Work Package 3 Market Uptake | T3.2 Product Definition

Deliverable 3.3: Report on customer value propositions for distributed flexibility

Partner responsible: 70GigaWatt
Partners involved: EnergieID, Energent, Ecopower and NextKraftwerke

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Introduction

This document outlines the potential value a household can gain through using flexibility. The technologies considered are solar panels, heat pump, electric vehicle and home battery.

The value streams used to create value through flexibility are optimised self-consumption, the spot market, the imbalance market and ELIA services in the form of FCR and aFRR. The intraday market is not considered, but that value stream will be indicatively approached as a fraction of the imbalance market.

This note is an addition to an excel file in which the calculations are made and where users can fill in their own system parameters and hypotheses. In the excel, all cells markets in YELLOW are parameters that can be changed by the user.

In the tab "General Assumptions", values can be given for the average market price, the annual electricity consumption of a household excluding heat pump and electric vehicle and the annual heat consumption of the dwelling.

General assumptions		default	
average annual market price	70	70	€/MWh
consumption household, no heatpump	4000	4000	kWh/a
heat demand household	15000	15000	kWh/a

In the tabs with the calculations themselves, the set of specific assumptions can be filled in (example for the heat pump shown below).

Assumptions		default	
average annual market price	70		kWh/a
Heat Demand	15000		kWh/a
Power Heat Pump	4	4	kW
SPF	3,50	3,50	
annual consumption heat pump	4285,71		kWh/a
Coldest hour	1,50		kWh/h
Dimension OK?	TRUE		
ELIA service factor	25%	25%	

The results show the potential value of a specific optimisation. The value is always shown relative to a baseline. That baseline is a standard scenario looking at the costs relevant to the value stream or technology considered.

It has to be noted that the results of these simulations provide a theoretical order of magnitude of the potential value of using flexibility. In reality, the value might be different due to case optimisation.

Home Battery

The baseline for the home battery scenario's is a household's electricity consumption according to a standard consumption profile; the Real Load Profile RLP. As a valuation, the spot value is used. Other value parameters are not directly relevant as the battery in itself only shifts electricity from one hour to another. There might also be an impact on the distribution tariff in the form of a reduction of the peak consumption. This is discussed in a separate comment.

In the scenario's calculated, only the battery charging and discharging is optimised. In many cases, a home battery is installed to optimise self consumption from PV. Self consumption optimisation is not discussed here but in a separate section later.

Day ahead spot market optimisation

The assumption is made that the battery is charged to full and discharged to zero every day. Charging is done during the cheapest hours of the day, discharging during the most expensive hours. The full power of charging is used.

This scenario is realistic and feasible. Hourly spot prices for a day are fully known the previous day after publication of the day ahead auction results (usually at 13h). These prices are fully transparent to the consumer. So the battery charging/discharging program can be fully automated on available data.

Imbalance value optimisation

The assumption is made that the battery is charged to full and discharged to zero every day. Charging is done during the cheapest imbalance hours of the day, discharging during the most expensive imbalance hours.

The theoretical value in optimising a battery on imbalance value is very high, because the variations in imbalance prices is much more extreme than on the spot market. But this is a highly theoretical case which is practically impossible to achieve. The imbalance prices are not a priori known and only revealed ex post. So it is not possible to schedule battery charging/discharging on known imbalance prices. The predictability of imbalance is highly questionable. Should imbalance predictions become more reliable, it is likely that this better predictability will also dampen the effect on imbalance volume and imbalance prices.

Part of the value of imbalance could be captured through the intraday market. If imbalance threatens to occur due to circumstances (e.g. less wind than predicted day ahead), that value may already occur in the intraday market. Therefore, the feasibility of this option is pragmatically set to 20% for now.

ELIA services

Batteries can also deliver flexibility services to ELIA; FCR, aFRR down and aFRR up. To estimate the theoretical potential, we assume that a pragmatic 33% of the battery power is available for these services. 100% is not possible because the battery needs to be in the correct state to deliver a service. E.g., aFRR up can only be delivered if the battery is sufficiently charged.

Nonetheless there is some potential in offering this service if distinct charging/discharging patterns emerge. If the battery is optimised on day ahead value, the state of the battery is know in advance and directional ELIA services could be offered during distinct periods depending on the battery state. This also implies that the battery is not 100% available to deliver ELIA services; hence the pragmatic 33% availability.

