AmsTErdam BiLbao cItizen drivEn smaRt cities

Deliverable 9.2

Monitoring and Evaluation Framework
Indicator Database with interface

WP9, Task 9.2

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Author(s):	UNIVERSITY of DEUSTO: Roberto Garay, Tony Castillo, Itziar Salaverria, Xabier Cantero, Muhammad Talha Siddique, Ainhoa Arriazu PSI, Kannan Ramachandran CARTIF, Jose Luis Hernandez

[1] PU = Public
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DoA	The objective of this WP is to provide monitoring of the measures implemented for the PEDs, as well as impact assessment and evaluation of key performance indicators (KPIs), covering 8 main categories of aspects: environmental, economic, social, energy, mobility, spatial, general characteristics and communication. Monitoring will focus on the actual performance of the PED measures, while impact assessment will compare the actual performance with the performance in business-as-usual scenarios (BAU), and evaluation will compare target actual and target performance. To accomplish the tasks, a set of KPIs is defined in close collaboration with other WPs on PED developments and measures implementation. KPIs will be quantified based on data collected from other WPs on energy and water consumption, pollutant emissions, energy demand patterns (e.g. demand pattern for community EV usage), investment cost, financing of PED measures, spatial information, etc. The WP will also monitor the progress achieved, innovation aspects that arise from the project, the perspectives of citizens, such as the changes that residents and stakeholders experience under the transformation to a PED, their inputs and potential changes on behaviours. Life cycle perspectives will be incorporated in the impact assessment in order to address the issue of burden shifting from one sector to another. The approach will facilitate applying the monitoring and impact assessment approaches to the fellow cities, and shed light on possible roll out of PED measures in a broader range of other European cities.		
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Disclaimer

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Executive Summary

This document presents the methodology, data sources and processes for the monitoring of the PED performance of the ATELIER demonstration sites.

Performance is monitored with regards to a set of Key Performance Indicators (KPIs), covering a wide range of dimensions. Based on the overall aim of the project, PED performance is assessed against the agreed-upon baseline case in the BEST table values.

While the PED performance at the design stage was based on standard boundary and technical conditions, it is necessary to adjust it to reflect real-world operational conditions, such as building occupancy rates, local weather, and the primary energy equivalent of energy sources. To achieve this, a cascade of scenarios is developed to quantify a correction factor or coefficient, allowing for a comparison between the actual performance of the PED and the initial plan. Thus, with this monitoring framework, the BEST table value can be adapted to real-conditions or used to compare the monitored performance with design values, helping to assess potential deviations during implementation or usage.

The current document presents a structured approach to PED monitoring, feasibility analysis of such approach over real-life data sources, requirements with regards to GDPR, adaptations for climate and static factors, data interactions, engineering revision of data sources, practical applications to the KPI calculation, reporting, and mitigation processes for potential missing data, among other items.

1 Introduction

ATELIER is research project on Positive Energy District (PED) development. Within ATELIER, two such districts will be developed in Amsterdam and Bilbao. ATELIER WP9 aims at performing the monitoring of such developments.

Monitoring shall be performed with regards to many Key Performance Indicators (KPIs), covering a wide range of dimensions. This document develops the methodology to do so, including the identification of data sources, as well as the definition of databases and processes to implement such methodology.

A large share of the actual methodology is linked with energy-related metrics, as it is the cornerstone for latter assessment of economic and environmental metrics.

Based on the overall aim of the project, PED performance is assessed against the agreed-upon baseline case in the BEST table values.

The presented approach encompasses a total of six evaluation scenarios, each addressing different stages of the PED evolution, confronting deviations due to Design, Implementation, Usage and Climate.

These scenarios are considered for Energy and Economic Assessments. KPIs for these dimensions are expected to vary relevantly due to climate, static factors and variations due to the construction process. Performance for other dimensions KPI are only confronted with regards to the baseline.

2 Performance assessment approach

This document sets out the PED monitoring criteria for ATELIER. It is based in the ATELIER BEST table values, and particularized based on IPMVP methodology, considering adaptations for changes in climatic and static factors, as well as the particularities of PED configurations and data sources.

PED performance is defined at high level in ATELIER BEST table values. Performance metrics are stated under standard conditions (i.e. climate) at very high aggregation level.

KPI definitions (D9.1), associated formulae, monitoring points and reference boundaries developed within ATELIER provide greater detail for the performance assessment.

Monitoring works need to perform adaptations that consider the following facts:

- Real-life meteorology will differ from standardized climate data
- Actual usage of buildings and technical systems will differ (i.e. lower population speed[2])
- Reference parameters at technical system (i.e. COP) or general system (i.e. Primary Energy Factors) will vary

Considering this, the adaptations from the monitoring works will be transferred to the performance assessment process.

Also, monitoring will be performed at time-aggregated levels, but with ~monthly resolution. This requires the re-interpretation of PED performance assessment at yearly aggregation levels, and live data streams (~hourly resolution) at the correct time aggregation level.

To the greatest extent possible, monitoring will be performed by considering the smallest possible scope and most clear boundary conditions. In particular, the following assumptions will be performed:

- In new buildings, Nearly Zero Energy Building (NZEB) performance levels are already required by local regulations[3]. This implies that there is no differential investment between ATELIER and the baseline.
- All economic costs and revenues will be estimated considering publicly available tariffs and calculation methods. Bilateral agreements will not be considered.
- Cost associated to distribution systems (i.e. electricity, district heat and geothermal systems) will not be considered. These are meant to be imposed by local regulations as part of the development obligations. Additional costs due to increased infrastructure size are considered not to be significant nor easy to define.
- Geothermal systems are known to have a very long service life. They are considered to be part of the overall infrastructure of the area. However, given their specific use as heat sources & sinks, they are key in the energy system. They will be integrated in payback calculations as annualized costs. This avoid that these are a burden in the overall economic calculation, while ensuring that their costs are considered.
- Small energy/cost/revenue streams will be disregarded. Assuming that these are below 10% of the total magnitude to be assessed.

[2] Once erected, there are periods where buildings are fully or partially empty as dwellers move-in.
[3] i.e. Spanish Technical Building Code. Basic Document for Energy (recast 2022), but this is applicable to any EU country (where Energy Performance of Buildings Directives are transposed to national regulations) and many other developed countries worldwide.

Specificities for Life Cycle Assessment

Life Cycle Assessment is specifically dealt with in a dedicated deliverable. Please refer to section 8 “Applying Life Cycle Assessment (LCA)to Positive Energy Districts (PEDs)” for details.

2.1 Scenarios to be compared

In the frame of Atelier, PED performance will be assessed based on the set of scenarios defined in *Table 1*

Table 1. Performance Assessment Scenarios

Scenario	Content	Comments
I	BEST table values.	Based on synthetic climate, usage and conversion factors.
II	BEST table values. With corrections for Climate.	Corrected with actual climate.
III	BEST table values. With corrections for Climate, Reference parameters & Usage factors.	Corrected to real climate, usage and conversion factors.
IV	PED. Actual performance.	As monitored on-site.
V	PED. Actual performance. Corrected for usage factors.	Considers that variations in the usage factors, so that the underlying performance can be better compared with the baseline.
VI	PED. Actual performance. Corrected for usage factors. With reference climate, parameters & corrected for energy exports.	Corrects for energy exports, so that the impact coming from decisions at district development levels are avoided.

The scenarios will be compared as per *Table 2* so that specific performance can be assessed.

Table 2. Specific scenarios to be compared for the adaptation of performance at different stages

Confrontation	Baseline	Monitored Scenario	Question to be answered
Climate	I	II	Is the performance of the PED impacted by climate change, or non-realistic assumptions with regards to climate?
Technical assumptions	II	III	Is the performance of the PED impacted by inaccurate technical assumptions?
Goodness of implementation	III	IV	Is there a performance gap in the PED due to deviations in the implementation phase?
Goodness of business case	II	IV	Considering the actual situation of the PED only with corrections for climate, is the business case sound?
Impact	I	VI	Fitness of PED performance to the target.

The KPIs will be obtained for both individual scenarios and/or for specific confrontations. Figure 1 summarizes the Scenarios and Confrontations with their main characteristics.

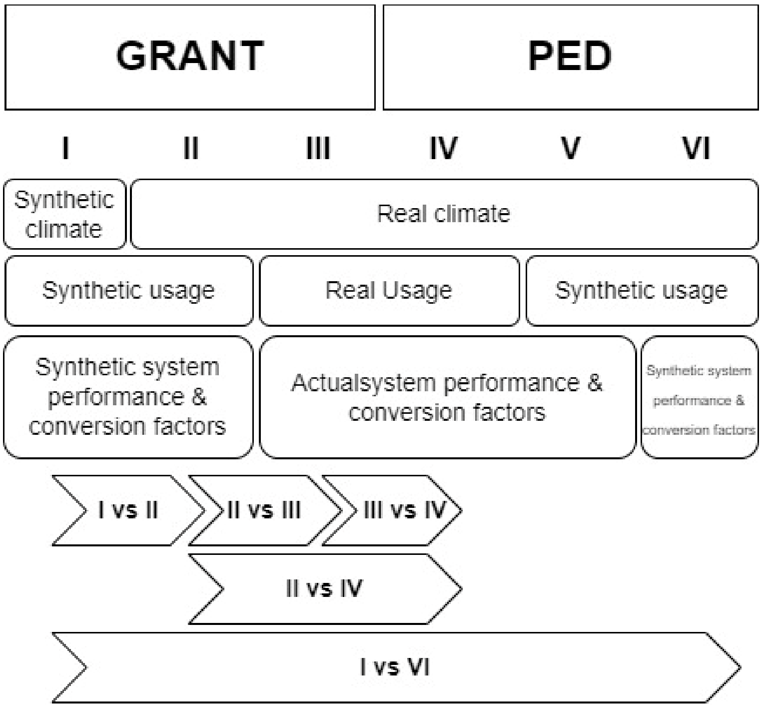

Figure 1 Synthesis of Scenarios and comparisons for the adaptation of performance at different stages

These scenarios are considered for Energy and Economic Assessments. KPIs for these dimensions are expected to vary relevantly due to climate, static factors and variations due to the construction process. Performance for other dimensions KPI is only confronted with regards to the baseline.

3 Adaptation for static & dynamic factors

In agreement with the International Performance Measurement & Verification Protocol (IPMVP)[4], measurements need to be properly contextualized. This requires that changes factors affecting the system are corrected. The following factors are relevant:

- Parameters. A priori knowledge or reference values are defined outside the monitoring work. i.e. Country-level Primary Emission Factors.
- Static factors. Items that are expected (most possibly) to be constant in the lifetime of the monitoring works. i.e. number of opening hour in a building.
- Dynamic factors. Items that are expected to change in the lifetime of the monitoring works. i.e. climate.

