to traditional demand types (residential, industrial and commercial sector)
- Special flexibility is implemented for the transport sector (EV) and Power-to-X.

General flexibility

General flexibility is realized through virtual storages for each demand type. The model decides how large a share of the final electricity demand can be shifted in time by investing in the optimal amount of storage. Virtual storage is an option for end-use sectors to adjust their natural consumption patterns in order to benefit from lower power prices. The total socio-economic cost is also reduced.

The share of the demand which can be moved in time is sector- and year-dependent. It is assumed that by 2050 20% of the industrial demand, 10% of the commercial demand and 7% of the residential demand is flexible. The amount of flexible demand increases linearly with time, with the first non-null value in 2020.

Electric vehicles

Flexibility to the EV demand is added by defining a *natural charging pattern* and a *range for flexible charging* (Figure 3). The range for flexible charging is made dependent on a maximum yearly storage volume (cars) available for flexibility purposes along with availability profiles defined hour-by-hour (parked cars that can be plugged in, Figure 4). The number of vehicles (storage size) providing system flexibility lies within a range that becomes wider with the years. Virtual storage allows only for intra-day shifting of consumption and the optimization of charge and discharge patterns is done only when convenient.

Flexibility represents the willingness of the vehicle stock to perform up- and down-regulation, relative to the natural charging behaviour. In Table 2 the up- and down-regulation parameters used in the modelling are shown.

Down-regulation acts as a charging reduction from the natural charging pattern; down-regulation is bound by a lower limit, which is also the lower limit for the flexibility range (lower limit for charging in a given hour). In other terms, the down-regulation parameter represents how large a share of the vehicle stock is willing to refrain from charging. This share increases with time.

On the contrary, up-regulation is the opportunity the vehicle stock has to load its virtual battery. Hourly availability profiles define the share of parked cars (total available volume, Figure 4), to which the up-regulation parameters in Table 2 are applied. The result is the lower and upper flexibility ranges in Figure 3 (dashed lines).

Table 2. Up- and down-regulation parameters for EVs.

	2020	2030	2040	2050
Down-regulation (share of vehicles willing to refrain from charging)	20%	40%	60%	80%
Up-regulation (share of vehicles willing to charge)	1%	8%	14%	20%

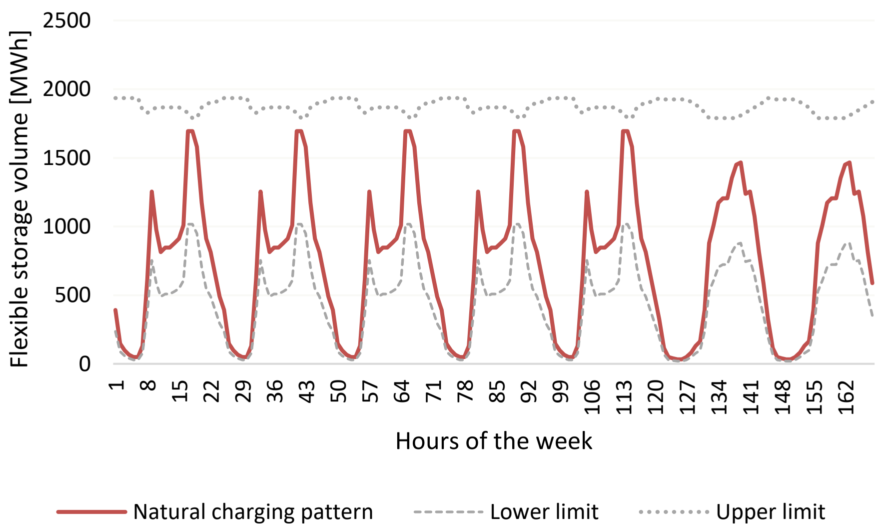

Figure 3. Natural and flexible charging profiles for EVs (2030).