Combined value streams

It is not possible to fully combine all value streams. But it is possible to grasp opportunities. E.g. when a home battery is optimised on the day ahead prices, a default charging/discharging schedule is set. Then, during the day, that schedule can be finetuned using other value streams such as intraday opportunities or to provide an ELIA service. Of course, then the day ahead schedule is altered and part of the value stream in day ahead optimisation is sacrificed to capture another value stream.

Some value streams cannot be combined. E.g., an asset cannot participate in FCR and aFRR simultaneously.

Comment distribution tariff

In the context of the capacity tariff, it is advisable to take into account the maximum consumption peak in the charging/discharging schedule. The daily optimisation value of the battery is low compared to the impact on the capacity tariff. For the default case, the potential savings are in the order of magnitude of €165 per year, which is less than €1 per day. The capacity tariff amounts to €40 per additional kW peak. So avoiding exceeding the monthly peak has a higher value and thus a priority than optimising the market value of the battery while potentially increasing the consumption peak.

In all cases also the offtake (kWh) related grid tariffs, taxes and levies need to be taken into account. A battery could offer much more value in terms of price arbitration and Elia services if whatever was taken from the grid and re-injected later didn't face these costs. As it is there are very little situations in which charging the battery from the grid to perform a second daily cycle (i.e. also reducing life time of the battery) would make sense. This would only be the case when negative prices drop below the point corresponding to the positive offtake related costs.

Simulation results

The table below shows some simulation results on the potential savings to be made using a home battery under a set of hypotheses.

Variations are made on

- Market price; default €70/MWh, high €100/MWh and low €40/MWh
- Household consumption; default 4000kWh/y, low 2000kWh/y and high 8000kWh/y

HOME BATTERY						
Assumptions						
average annual market price	kWh/a	70	100	40	70	70
RLP consumption	kWh/a	4000	4000	4000	2000	8000
Battery	kWh	10	10	10	10	10
Battery power	kW	3	3	3	3	3
Efficiency		95%	95%	95%	95%	95%
ELIA service factor		33%	33%	33%	33%	33%
Fraction imbalance value captured		20%	20%	20%	20%	20%
Results						
BASELINE: RLP cost, no battery	€/year	290	409	172	145	581
Annual savings compared to baseline						
with battery - Spot	€/year	-165	-234	-96	-165	-165
with battery - Imbalance	€/year	-115	-147	-84	-115	-115
with battery - ELIA FCR	€/year	-221	-231	-211	-221	-221
with battery - ELIA aFRR down 4h	€/year	-61	-102	-19	-61	-61
with battery - ELIA aFRR up 4h	€/year	-299	-338	-260	-299	-299

Heat Pump

The baseline for the heat pump is that the household's heat is delivered according to a standardised profile. The assumption is made that the heat pump is used every day to cover heat demand according to normalised RLP0 gas profile; a proxy for hourly heat demand. That profile is then rescaled to the electricity consumption of a heat pump. For the valuation, the spot market price is used. Other value parameters are not directly relevant as the timing of the heat pump charging in itself only shifts electricity from one hour to another. There might also be an impact on the distribution tariff in the form of a reduction of the peak consumption. This is discussed in a separate comment.

Day ahead spot market optimisation

In the reference, heating is done according to the standard profile. In the optimised case, the heat pump is activated during the cheapest hours of every day to cover daily heat demand.

This scenario is realistic and feasible, providing the thermal inertia of the building is sufficient or heat buffering is present. Hourly spot prices for a day are fully known the previous day after publication of the day ahead auction results (usually at 13h). These prices are fully transparent to the consumer. So the daily heat pump activation schedule can be fully automated on available data.

Imbalance value optimisation

In the optimisation on imbalance, the assumption is made that the heat pump is activated during the cheapest imbalance hours of every day to cover daily heat demand.

The theoretical value in this optimising very high, because the variations in imbalance prices is much more extreme than on the spot market. But this is a highly theoretical case which is practically impossible to achieve. The imbalance prices are not a priori known and only revealed ex post. So it is not possible to schedule heat pump activation on known imbalance prices.