Adaptations to these factors can be performed in different ways:

- Projecting actual performance over the conditions defined in the baseline. (i.e. pre-intervention climate)
- Projecting baseline performance over the actual conditions in the monitoring process. (i.e. post-intervention climate)
- Projecting baseline and actual performance over standardized conditions (i.e. synthetic climate file)

In the particular case of ATELIER, and EU Smart City project monitoring approach, the following shall be considered:

- The pre-intervention condition is non-existing. Impacts were defined based on synthetic business cases. Thus, pre-intervention and synthetic conditions are equivalent. The targets defined in ATELIER are defined based on threshold values & targets defined in national building codes & engineering practice. They shall be considered as simulated values as per the IPMVP[5]
- Different aims in the PED monitoring require a twofold approach in the PED performance assessment & reporting:
    - The assessment framework requires that the expected performance is compared directly with the outcomes of the PEDs. This will be done through a direct confrontation of the targets set in the grant with (properly corrected) actual performance of the PEDs.
    - Insights and reports to the local stakeholders at PED level require to focus at the real system. This will be done through the correction of the targets set in the grant prior to the confrontation with the actual performance of the PED.

[4] International Performance Measurement & Verification Protocol. Volume I: Concepts and Options for Determining Energy and Water Savings, 2002, available at: https://www.nrel.gov/docs/fy02osti/31505.pdf

[5] This makes the assessment not fully compliant with IPMVP criteria. But ATELIER is claiming full performance (to achieve PED performance) rather than relative (to improve a building/neighbourhood by a certain difference). In this context it makes sense to do so. Reference to IPMVP is kept as much as possible due to its relevance in the context of monitoring and valuation of interventions.

3.1 Adaptation for climate factors

The focus of adaptation revolves around climate-related factors, and the following variables are taken into consideration for this purpose:

- Irradiance power in the horizontal axis registered by the sensor (kWh/m^2).
- Temperature of the air registered by the sensor (℃)

Based on these variables, climate metrics will be developed (cumulated at monthly/yearly bins):

- Heating Degree-Days (HDD)
- Cooling Degree-Days (CDD)
- Cumulated Irradiance

HDD and CDD are formulated as follows[6]:[7]

$$HDD = \sum_{i=1}^{365} (T_{base} - T_i)^+$$

$$CDD = \sum_{i=1}^{365} (T_i - T_{base})^+$$

Where:

- Ti is the Daily mean of the outdoor temperature
- X+ = MAX (X,0)

Linear corrections of the actual performance will be performed based on these metrics. The following performance metrics will be corrected along with their derived KPIs:

- Heating loads, based on Heating Degree-Days
- Cooling loads, based on Cooling Degree-Days
- Solar electricity production, based on Total monthly Irradiance
- Solar heat production, based on Total monthly Irradiance

All corrections will be performed at aggregated level. Typically at monthly and yearly time frames. For the applications at lower resolution levels (i.e. electricity, due to different hourly prices), linear corrections will be made, based on the linear differences at monthly level.

[6] Definition mostly taken from https://www.energy-a.eu/cooling-degree-days-and-heating-degree-days but Ti replaced for the MEAN DAILY TEMPERATURE
[7] Formulae for yearly value (365 values), but can be done at monthly resolution (28/29/30/31 values)

Below, an example is shown for the correction between Scenarios I (synthetic climate) and II (real climate):

- Scenario I
    - (estimated in Grant Agreement)
        - Heating load: 1000kWh
        - COP: 2.5
        - Distribution loss: 0.1
        - Electricity load (associated to heating): 444.444 kWh
        - Electricity costs (associated to heating): €100
        - Average electricity costs: 0.225 €/kWh
        - Heating degree-days: 1000 HDD
- Scenario II (real climate)
    - (measured)
        - Heating degree-days: 900HDD
    - (Stable factors)
        - COP, Distribution loss & Average electricity costs
    - (Corrections)
        - Heating load: 1000 * 900/1000 = 900kWh
        - Electricity load: 444.444 kWh * 900/1000 = 363.636 kWh
        - Electricity costs: € 363.636 * 0.225 = € 81.8181

3.2 Adaptation for usage factors

Monitoring needs to perform corrections due to transitory phases linked to the population of districts, and/or market-related issues affecting the stabilized population/usage in buildings:

- The progressive population of buildings makes it reasonable to expect that occupancy of the buildings will be far from the originally planned[8] occupancy (f.i. 20%, 50% or 90%) for long periods.
- Occupancy rates of commercial buildings will rise progressively
- Variations in operational schedules of commercial buildings may occur due to changes in working calendars or other in-company policies.

It is required that a proper usage factor is calculated to analyse the performance of the districts. This is very relevant for reporting periods since this guarantees consistent monitoring and update it to account for changes in building occupancy levels.

Corrections will be performed over the variables related to end-uses:

- Heating loads
- Cooling loads
- Electric loads

These corrections will be done based on index variables:

- For residential buildings: Flat/…occupancy levels (number of flats where electric load curves comply with a threshold criteria)
- For commercial/office buildings: Reports from facility managers or estimations by data analysts[9]
- Overall: Reports by data providers[10]

A linear correction of usage factors will be performed, where final loads will be corrected and propagated.

[8] As per the PED design or BEST tables.
[9] i.e. preliminary inspection by Deusto/Cartif
[10] Iberdrola, Telur, Spectral

Examples[11] for forward (scenarios II -> III)and backward (scenarios IV -> V) correction of usage factors are presented below (as a continuation of the example in section 0).

Forward correction

- Scenario II
  - (measured)
    - Heating degree-days: 900HDD
  - (assumptions, estimations & previous corrections)
    - Heating load: 900kWh
    - COP: 2.5
    - Distribution loss: 0.1
    - Electricity load 363.636 kWh
    - Electricity costs: € 81.8181
    - Average electricity costs: 0.225 €/kWh
    - Building usage: 100%
- Scenario III (real usage)
  - (measured)
    - Building usage: 50%
    - Building usage in February: 2 weeks closed for big repairs
    - HDD in February: 230HDD
    - Building usage in August: 25% (holidays)
    - HDD in August: 0 HDD
  - (Stable factors)
    - COP, Distribution loss & Average electricity costs
  - (corrections)
    - Heating loads: 900 * 50% * ((900HDD-230HDD)/900HDD) =
      = 900 * 0.3722 = 335 kWh
    - Electricity load: 363.636 kWh * ((900HDD-230HDD)/900HDD) =
      = 363.636 kWh * 0.3722 = 135.345 kWh
    - Electricity costs: €135.345 * 0.225 = € 30.45

[11] Scenarios III-V also consider updates to performance and conversion factors. But these are not included in the example for simplicity.

<u>Backward correction</u>

- Scenario IV
  - (Estimated)
    - Distribution loss: 0.1
  - (Measured)
    - Heating degree-days: 900HDD
    - Heating load: 320 kWh
    - Electricity load 150 kWh
    - Electricity costs: € 27
    - Building usage: 50%
    - Building usage in February: 2 weeks closed for big repairs
      - HDD in February: 230HDD
    - Building usage in August: 25% (holidays)
      - No effect in heating loads (HDD in August: 0 HDD)
  - (Calculated)
    - COP: 2.37
    - Average electricity costs: 0.18 €/kWh
- Scenario V (synthetic usage)
  - (Assumption)
    - Building usage: 100%
  - (Stable factors)
    - COP, Distribution loss & Average electricity costs
  - (Corrections)
    - Heating loads: 320 kWh * (900/(900-230)) * (100%/50%) =
      = 320 kWh * 2.6865 = 859.7 kWh
    - Electricity load: 976.93 kWh * (1/(1-0.1)) * (1/2.37) = 458 kWh
    - Electricity costs: € 458 * 0.18 = € 82.44

3.3 Adaptation for engineering assumptions (reference parameters)

This applies to all parameters considered in the definition of the BEST tables, as well as the KPIs.

The following reference parameters are considered:

- Performance of technical equipment (i.e. COP of heat pumps, distribution loss, etc.)
- Country-level indexes (i.e. Primary Energy Factors and CO2 emission factors)

The following two scenarios are considered:

- Parameters used in the definition of the PED objectives (Grant). These come from tabulated values.
- Parameters from the real-life implementation of the PED. (some) Parameters from technical equipment will be calculated based on real performance. Country-level indexes will be updated with the latest available data.

3.4 Adaptations for economic assumptions

Economic tariffs will be performed in agreement with reference energy tariffs. As an example case, energy tariff for Bilbao is provided in Annex II .

4 Further definition of high-level Monitoring

High level monitoring in ATELIER are defined as unique figures (i.e. yearly thermal energy imported/exported to the PED), that need to be referenced to actual system boundaries, confronted with various subKPIs (i.e. segregation of Heating & Cooling energy) and projected over different timespans and varied climate conditions.

System boundaries along with input signals are specifically set in Annex I. KPI (& subKPI) definitions are set in Annex III.

With regards to time and climate projections, all of these will be done based on Heating & Cooling degree days. For solar technologies, solar irradiation over the horizontal plane will be considered. Unless otherwise stated, the following reference temperatures will be considered:

- Heating Degree Days: 15ºC
- Cooling Degree Days: 22ºC

In all cases, timespans not shorter than 1 month will be considered.

In the case of subdivision of aggregated energy metrics, Heating and Cooling Loads will be disaggregated as the fraction of Heating/Cooling Degree Days vs the sum of Heating+Cooling Degree Days of the reference period. It is acknowledged that this process is highly speculative. It will be performed only as the initial step in the correction of BEST data, over full year synthetic climate data.

5 Data quality issues

It is expected that time series arising from data suppliers will have some missing or outlier data.

Metering is performed through utility meters[12]. These systems are regulated by law and standardized procedures. Data quality is expected to be in good quality at all times. with no relevant outliers. Shall there be any issue with regards to outliers, specific procedures will be defined at that moment.

There is however a possibility that data supply is interrupted due to real-life issues. In this cases, three possible situations may occur:

- Data is missing for <1week[13]. In this case, the available data will be expanded so that it provides synthetic data for the full reporting period.
    - Extrapolation of energy data will be performed considering degree-hour / solar irradiance criteria.
    - Escalation of EV usage will be performed considering the number of days
- Data is missing as per the previous statement. But the cumulated value is available in the first reading after the data failure[14]. In this case, the cumulated data is backpropagated to the period of failure as per the aforementioned criteria.
- Data is missing for periods >25% of the reporting period. Two possibilities arise:
    - If the aggregation of 2 reporting periods results in a failure <25% of the total data. This shall be done. Then the previous procedures are performed.
    - Otherwise. This period shall not be reported.

[12] Used for invoicing heat and electricity to customers.
[13] Or <25% of the reporting period.
[14] This is typical of heat meters for cases where the failure was only on the communications part.

6 Specific provision for each site

The overall performance monitoring methodology has been defined based on a broad definition of the PED developments in ATELIER, as well as general performance assessment methodologies such as IPMVP.

This section incorporates the particularities of the each PED development in the project, regarding its zoning, implementation, timing, data sources, etc.