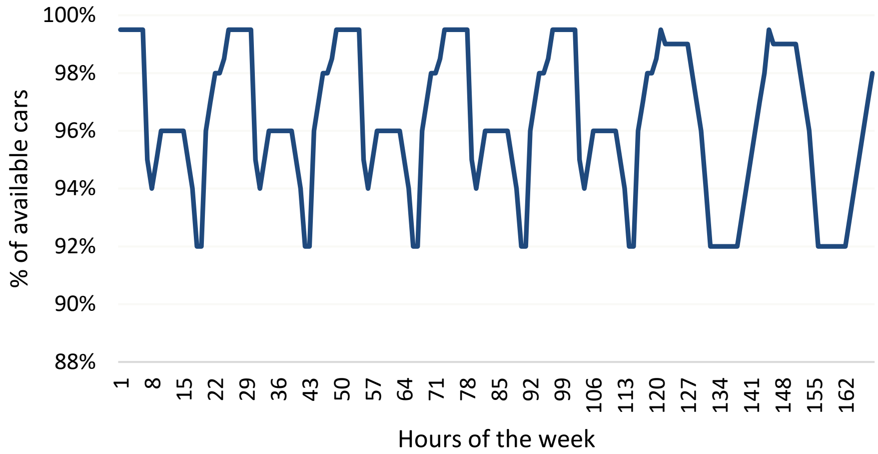

Figure 4. Share of cars available to charge (example of weekly pattern).

The EV load is assumed to be inflexible one hour a day in the morning at 7 a.m. to prevent EV load shifting across days. It is assumed that load shifting for EVs will only happen within any single day. A part of the stock is willing to adjust its natural charging pattern. This share of the stock increases with the years.

The total down-regulation capacity from demand-response in the above-mentioned sectors exceeds 20 GW in 2050 (Figure 5), with industry holding the highest potential.

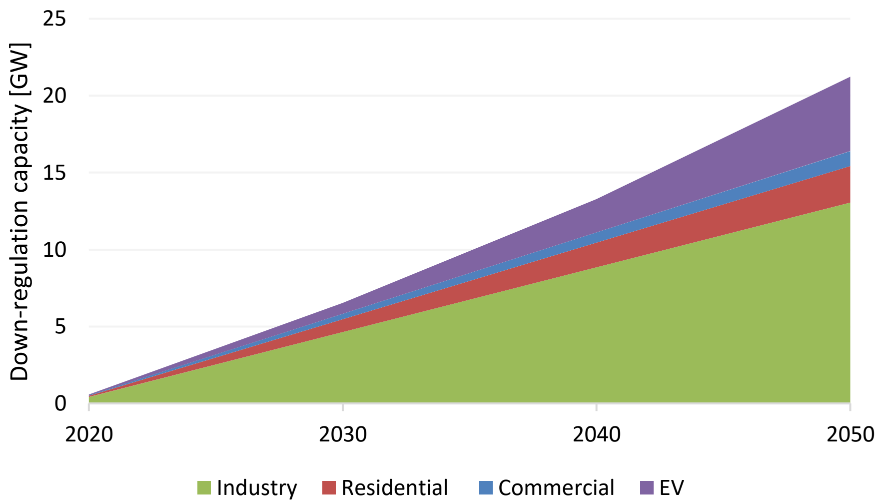

Figure 5. Down-regulation capacity by sector.

Power-to-X

The electricity for the production of hydrogen and e-fuels has a flat daily and seasonal profile, but flexibility is added in the form of seasonal hydrogen storage. In this manner, hydrogen produced from electrolysis in hours of low electricity prices can be stored and supply the need over the rest of the day or week. Both hydrogen production facilities (electrolysers) and hydrogen storage are endogenous investment options, that is the model opts to invest in the optimal asset size. Hydrogen produced in one region can be “shipped” at a cost of 15 USD/MWh to other regions, if convenient. This adds additional flexibility to the Power-to-X supply.

3 References

Danish Energy Agency and Ea Energy Analyses. (2019). *Electricity demand projections - Background to Vietnam Energy Outlook report 2019.*

Ea Energy Analyses and Energy Modelling Lab. (2020). *Model-linking of TIMES and Balmorel.*