Part of the value of imbalance could be captured through the intraday market. If imbalance threatens to occur due to circumstances (e.g. less wind than predicted day ahead), that value may already occur in the intraday market. Therefore, the feasibility of this option is pragmatically set to 20% assuming part of the value could be captured by either predicting the imbalance price or by taking action on the intraday market.

ELIA services

Heat pumps can also deliver flexibility services to ELIA; FCR, aFRR down and aFRR up. An activated heat pump can temporarily be shut down and an inactive heat pump can be activated. But these possibilities have to be in line with the reality of the heat pump. E.g., a heat pump that is only active during one hour a day due to insufficient heat demand, can only deliver this ELIA service for one hour. To estimate the theoretical potential, we assume that a pragmatic 25% of the daily heat pump electricity consumption is available for these services. 100% is not possible because the heat pump needs to be in the correct state to deliver a service at the time ELIA activates the reserve. E.g., aFRR up can only be delivered if the heat pump is active and can be shut down.

Nonetheless there is some potential in offering this service if distinct heating patterns emerge. If the heat pump is optimised on day ahead value, the state of the heat pump can be assessed in advance and directional ELIA services could be offered during distinct periods depending on the heat pump activation state.

Combined value streams

It is not possible to fully combine all value streams. But it is possible to grasp opportunities. E.g. when a heat pump is optimised on the day ahead prices, a default heating schedule is set. Then, during the day, that schedule can be finetuned using other value streams such as intraday opportunities or to provide an ELIA service. Of course, then the day ahead schedule is altered and part of the value stream in day ahead optimisation is sacrificed to capture another value stream.

Some value streams cannot be combined. E.g., an asset cannot participate in FCR and aFRR simultaneously.

Comment distribution tariff

In the context of the capacity tariff, it is advisable to take into account the maximum consumption peak in the heat pump schedule. With a capacity tariff of €40/kWpeak, every additional peak will therefore result in an increase in distribution costs. It is advisable to take into account the simultaneous activation of the heat pump and other big consumers. A higher simultaneous use during cheap hours implies a better utilisation of the lowest possible market prices, but is also increase the capacity tariff.

Simulation results

The table below shows some simulation results on the potential savings to be made using a heat pump under a set of hypotheses.

Variations are made on

- Market price; default €70/MWh, high €100/MWh and low €40/MWh
- Heating demand; default 15000kWh/y, low 7500kWh/y and high 22500kWh/y

HEAT PUMP						
Assumptions						
average annual market price	kWh/a	70	100	40	70	70
Heat Demand	kWh/a	15000	15000	15000	7500	22500
Power Heat Pump	kW	4	4	4	4	4
SPF		3,50	3,5	3,5	3,5	3,5
annual consumption heat pump	kWh/a	4286	4286	4286	2143	6429
Coldest hour	kWh/h	1,5	1,5	1,5	0,7	2,2
Dimension OK?		TRUE	TRUE	TRUE	TRUE	TRUE
ELIA service factor		25%	25%	25%	25%	25%
Fraction imbalance value captured		20%	20%	20%	20%	20%
Results						
BASELINE: RLPoG Heat Pump cost	€/year	325	440	211	163	488
Annual savings compared to baseline						
Heat Pump optimised on spot	€/year	-111	-152	-71	-61	-148
Heat Pump optimised on imbalance	€/year	-64	-82	-46	-37	-84
Heat Pump optimised on FCR	€/year	-24	-24	-23	-10	-39
Heat Pump optimised on aFRR down 4h	€/year	-7	-10	-4	-3	-11
Heat Pump optimised on aFRR up 4h	€/year	-38	-38	-37	-16	-60

Electric Vehicle

The baseline is that the electric vehicle is charged every day for the daily average milage according to a standardised profile, the RLP. For the valuation, the spot market price is used. Other value parameters are not directly relevant as the timing of the car charging in itself only shifts electricity from one hour to another. There might also be an impact on the distribution tariff in the form of a reduction of the peak consumption. This is discussed in a separate comment.

No Vehicle-to-Grid is assumed. So the car is only charged, not discharged. For charging/discharging valuation, we refer to the Home Battery case.

Day ahead spot market optimisation

The assumption is made that the battery is charged every day to cover the average kilometres driven daily. In the day ahead optimisation, charging is done during the cheapest hours of the day.