Atelier PEDs are composed as follows:

- Bilbao
    - Three zones in the same district: North/Center/South
    - Residential and commercial buildings
    - PV plants, Ground-Source Heat Pumps
- Amsterdam
    - Three districts: Schoonschip[15], Republica & Poppies
    - Residential, hospitality and commercial buildings
    - PV plants, Ground-Source Heat Pumps, Electric vehicle charging infrastructure, electric battery

A full list of peds, blocks, buildings, technologies available as annex II (energy tariff information) to this document.

[15] No data available

6.1 Bilbao

6.1.1 Scope of assessment

The scope of the assessment is as follows:

- North Area
  - 3 residential buildings, with associated ground-source heat pumps and photovoltaic electricity production
- Central Area
  - 2 office buildings (Beta I & II) buildings, with associated ground-source heat pumps and photovoltaic electricity production
  - Connection of several existing residential buildings to GSHP[16]
- South Area
  - Papelera building[17]

6.1.2 Known issues

The BEST table incorporates heating and cooling loads, as well as renewable energy production and conversion factors, in agreement with PED design, BEST criteria, and local definition of NZEB scopes. Nevertheless, there are some issues that should be made explicit to avoid misunderstandings. BEST tables:

- Do NOT consider electromobility (out of the scope of CTE)
- Do NOT consider electric consumption in residential buildings (out of the scope of CTE)
- Consider electric use in tertiary buildings for lighting
- Thermal energy export is considered as the export POTENTIAL of the geothermal field. This will be incorporated to Scenario VI

Usage factors:

- The energy consumption of residential buildings <u>will </u>need to be adapted as per the baseline energy consumption of actually occupied buildings. At the moment, the residential buildings are not having enough occupants which would reflect a reliable number related to its energy consumption. For this reason, energy consumption needs to be adapted
- The energy consumption of Tertiary buildings <u>may </u>need to be adapted as per the baseline energy consumption of actually occupied buildings. The reason for adaptation is similar to residential buildings, where the current status does not reflect the baseline numbers and thus, adjustment is needed

Heat pump data:

- In March 2025 data is only available for Beta I. The data source will be further populated with the integration of GSHPs in other buildings.

[16] These buildings have been recently confirmed with building owners, and the definition of the monitoring approach is yet unclear. It may be similar to buildings in the Nort Area.
[17] This building has been recently confirmed with the building owner (municipality) and tenant. The definition of the monitoring approach is yet unclear. It may be similar to office buildings in the Central Area.

- The GSHPs in RZ13.3 will be purposefully deactivated to perform A/B[18] testing in the bilateral agreements of TELUR with building owners. The monitoring shall apply the average performance of the active GSHPs to the heating loads in RZ13.3.

The effect of smart lighting is small and difficult to measure. Will be considered as per the BEST table.

6.1.3 Data sources

6.1.3.1 Climate

In the case of Bilbao, climatic data will be extracted from Opendata Euskadi. Data for the Meteorological station installed at Punta Zorrotza will be used. Two backup stations are also available in the area (Deusto, and the Airport of Bilbao).

The information of the main meteorological station is the following:

Location: ZORROTZA
Longitude: -2.968458
Latitude: 43.284980
Altitude: 5 m

Figure 2 shows the evolution of the irradiance and temperature from 2022-01-01 to 2023-05-11.

The data will be accessed by means of an API provided by Euskalmet -Basque Meteorological Agency. Data is loaded and available through the API quarterly[19].

[18] A/B testing is defined as a comparative test where two options are experimented side-by-side with different pools of users. This approach is increasingly common in IT systems (i.e. web intefaces), but not so common in Buildings/PEDs/HVAC, as there are limitations to have several buildings with the same conditions. The situation in Bilbao, with three equal buildings constructed at the same time allows to perform side-by-side tests where one building keeps a non-geothermal heat source and the outcome is compared.
[19] Deusto has developed custom code for the acces to this API. https://github.com/DeustoTech/atelier-data-tests.git

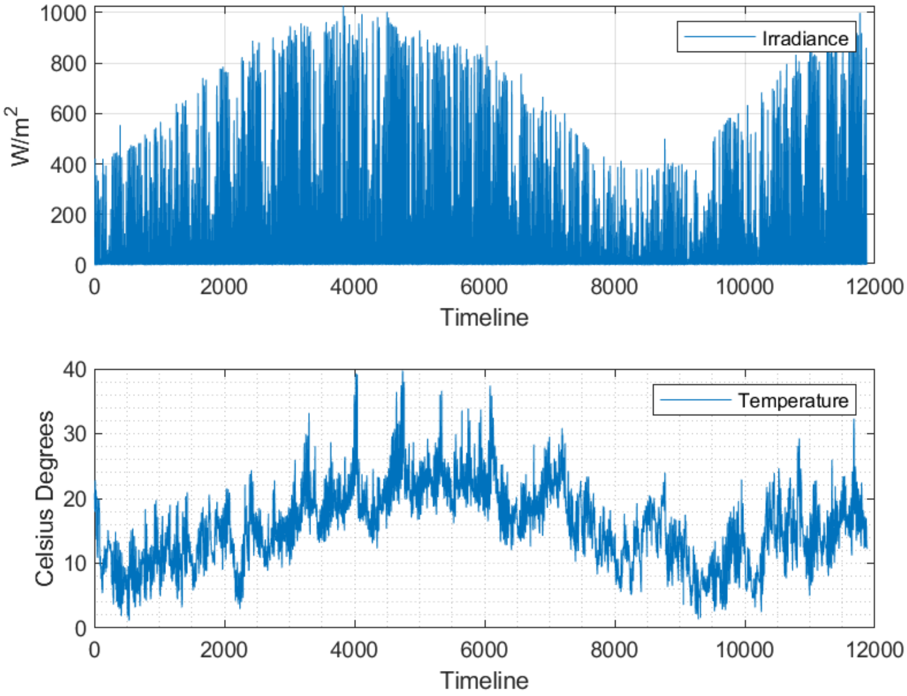

Figure 2 Global irradiance and temperature at the station Punta Zorrotza.

Alternatively, open weather data coming from open meteo will be used.

6.1.3.2 Geothermal systems

The data provided by Telur (Ground-Source Heat Pump system operator) comes from the geothermal network managed by them. The data on real time heat production and electricity consumption is available on a live dashboard[20] from where datasets can be downloaded.

The energy systems in these buildings comprise of heat pumps. The signals received from these heat pumps include data on flow rates, supply and return temperatures, as well as heating and cooling loads. Additionally, there is comprehensive data regarding the energy consumption of each heat pump. This setup allows for a thorough analysis of both thermal and electrical energy usage within the building. The dataset employed for this analysis is in a time series format, providing cumulative readings of both thermal and electrical loads. The data is recorded at 10-minute intervals, ensuring a granular and detailed understanding of the building's energy performance over time.

An initial analysis of data from one of three buildings in the geothermal network shows the energy consumption pattern of the building. The pattern is typical of an educational building with main usage during the working hours and relatively low consumption on weekends. Further energy signature analysis reaffirms this pattern by highlighting the difference in thermal load during weekdays and weekends. Figure 3 depicts the electrical and thermal load for heat pump 2 in the building.

[20] https://zeus.telurgya.com:3030/general.html

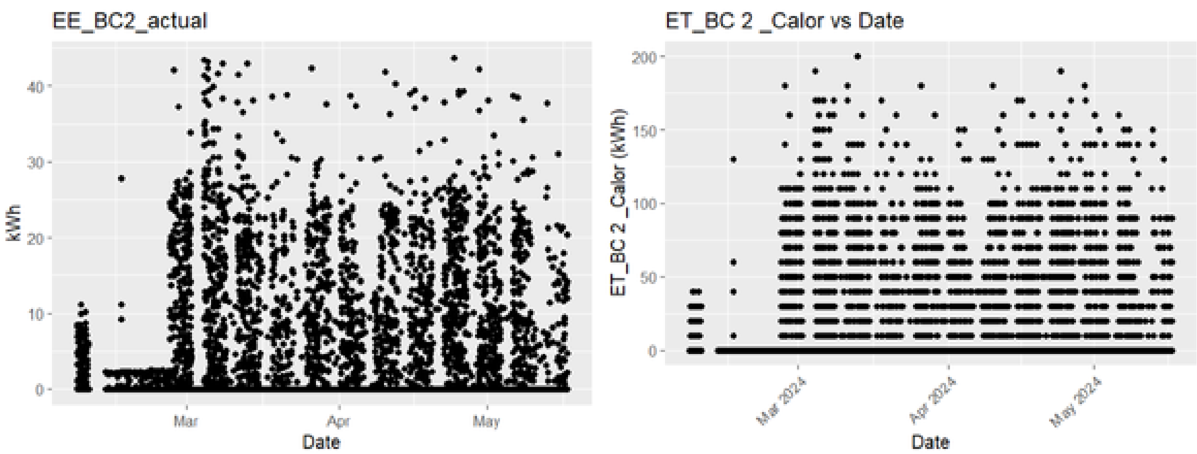

Figure 3 Electric consumption (Left) and thermal load (Right) of heat pump 2

6.1.3.3 Electricity data for large buildings (Iberdrola Clientes)

The data from Iberdrola Clientes mainly consists of electrical and comfort signals of Beta buildings. This data comes from electrical meters and is categorized with respect to different portions of the buildings.

The data for electrical signals contains various signals including 3 phases, neutral current, frequency, power factor for each phase, total harmonic distortion of current for each phase, voltage between each phase, apparent, active and reactive power for each phase.

Apart from the electric signals, there is also data related to temperature, humidity and carbon dioxide concentration. Figure 4 shows the power consumption from various part of one of the buildings

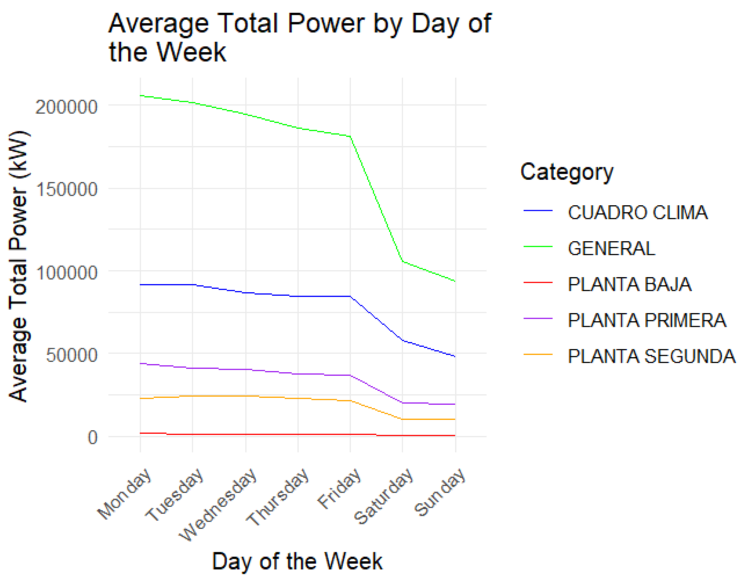

Figure 4 Power consumption for various parts of the building (digipen)

6.1.3.4 Electricity load data for households and small consummers (Iberdrola Distribución - IDE)

Iberdrola Distribución will provide information on the electricity usage in residential households. This information is subject to GDPR clearance. In agreement with IDE criteria, GDPR clearance will be achieved if more than data is aggregated for more than 10 electric meters.

