F. BATTERIES MODELLING

Electricity storage in the form of batteries is increasing in the electricity system. Batteries can be installed in different scales: (i) industrial projects (or large-scale batteries), or small-scale batteries in the residential sector (usually behind the meter).

F.1. LARGE-SCALE BATTERIES

Several industrial and energy players are investing in largescale battery projects. These have different business models earning revenues from the various electricity market (e.g. Day-Ahead, Intra-Day, Balancing). Hence, as these are expected to react to market prices, they can be explicitly modelled in the hourly economic dispatch model.

Their modelling is based on the following components:

- a power output (in MW);
- a storage size (in MWh) and
- a round-trip efficiency (in %).

As long as the battery contains energy, it can output power while respecting the maximum power output. If the State of Charge (SoC) of the battery is null, then no power can be outputted by the battery. Likewise, as long as the battery is not full, it can charge electricity from the grid.

The duration of existing large-scale batteries considered in the present study is based on known information from existing installations and future projects. Concerning the existing fleet, a 2-hours duration is assumed for the smaller older batteries and, depending on the available information from future projects (i.e. from BNEF), a 2-hours or 4-hours duration for the larger, more recent batteries is considered. For additional battery capacity in future years, a 4-hours duration is always assumed.

The model charges and discharges the battery in order to minimise electricity prices on the market, while respecting grid constraints. Note that batteries are not modelled individually but are aggregated as one battery for each country.

F.2. RESIDENTIAL BATTERIES

With subsidies and market reform incentivizing self-consumption, there is a growing installation of batteries in the residential sectors. Most of the time, these batteries are nowadays operated based on a local signal (e.g. charging with excess of PV panels production). However, in the future, part of these residential players could be financially incentivised to let aggregators operate their residential batteries in electricity markets (e.g. for balancing).

	Local Flex (H)	Market Flex (M)
Residential batteries	Optimised at Home: Minimise your costs following regional tariffs, or maximise PV self-consumption	Optimised in the Market: Minimise your costs following market signal based on merit-order dispatch
Rationale	B2H Batteries to home	B2M Batteries to market
Modelling	Pre-defined time series	Dispatched by the model following energy and power constraints

Table F-1: Summary of operation mode of residential batteries

This is accounted in the modelling of residential batteries in two-ways (as summarised in Table F-1):

(i) ‘Out of market’ batteries (locally optimised) and;

(ii) market dispatched (or optimized) batteries.

Home batteries are assumed to have an average duration of 2 hours. This assumption comes from a market review of popular models being sold in Belgium. Information are given in the Table F-2.

TABLE F-2 — EXAMPLE OF MOST POPULAR BATTERY MODELS SOLD IN BELGIUM [EAS-1]

MODEL	Energy [kWh]	Power [kW]	Duration [hours]
Tesla - Powerwall	13.5	5	2.7
Sonnen – ecoLinx	20	10	2
LG Chem – RESU	9.8	5	1.96

F.2.1. 'OUT OF MARKET' DISPATCH (optimised locally)

Batteries are by essence controllable and flexible assets, whose role is to dampen variability: to absorb excess energy and limit power increase. Different local signals (in opposition to market signals), exist to incentivise battery owners to dispatch the use of batteries. For the next AdeqFlex'25 study, major improvements have been included in the study for the B2H profile. Notably, the profile now considers regional differences in Belgium both in terms of (i) tariff and (ii) PV self-consumption.

Regarding the first improvements, it is known that regional tariffs are either already or planned to be implemented in Belgium. In 2023 the capacity tariff started in Flanders[1], and a Time-of-Use tariff is expected in Belgium by 2026[2]. These two tariffs will impact the way people charge their cars, giving them incentives to charge in a way that is best for the grid (i.e.: minimising peak, or outside peak hours). However, both tariffs will not impact charging behaviour in the same way. For this reason, the next AdeqFlex'25 study, includes profiles for each tariffs / region.

These profiles were developed by minimising the consumer bill. Starting from a synthethic load profile (representative of a residential load curve or a user across Belgium) from Synergrid[3], an algorithm dispatched the battery. Given constraints on power and storage capacity, the algorithm does so to minimise cost (considering energy costs as well as an estimate of tariff costs).

Also, the locally optimised profile now considers PV self-consumption. With greater and greater PV penetration in the residential and tertiary sector, it is expected to have flexible electrified assets (like residential batteries) integrate renewable energy directly where it is produced. These profiles then consider the different climate years (and related local PV production) run in the study.

Hence, there are different profiles for the region of Flanders and Wallonia, and this profile differs for each day of each climate year. An illustrative example for a day in winter, with PV self-consumption is given on figure E-6. The figure depicts averaged residential battery profile for each region, in winter, with PV self-consumption.

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[1] The capacity tariff | Flanders.be
[2] Méthodologie tarifaire 2025-2029 | CWAPE
[3] Profils de charge synthétiques - Profils de production synthétiques - Profils de charge réels - Synergrid

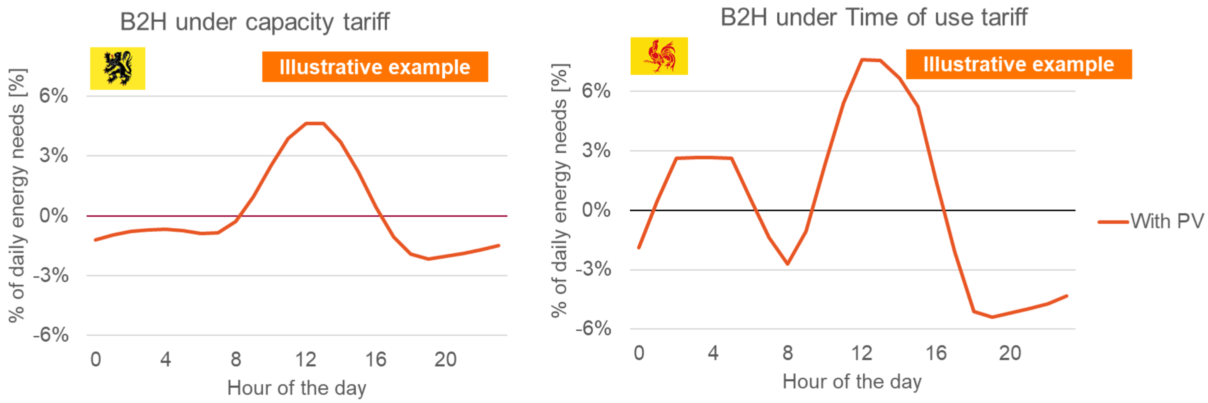

Figure F-1: local charging profile (B2H) for two different tariffs (capacity tariff, and time of use tariff), with PV production

F.2.2. 'IN THE MARKET' DISPATCH (batteries optimised by the market)

Using residential storage assets to maximise self-consumption is one step to integrate more RES in the future. However, going a step beyond would be to ensure market dispatch of these assets: to ensure that for each hour of the day, the behavior of batteries can help the market to minimise electricity prices, but also minimise CO2 emissions or offer ancillary services through better managing the electricity demand throughout the day. With the right market reforms and infrastructure, aggregators could pilot residential batteries in such a way and respond to market signal. This section describes how this is modelled by Elia. It consists of the same model than for large-scale batteries. The model needs three components to operate a market dispatch of batteries:

- a power output (in MW);
- a storage size (in MWh) and
- a round-trip efficiency (in %).

As long as the battery contains energy, it can output power while respecting the maximum power output. If the State of Charge (SoC) of the battery is null, then no power can be outputted by the battery. Likewise, as long as the battery is not full, it can charge electricity from the grid.