This scenario is realistic and feasible, with the nuance that the car has to be home and plugged in. The value shown in the simulation is a theoretical maximum value where all the hours of the day can be selected for charging. Hourly spot prices for a day are known the previous day at 13h and fully transparent to the consumer. So the electric vehicle charging can be fully determined based on available data."

Imbalance value optimisation

In the optimisation on imbalance, the assumption is made that the electric vehicle is charged during the cheapest imbalance hours of every day to cover daily demand.

The theoretical value in this optimising very high, because the variations in imbalance prices is much more extreme than on the spot market. But this is a highly theoretical case which is practically impossible to achieve. The imbalance prices are not a priori known and only revealed ex post. So it is not possible to schedule EV charging on known imbalance prices.

Part of the value of imbalance could be captured through the intraday market. If imbalance threatens to occur due to circumstances (e.g. less wind than predicted day ahead), that value may already occur in the intraday market. Therefore, the feasibility of this option is pragmatically set to 20% assuming part of the value could be captured by either predicting the imbalance price or by taking action on the intraday market.

ELIA services

Electric vehicles can also deliver flexibility services to ELIA; FCR, aFRR down and aFRR up. E.g., a charging electric vehicle can temporarily stop charging. But these possibilities have to be in line with the reality of the electric vehicle. E.g., an electric vehicle that needs to charge 4 hours per day is only available during 4 hours a day to deliver this ELIA services. To estimate the theoretical potential, we assume that a pragmatic 25% of the daily electricity consumption for charging is available for these services. 100% is not possible because the EV needs to be in the correct state to deliver a service at the time ELIA activates the reserve. E.g., aFRR up can only be delivered if the EV is charging and the charging can be stopped.

Nonetheless there is some potential in offering this service if distinct loading patterns emerge. If the EV charging is optimised on day ahead value, the charging state of the EV is known in advance and directional ELIA services could be offered during distinct periods depending on the EV loading state and battery content.

Combined value streams

It is not possible to fully combine all value streams. But it is possible to grasp opportunities. E.g. when EV charging is optimised on the day ahead prices, a default charging schedule is set. Then, during the day, that schedule can be finetuned using other value streams such as intraday opportunities or to provide an ELIA service. Of course, then the day ahead schedule is altered and part of the value stream in day ahead optimisation is sacrificed to capture another value stream.

Some value streams cannot be combined. E.g., an asset cannot participate in FCR and aFRR simultaneously.

Comment distribution tariff

In the context of the capacity tariff, it is advisable to take into account the maximum consumption peak in the EV charging schedule. With a capacity tariff of €40/kWpeak, every additional peak will therefore result in an increase in distribution costs. It is advisable to take into account the simultaneous charging of the EV and other big electricity consumers. A higher simultaneous use during cheap hours implies a better utilisation of the lowest possible market prices, but is also increase the capacity tariff.

Simulation results

The table below shows some simulation results on the potential savings to be made for electric vehicles under a set of hypotheses.

Variations are made on

- Market price; default €70/MWh, high €100/MWh and low €40/MWh
- Distance drive annually; default 30000km, low 15000km and high 60000km

ELECTRIC VEHICLE						
Assumptions						
average annual market price	kWh/a	70	**100**	**40**	70	70
Battery	kWh	80	80	80	80	80
Charger	kW	4	4	4	4	4
Annual use	km/a	30000	30000	30000	**15000**	**60000**
Energy use	kWh/100kr	20,00	20,00	20,00	20,00	20,00
Daily use	kWh/day	16,4	16,4	16,4	8,2	32,9
ELIA service factor		25%	25%	25%	25%	25%
#hours available for ELIA service		4	4	4	2	8
Fraction imbalance value captured		20%	20%	20%	20%	20%
Results						
BASELINE: Charge EV on RLP	€/year	436	614	258	218	872
Annual savings compared to baseline						
EV charge optimised on spot	€/year	-156	-212	-99	-86	-247
EV charge optimised on imbalance	€/year	-90	-117	-63	-54	-136
EV charge optimised on FCR	€/year	-37	-38	-35	-18	-74
EV charge optimised on aFRR down 4h	€/year	-10	-17	-3	-5	-20
EV charge optimised on aFRR up 4h	€/year	-50	-56	-43	-25	-100

PV and Self Consumption

The baseline is the electricity consumption of a household without PV according to a standard consumption profile RLP. Then, solar panels are added and finally the self-consumption of these solar panels is optimised.