This criteria is suitable for the needs of ATELIER as follows:

- Residential buildings are part of the scope of ATELIER in North and Central Area.
- In Central Area, buildings are relatively small, If all buildings are grouped together, these will result in an aggregation of more than 10 electric meters.
- In North Area, electricity supply to each building is distributed among substantially more than 10 meters.

The following information will be obtained:

- Hourly load curve of each aggregation
- Indicator of usage of buildings (number of meters fulfilling the criterion)
- Indicator of usage of electric vehicles (number of meters fulfilling the criterion & number of days/month)

6.2 Amsterdam

The performance monitoring approach has been initially established for Bilbao, where data access was sorted throughout 2022-23, and was then expanded to Amsterdam in 2023-24.

As of March 2025, data is available for the Republica site and the consolidation of of data sources in a main database has been performed (D9.3) with data until the end of 2024.

6.2.1 Scope of assessment

Monitoring will be performed over three sites:

- Republica
- Poppies
- Schoonschip

The scope of monitoring is the following:

- Buildings in the Poppies and Republica
- Electromobility on the 3 sites
- Electric and DH energy supply on the 3 sites
- 1 off-site PV plant in Republica

6.2.2 Specific issues

Data Sources:

- There is no cooperation in Schoonschip, where building owners will not provide access to the data. In agreement with this, Schoonschip will not be monitored.

Implementation:

- Biogas plant will not be active in the lifetime of Atelier. Not included in the BEST tables

BEST Table:

- Electromobility & streetlighting are not included in the BEST tables
- Energy estimations were made based on Dutch EPC criteria (at the time of the tenders for the developers). In agreement with this, Heating loads and PV systems were assessed jointly. These were partially segregated into the BEST table as follows:
    - Dutch EPC coefficient
        - 1 =~100kWh/m2/y
        - Residential was 1 in 2000 & meant to go down to 0 gradually
        - Tertiary was ~1.5 in 2000
    - Coefficients for the neighbourhoods are available in the BEST tables.

Usage factors:

- The energy consumption of residential buildings will need to be adapted as per the baseline energy consumption of actually occupied buildings
- The energy consumption of Tertiary buildings may need to be adapted as per the baseline energy consumption of actually occupied buildings

6.2.3 Data sources

6.2.3.1 Climate

In the case of Amsterdam, Data will be obtained from METEONORM. METEONORM is a meteorological service that provides data for any location in Earth, based on interpolation from existing weather stations. Data can be accessed through an API.

The information of the main meteorological station is the following:

Location: AMSTERDAM
Longitude: 4,900
Latitude: 52,350
Altitude: 0 m

Figure 5 and Figure 6 shows the evolution of the irradiance and temperature respectively

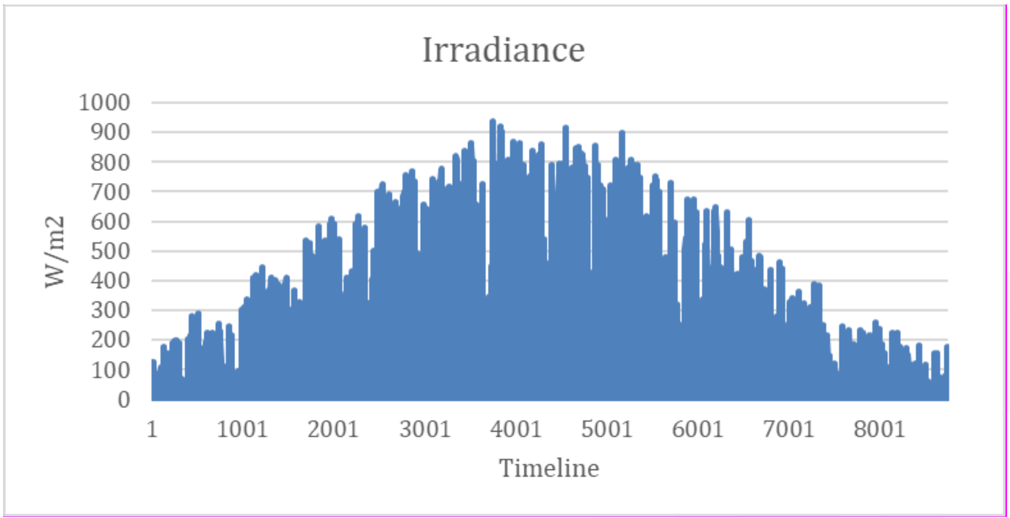

Figure 5 One year irradiance in Amsterdam

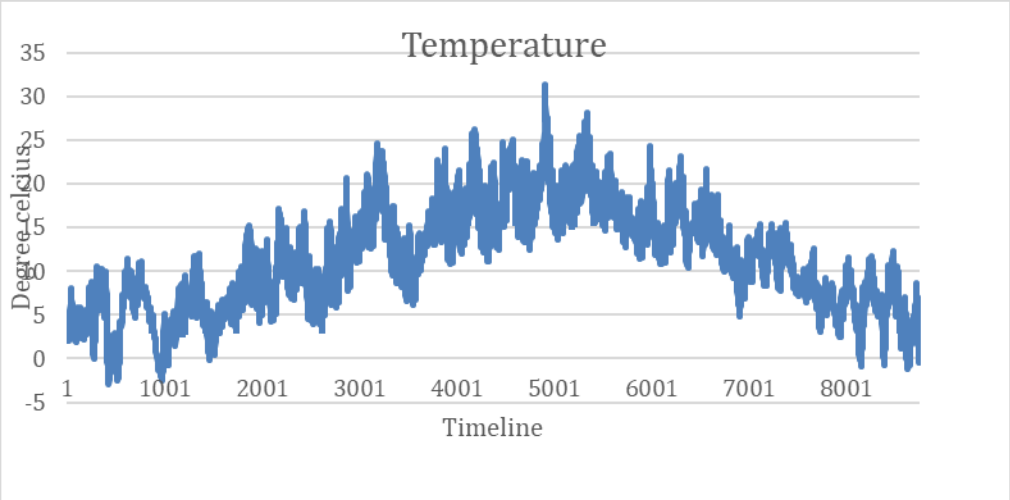

Figure 6 One year temperature in Amsterdam

Alternatively, open weather data coming from [open meteo](#) will be used.

6.2.3.2 Electricity

Electricity data is provided by SPECTRAL. The electricity data collected is for 7 different buildings from the July of 2023 up until December 2024. The time series data seems to suggest that building 7 has the highest consumption through out the selected time period with peaks around 300 kW. Other visible consumption seems to be from building 2,3,4 towards the end of the time period. A time series plot is presented in Figure 7

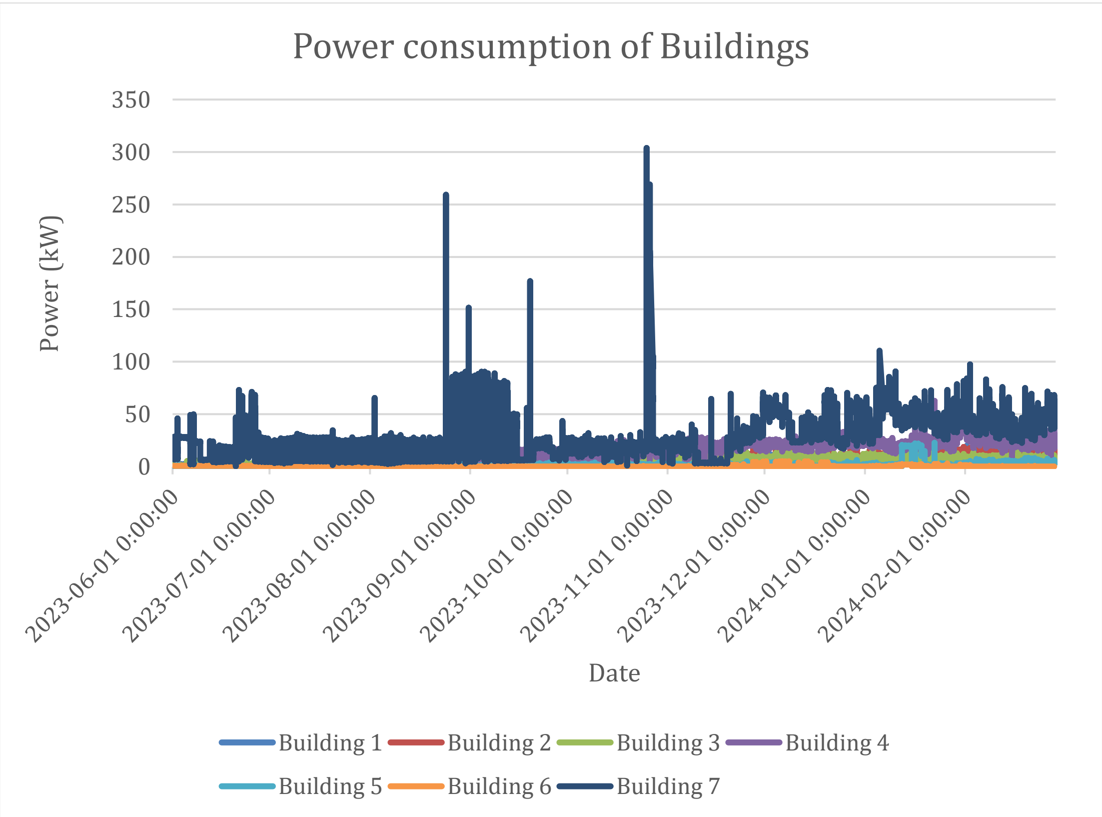

Figure 7 Power consumption of Amsterdam buildings

6.2.3.3 Heat

Heat data information is provided by the external heat metering provider with uneven resolution.

Additionally, electricity used for Domestic Hot Water (DHW) boosters[21] . This data is also provided by the same external provider.

[21] DHW boosters are technical systems that allow District Heating (DH) systems to meet DHW service temperatures. Modern DH systems deliver heat at the lowest possible temperature levels, while DHW service temperatures nee to be higher due to comfort and safety(legionella) issues. This is achieved by the booster systems (several technologies that rise temperature levels, and use electricity in the process).

7 Data Base Design & Structure

7.1 Data source integration

The current agreements[22] are that data will be obtained in the following way:

- TELUR: Direct access to data through API
- Iberdrola Clientes: FTP dump, continuous
- IDE: E-mail deliveries, 15 days after month finalization
- Euskalmet: Quarterly updated in API
- Meteonorm: Continuous[23]
- OpenMeteo: Continuous
- Spectral: E-mail deliveries, after month finalization

Economic information will be obtained in the following way:

- Pool data (i.e., PVPC) will be obtained from the corresponding data sources (annex II (energy tariff information)).
- Bilateral contracts will be calculated manually by applying the indexation criteria.

These datasets will be integrated manually in the database.

7.2 Stored data

For each site, the same structure shall be followed[24][25]:

Level 1: PED
Level 2: Block/Building

The following types of data are considered:

A. Time-aggregated (~monthly, yearly)
B. Time-series (~hourly)

For **energy-related** data, the following data structure will be performed:

In Level 1, the following information shall be stored:

- Climate. Heating Degree Days — A
- Climate. Cooling Degree Days — A
- Climate. Cumulated Solar Irradiation — B

[22] Or data source availability (i.e. for standard meteorological services)
[23] With a relevant cost of 100€/query. To be updated quarterly.
[24] Some items may only be available at an aggregated level
[25] A detailed list of system boundaries, and blocks within each PED is available in Annex I (system boundaries)

In Level 2, the following information shall be stored[26]:

- Thermal Energy. Heating. Demand A
- Thermal Energy. Cooling. Demand A
- Thermal Energy. Heating. Imported A
- Thermal Energy. Cooling. Imported A
- Thermal Energy. Heating. Exported A
- Thermal Energy. Cooling. Exported A
- Electric Energy. Heating & Cooling. Delivered B
- Electric Energy. Total. Delivered B
- Electric Energy. PV. Exported B
- Share of building in use A
- Electrical Energy. Demand. (energy needs) B
- EV chargers in use A
- EV charges A
- Electric Energy. EV charging Imported A

For **economic** data, the following data structure will be performed:

In Level 1, the following information shall be stored:

- Investment cost, aggregated at PED level A
- Electricity tariff. Households. Purchase price B
- Electricity tariff. Households. Selling price B
- Electricity tariff. Large consumer. Purchase price B
- Electricity tariff. Large consumer. Selling price B
- Nat. Gas tariff. Households. Purchase price B
- Nat. Gas tariff. Households. Selling price B
- Nat. Gas tariff. Large consumer. Purchase price B
- Nat. Gas tariff. Large consumer. Selling price B
- Heat tariff. Purchase price B

[26] Some of this may be filled-down based on simplified calculation procedures

7.3 Data Base Diagram

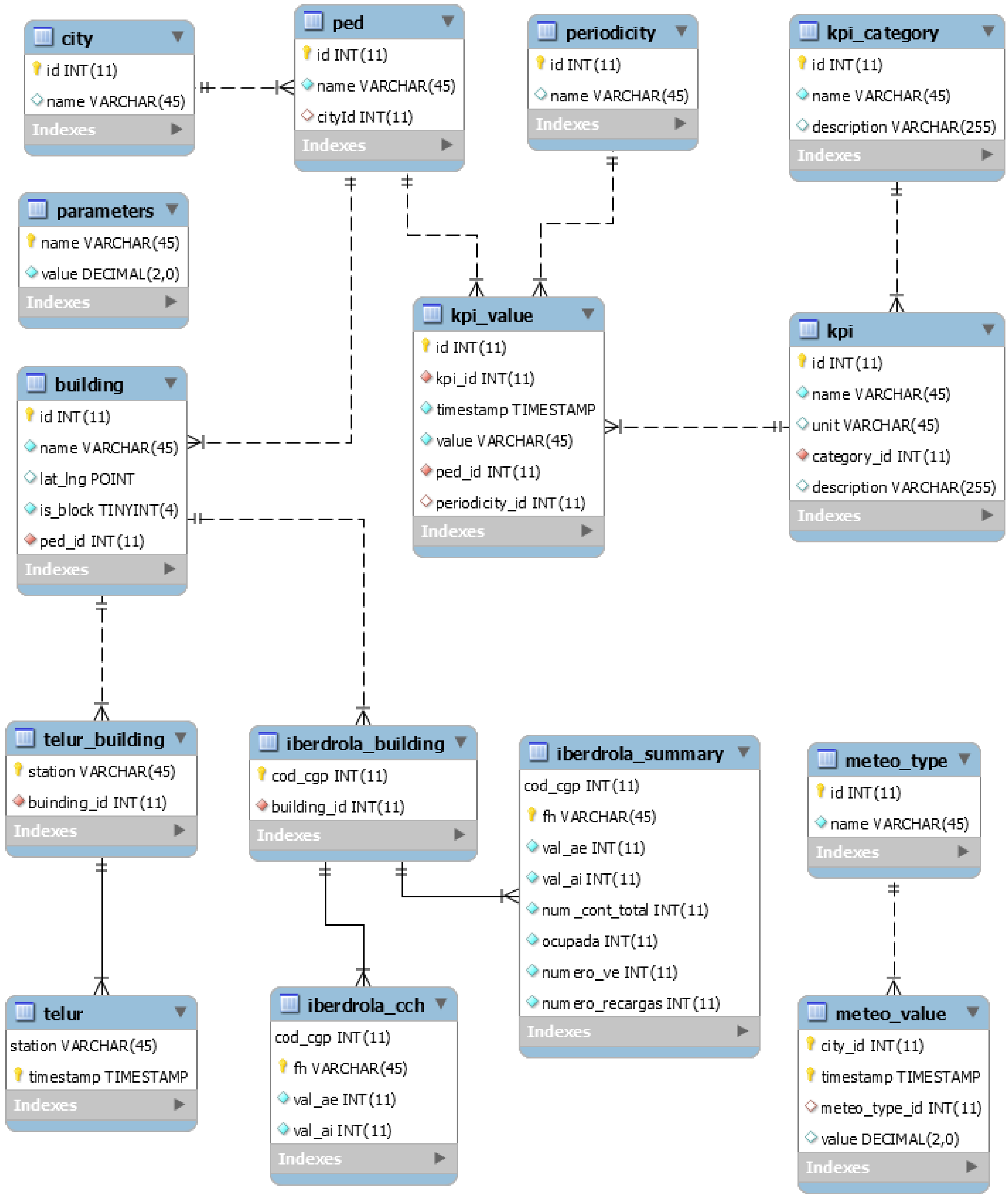

Figure 8 Data base diagram

8 Applying Life Cycle Assessment (LCA)to Positive Energy Districts (PEDs)

A unique feature of the ATELIER project is its use of Life Cycle Assessment (LCA). In typical smart city projects that features the concept of Positive Energy Districts (PEDs), energy use is primarily calculated based on the building's operational phase, including for example, heating, air conditioning, and other electricity consumption. As a result, there has been a strong focus on reducing building energy demand through various energy efficiency measures such as improved insulation, triple-glazed windows, and incorporating onsite renewable (e.g. solar photovoltaics) or other more efficient energy supply technologies (e.g. district heating). While these measures effectively lower operational energy use and greenhouse gas emissions (GHG), they do not account for the energy used or GHG embodied in the production of materials required for building construction or renovation.

To assess the overall environmental performance of sustainable buildings and districts, it is essential to consider not only the operational phase of buildings, but also the production and construction stage, as well as the end-of-life disposal and treatment of building materials. In this project, we apply LCA to evaluate broader impacts beyond energy use of the operational phase, by including life cycle GHG emissions and environmental footprint which encompasses other environmental performances such as resource use, particulate matter, acidification, etc [2]. However, unlike conventional PED energy monitoring, LCA requires extensive input data—such as the bill of materials during construction phase—which is not always readily available and requires data compilation from various sources and stakeholders.

As part of the ATELIER project, we developed an LCA methodology applicable for a sustainable urban district in accordance with the life cycle stages defined in EN15978 [2] and the available data from one of the demonstration sites, namely, Poppies in Amsterdam (Figure 2). The project also contributed to two IEA's EBC Annes, and [3][4]. several associated research articles have been published [5][6][7][8].

Using these methods, we conducted an LCA for the Poppies building in the Amsterdam PED. Poppies is a mix-use urban district located in Amsterdam, consisting of four building blocks, which are mainly pre-fabricated small-unit modular residential apartments, featuring easy adaptability for future transformation to other use, as well as restaurant, hotel and commercial spaces. The buildings are equipped with various sustainability features such as rooftop solar PV, aquifer thermal energy storage, and etc.

The LCA of Poppies provided insights into environmental impacts both within the PED and beyond its boundaries. Figure 11 outline key assumptions applied for the system and temporal boundary for Poppies. Figure 10 illustrates the total life cycle GHG emissions of Poppies (left), as well as the normalized life cycle GHG emissions in kilogram of CO_2 equivalent per square meter per year (kg CO_2 eq/m^2/year, right). As can be seen, is the normalized total GHG emissions of Poppies is about 12 kg CO_2 eq/m^2/year, which is relatively low in comparison with the average European residential buildings [9]. A comprehensive report detailing the LCA methodology, data collection, environmental assessment, and analytical results is available as Deliverable 9.2.1[10].

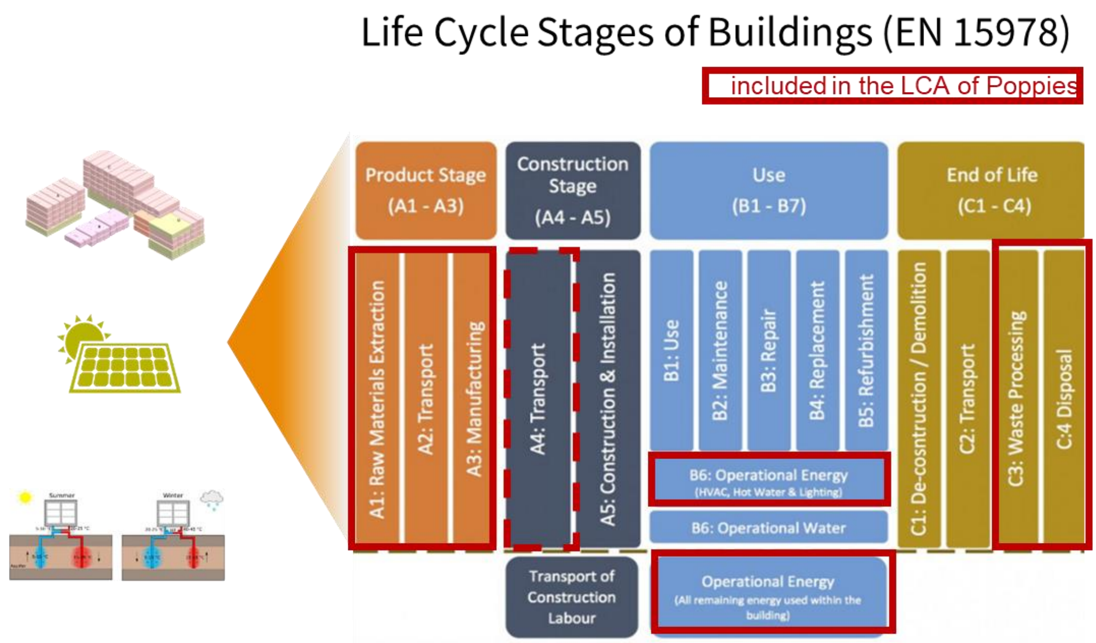

Figure 9: Life cycle stages of buildings according to EN 15978 and included life cycle stages for the LCA of Poppies - a case study applying LCA to a PED demonstration site in ATELIER