The value streams taken into account are the spot market and the distribution tariff, levies and contribution for green certificates GSC and cogeneration certificates WKC. The spot market provides the value at which electricity is bought from the market in case of consumption and sold to the market in case of injection. Distribution tariff, levies and GSC/WKC are considered because the distribution is charged on consumption, but not on injection.

With more frequent negative prices, curtailment of PV could also increase the value of PV. Curtailment is not taken into account here.

With PV

Solar panels are added following the standard production profile for solar electricity.

In the evaluation of the total costs, the household consumption profile and solar production profile are netted every hour. Consumption is valued at market price plus distribution tariff, levies and GSC/WKC contribution. Injection is valued at only the market price.

PV with optimised self-consumption

Consumption is assumed according to RLP profile. Production from SPP profile.

In the optimisation of self-consumption, the daily net balance is considered. The injection during hours of net injection is maximally transferred to the hours of net consumption. Load is thus shifted from net injection to all hours with net offtake proportional to that net offtake.

Comment on self-consumption

- The value calculated here is a theoretical value. The shift from hours with net injection may not be fully achievable due to practical reasons such as being present in the house or non-shiftable load (e.g. cooking at 19h).
- The addition of other technologies such as home battery, heat pump or electric vehicles can also facilitate the self-consumption of PV.

Simulation results

The table below shows some simulation results on the potential savings to be made with PV and improved self consumption under a set of hypotheses. The default case is for a household with 4000kWh gross consumption and 4000kWh gross PV production.

Variations are made on

- Market price; default €70/MWh, high €100/MWh and low €40/MWh

- Dimensioning of PV system; default 4000kWh/y, low 2000kWh/y and high 6000kWh/y

PV & Self Consumption						
Assumptions						
average annual market price	kWh/a	70	**100**	**40**	70	70
RLP consumption	kWh/a	4000	4000	4000	4000	4000
PV production	kWh/a	4000	4000	4000	**2000**	**6000**
Distribution tariff	€/MWh	50	50	50	50	50
Levies	€/MWh	50	50	50	50	50
GSC/WKC	€/MWh	16	16	16	16	16
Results						
BASELINE: without PV	€/year	754	873	636	754	754
Annual savings compared to baseline						
with PV	€/year	-413	-524	-302	-264	-546
with PV and optimised self-consumption	€/year	-542	-664	-419	-343	-696

Must haves for supplier and flexibility service provider

When a customer wants to participate in flexibility services, the customer is expected to meet some requirements. Firstly, the customer needs to have a digital meter installed in its dwelling to have the necessary metering data. In addition, the smart meter regime 3 (SMR3) needs to be activated and the customers are required to have a contract with its supplier based on a dynamic price (for the wholesale component). A more detailed description of requirements can be found in D3.5 'Report on business processes adaptation to enable the inclusion of small scale assets in the provision of flexibility services'.

The flexibility service provider needs solid price and imbalance value forecasting tools to capture added value in flexibility. These signals also need to be transparently shared with the customers through and interface.

Must haves hardware and tools

An absolute minimum hardware requirement to use and valorise flexibility is a digital meter operating in smart meter regime 3 (SMR3) where market processes are handled on a 15' basis. Digital meter and SMR3 are needed for the supplier or flexibility provider to interact with the customer. They are needed for all value streams; day ahead, imbalance and system services. To further facilitate, a dynamic price contract is also helpful.

To facilitate the interaction between the flexibility provider and the customer, an interface is needed for visualisation of dynamic prices and thus show the incentives to the customer.

Flexibility works best in an automated process. Therefore an energy management system EMS is needed to interface between the signals sent by the flexibility provider and the steering of the equipment of the customer.

To enable using the Elia services, hardware is also needed. For FRR, the BRP needs to install a steering box to trigger activation. For FCR, a local frequence meter needs to steer the FRC activation. For more info, see also reports in deliverables 3.6 and 2.1.

If steering is needed on distribution level (congestion, voltage), additional measurement and steering equipment may be needed.