Table 3.Illustration of Poppies construction phase assumption

	Included elements	**Key assumption of Poppies**
System boundary – product and construction phase	Construction materials consumption	- housing modules (data collected from Derix) - "skeleton" of buildings (data collected from Bouw Management Groen)
	Rooftop Solar PV	228 kWp, 40% of electricity generation for direct consumption onsite in Poppies 1 replacement after 25 years
	Aquifer thermal energy storage (ATES) Assumptions	life cycle inventory (LCI) data from literature adapted to Poppies LCI for unit thermal energy supply * thermal energy consumption (based on proposal)
System boundary – operational phase	Energy use	Assumptions based on the BEST table in the ATELIER project proposal
Temporal boundary		50 years, from 2025 to 2075

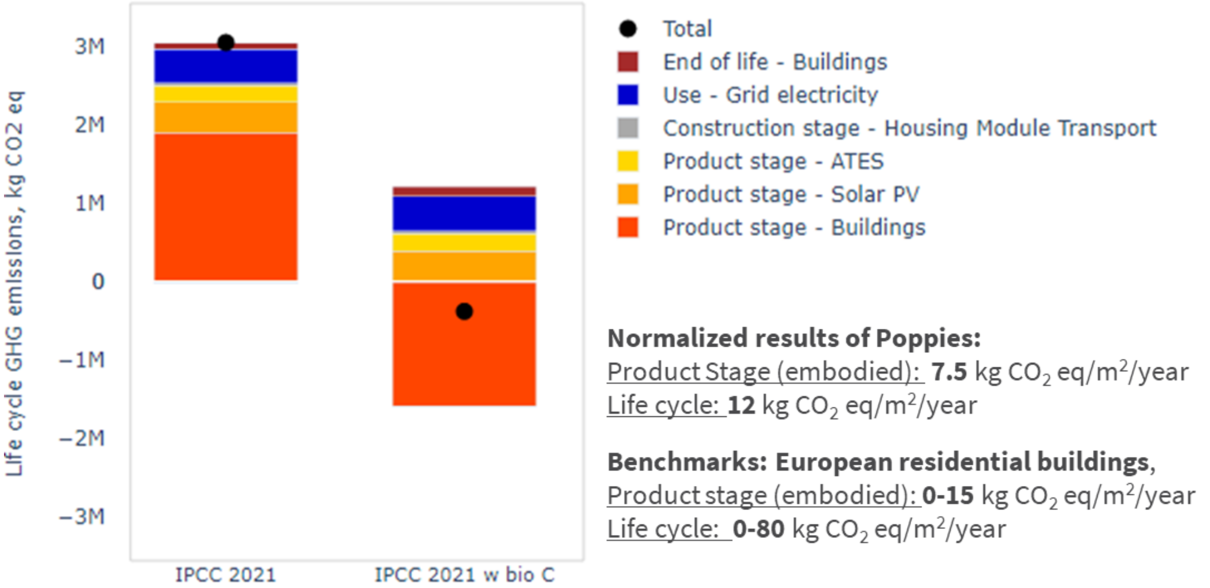

Figure 10: Life cycle impact from Poppies with benchmark to average European residential buildings (European residential buildings constructed following existing standards, based on Figure 5 [9])

For the LCIA results caused by a PED, we have divided the impacts geographically into the following categories according to the approach in Zhang et al. 2024 to evaluate its broader impacts [11], including: local (Amsterdam-specific) impacts (such as those from district heating), national impacts within the Netherlands, and international impacts outside of the Netherlands. The method developed within this WP is also feed into exploitable results[27].

[27] https://www.canva.com/design/DAGEJmdi2aY/KmxzP2R4eHG-C1ctOenJWg/edit

9 Reference

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[2] European Committee for Standardization (CEN). (2011). EN 15978:2011 - Sustainability of construction works - Assessment of environmental performance of buildings - Calculation method

[3] IEA EBC - Annex 83 - Positive Energy Districts https://annex83.iea-ebc.org/

[4] IEA EBC Annex 72 - Assessing Life Cycle Related Environmental Impacts Caused by Buildings https://annex72.iea-ebc.org/

[5] Ouellet-Plamondon, CM., Balouktsi, M., Delem, L., Foliente, G., Francart, N., Garcia-Martinez, A., Hoxha, E., Lützkendorf, T., Nygaard Rasmussen, F., Peuportier, B., Butler, J., Birgisdottir, H., Bragança, L., Dowdell, D., Dixit, M., Gomes, V., Gomes da Silva, M., Carlos Gómez, J., Kjendseth Wiik, M., Carmen Llatas Olivier, M., Mateus, R., Pulgrossi, LM., Röck, M., Ruschi Mendes Saade, M., Passer, A., Satola, D., Seo, S., Soust-Verdaguer, B., Veselka, J., Volf, M., Zhang, X. & Frischknecht, R. (2024). Comparison of 16 national methods in the life cycle assessment of carbon storage in wood products in a reference building. In G. Foliente, T. Lutzkendorf, J. Gibberd, N. Keena, & H. Walllbaum (Eds.), IOP conference series: earth and environmental science: Vol. 1363. World sustainable built environment (2024). Conference Proceedings. https://doi.org/10.1088/1755-1315/1363/1/012059

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[7] Ouellet-Plamondon, C., Ramseier, L., Balouktsi, M., Delem, L., Foliente, G., Francart, N., Garcia, A., Hoxha, E., Lützkendorf, T., Rasmussen, F. N., Peuportier, B., Butler, J., Birgisdottir, H., Dowdell, D., Dixit, M., Gomes, V., Silva, M. G., Gómez de Cózar, J. C., Wiik, M. K., Llatas, C., Mateus, R., Pulgrossi, L. M., Röck, M., Saade, M. R. M., Passer, A., Satola, D., Seo, S., Verdaguer, B. S., Veselka, J., Volf, M., Zhang, X., Frischknecht, R. (2023). Carbon footprint assessment of a wood multi-residential building considering biogenic carbon, Journal of Cleaner Production, 404, 136834. https://doi.org/10.1016/j.jclepro.2023.136834

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[9] Röck, M., Ruschi Mendes Saade, M., Balouktsi, M., Rasmussen, F. N., Birgisdottir, H., Frischknecht, R., Habert, G., Lützkendorf, T., & Passer, A. (2020). Embodied GHG emissions of buildings – The hidden challenge for effective climate change mitigation. Applied Energy, 258, 114107. https://doi.org/10.1016/j.apenergy.2019.114107

[10] ATELIER Deliverable 9.2.1 Life Cycle Assessment (LCA) of Poppies – a case study applying an LCA tool for Positive Energy Districts (PEDs) [to be finalized by the end of Apr 2025]

[11] Zhang, X., Heeren, N., Bauer, C., Burgherr, P., McKenna, R., Habert, G. (2024). The impacts of future sectoral change on the greenhouse gas emissions of construction materials for Swiss residential buildings. Energy and Buildings, 303, 113824. https://doi.org/10.1016/j.enbuild.2023.113824

Annex 1. System Boundaries

System boundaries need specific definition for each District and building type. These boundaries consider the specific energy systems in each PED, as well as the specific location of meters within the energy system. In some cases, information about the meters is only known when building owners deploy specific pieces of equipment and request connection to the energy grids, which may happen at a later stage. The information presented below has been defined based on the best available knowledge in the ATELIER consortium at the date of submission of this document, and may will require updates throughout the PED construction process.

For that end, a general nomenclature has been established to define the common grounds of the KPI definition. Figure 11 shows the definition in order to keep coherence between Bilbao and Amsterdam; then, providing a common conceptual approach, allowing for a comparative analysis of the performance, identifying the energy flows univocally.

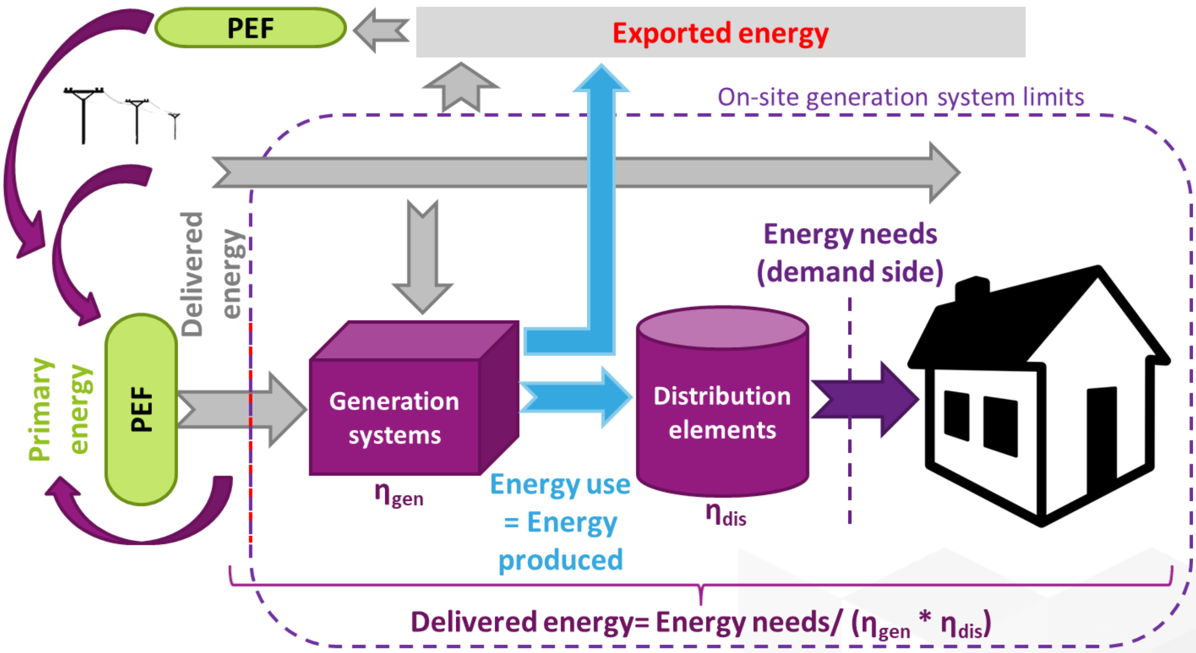


Figure 11. Boundaries definition

1.1 Bilbao

At time of writing this deliverable, not all the actions were completed in the city of Bilbao, but it will be completed in the upcoming months (extension period). Therefore, the monitoring programmes' schemas could need to be updated, whereas they are currently representing the desired location of the monitoring equipment for the indicators calculation. It should be remarked, sometimes, sensor cannot be physically located in the estimated located (for instance, due to physical access problems); hence schemas should adapt accordingly.

Within Bilbao, three areas are of interest within the project: North, Centre and South. Each zone of the Zorrotzaurre island is composed of a set of buildings with diverse energy systems, different connections and, then, different needs of monitoring. Having this in mind, monitoring programmes have been developed for each area and building (or set of buildings) with common energy systems.

Before detailing the schemas, it is worth detailing the legend to understand the different elements within the schemes. Figure 12 illustrates the elements that are included in the snapshots below. Smart meters, energy flows and other elements are depicted.

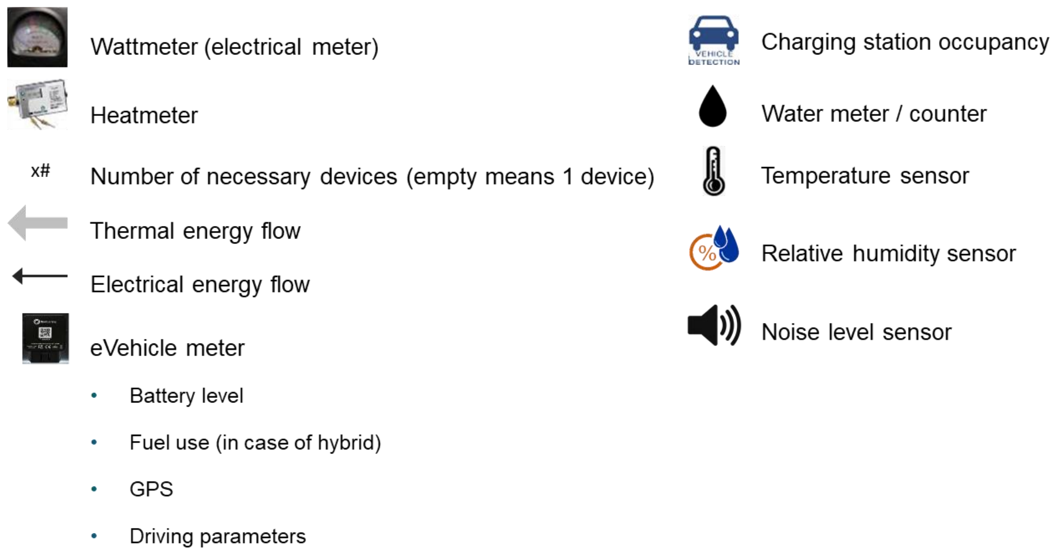


Figure 12. Legend for the monitoring programmes

1.1.1 North area

Starting with the North area of the island, first of all, the RZ buildings, composed of 3 condominiums (RZ13.1, RZ13.2 and RZ13.3). Two of them connected to the geothermal network and one with aerothermal system, as reflected in Figure 13. One 33 kWp PV system is also installed with connection to the grid, which supplies energy to the ground pumps, as well as the aero/geothermal pumps and building uses. In this sense, two uses are split: electrical vehicle and general uses (i.e., lighting, plugs, fridge…).

From all these energy systems, their connections and meters are included in the schema, as well as the amount of sensors to be included. For example, the electrical smart meters for each block is included (that is why 3 meters appear in the distribution line). Similarly, it is happening with the PV installation. One PV system is installed in each RZ13 building; therefore, 3 measurements are obtained (one for each condominium). Apart from the electricity measurements, thermal smart meters are deployed to obtain the thermal energy that is provided to the buildings from both the geothermal and aerothermal energy systems. Finally, it should be noted that energy being exported both thermal and electrical are measured to calculate the final balance.

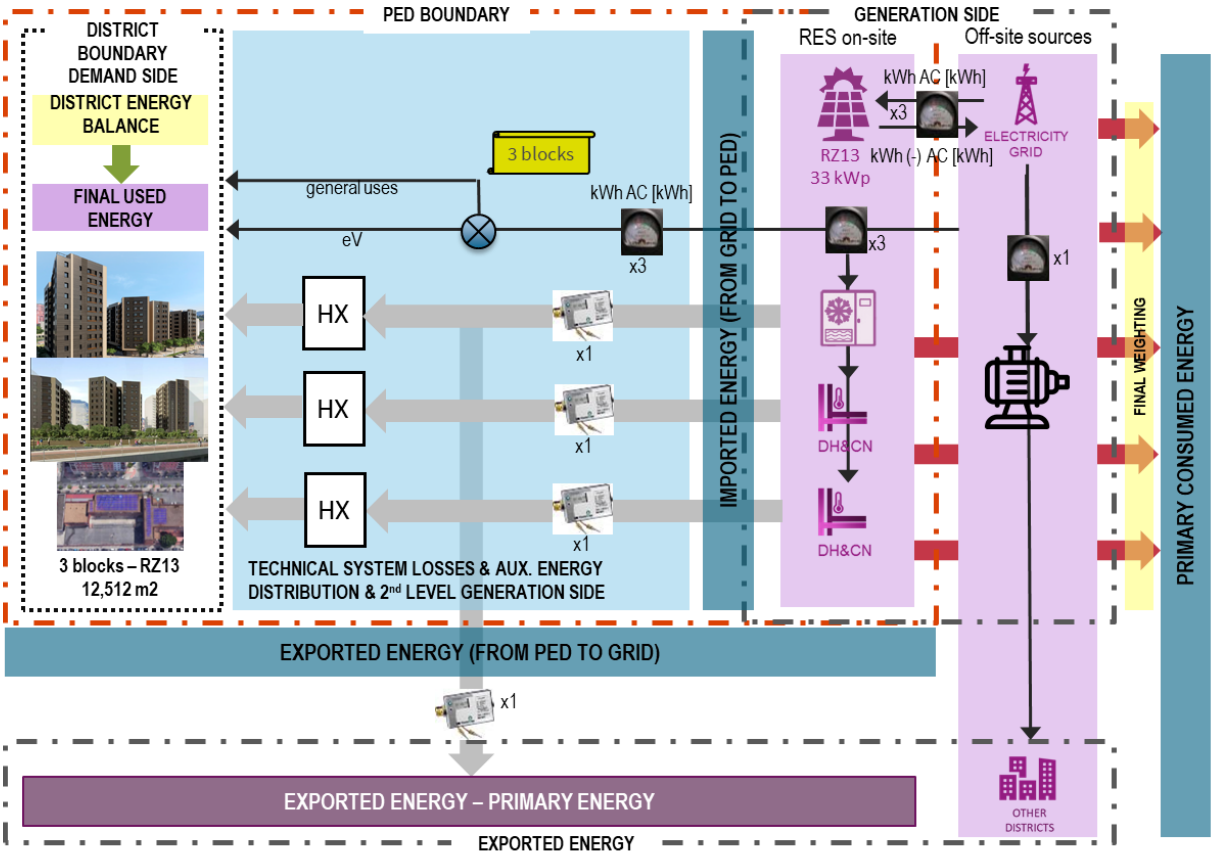


Figure 13. North area boundaries definition in Bilbao for RZ13 buildings

Second part is the 10 households, which are simpler. All of them are connected to the geothermal network. Then, one single heat meter is used to measure the thermal energy being used by the households. Moreover, electricity is directly obtained from the grid; thus, each electricity use for the household is measured (x10 smart meters). Moreover, the electricity used by the geothermal and ground pumps is illustrated. Finally, this case, as no renewable installation is included, no exported energy in terms of electricity is drawn. Figure 14 depicts the monitoring programme for this case.

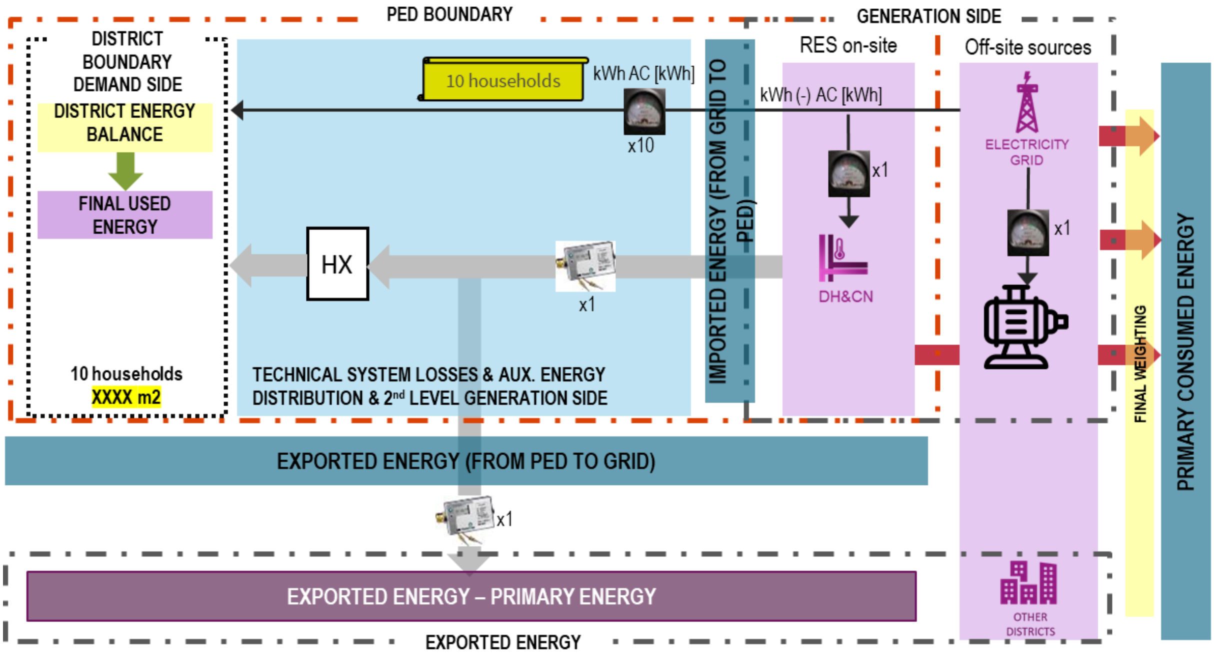


Figure 14. North area boundaries definition in Bilbao for 10 households

1.1.2 Centre area

Centre area is the most advanced zone, composed by two buildings: Beta I and Beta II. Within these two buildings, geothermal network is already connected and operating, providing thermal energy in the building. In this sense, monitoring is already being processed, with well-known data-points, which is indicated in the monitoring schemas as well. This univocally identifies the data being collected, facilitating the way to identify measurements and, thus, calculating indicators.

The case of Beta I building is illustrated in Figure 15. Beta I has two geothermal pumps and one existing aerothermal pump that is integrated into the new thermal network. Then, the 3 elements are monitored from the thermal energy use perspective. But also, water flow and temperatures are obtained as a way to calculate thermal energy. In terms of electricity, the geothermal, aerothermal and ground pumps are supplied by the grid, as well as the building itself. Therefore, no renewable connection is made, neither exported energy in electricity flow. Additionally, electricity measurements are split into three variables, one for each phase (L1, L2 and L3).

Beta II building is depicted in Figure 16, with a similar configuration than Beta I in terms of thermal energy. However, instead of having two geothermal pumps, it consists of one geothermal pump together the existing aerothermal pump. Notable to say that, thermal energy flows are printed because there is an evaporator line, as well as condensation pipe. Then, measurements are taken in both sides. Beyond thermal energy, electricity energy is similar as well, with the exception of the connection of a 20 kWp PV system to the grid, whose energy (active and reactive) is collected.

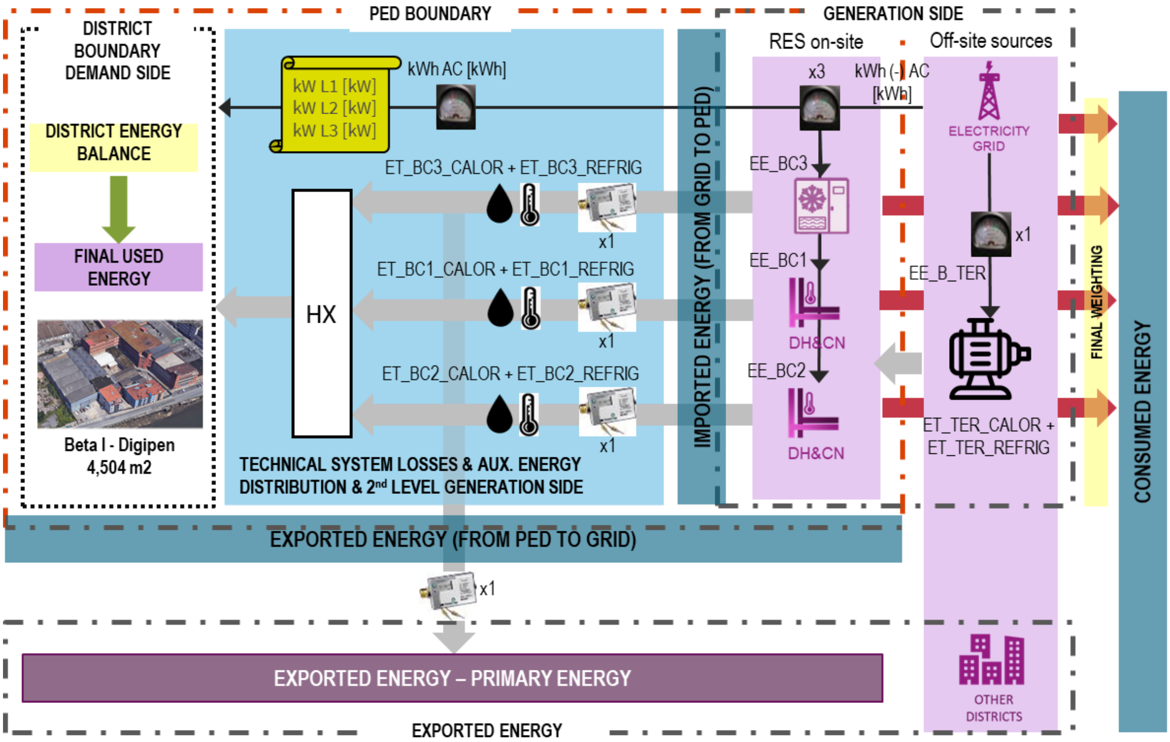


Figure 15. Centre area boundaries definition in Bilbao for Beta I building

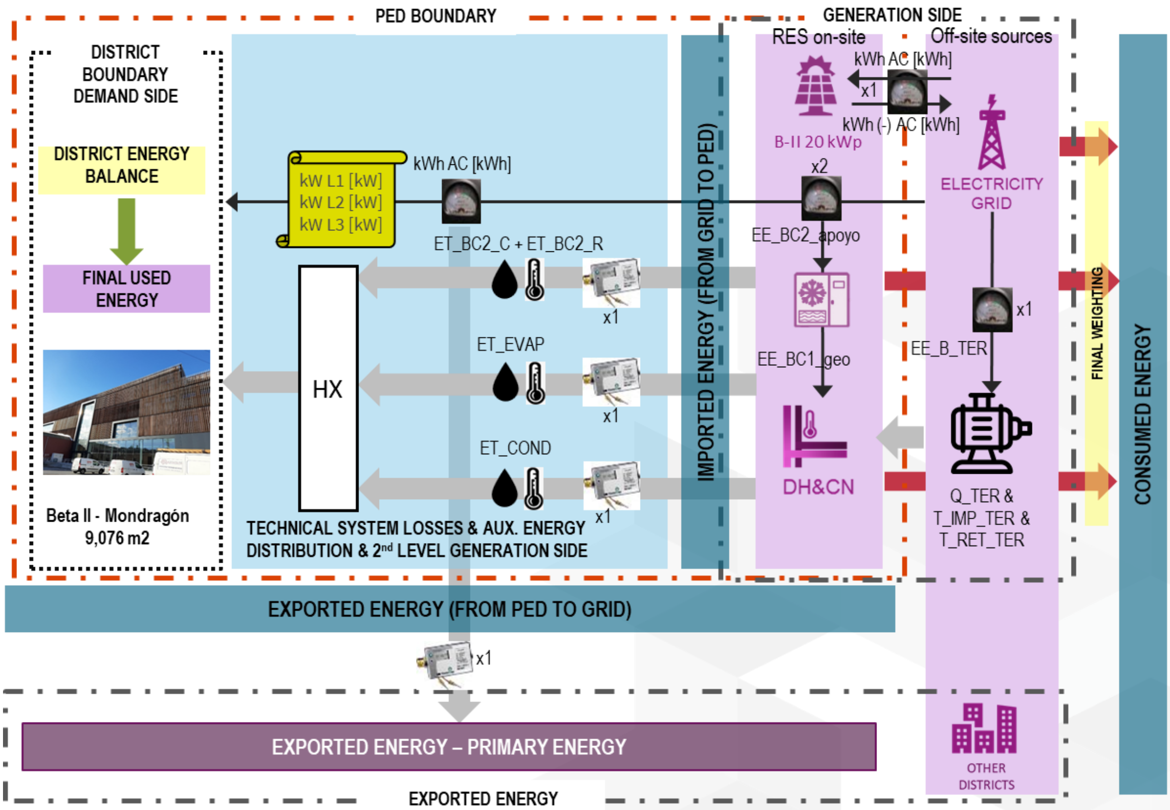


Figure 16. Centre area boundaries definition in Bilbao for Beta II building

1.1.3 South area

Last but not least, South area with one big block, named Papelera building. Figure 17 depicts the monitoring schema for this case. The thermal energy is composed of two elements: geothermal network connection and a solar thermal installation at rooftop that is being integrated into the geothermal network. Then, the contribution from the solar thermal and the geothermal sides are monitored. The case of electricity, Papelera building also counts on a 33.5 kWp PV installation connected to the grid. The electricity for the grid is used both for the geothermal pumps and building uses, as illustrated.

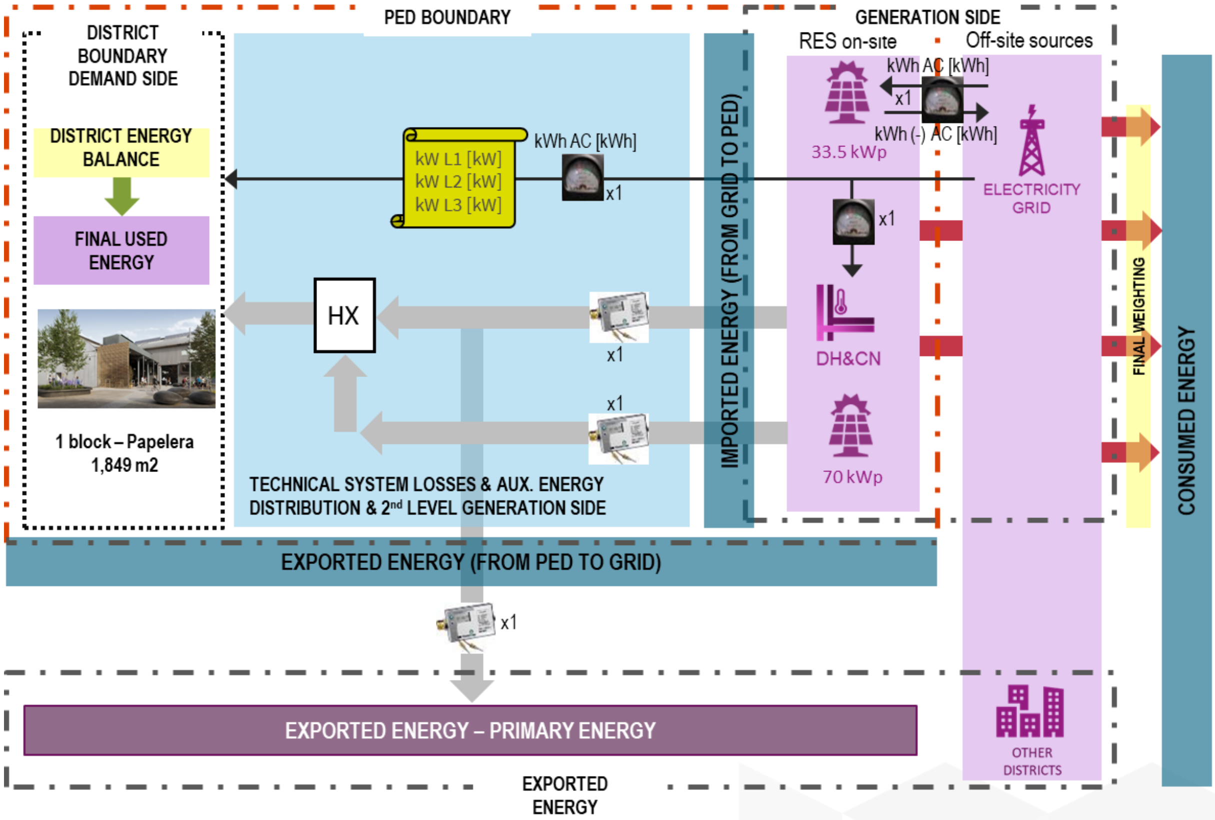


Figure 17. South area boundaries definition in Bilbao for Papelera building

1.2 Amsterdam

Amsterdam is composed by 2 districts: Republica and Poppies with its own energy systems. Moreover, in contrast to Bilbao, electrical mobility is more extended; which is also reflected in the monitoring programmes. Here, it should be also highlighted that actions are also being finished; hence, schemas could change in next releases.

1.2.1 Poppies

As anticipated before, the case of Poppies is still tentative as the works are being finished. In this sense, this district is simple. The 3 blocks under this district are supplied by a district heating with radiant floor. This district heating is generating heat in a single stage (that is why one single meter before the exchanger) and, then, uses for heating and domestic hot water are separated; thus, having 6 heat meters (3 buildings x 2 uses).

With respect to the electricity, the pumping needs are monitored. Moreover, PV system is installed, collecting imported and exported energy, and the electricity uses of the 3 buildings. In contrast to Bilbao, it should be remarked the PV system is not only connected to the grid, but also self-consumption; therefore an electricity flow goes from the PV to the buildings.

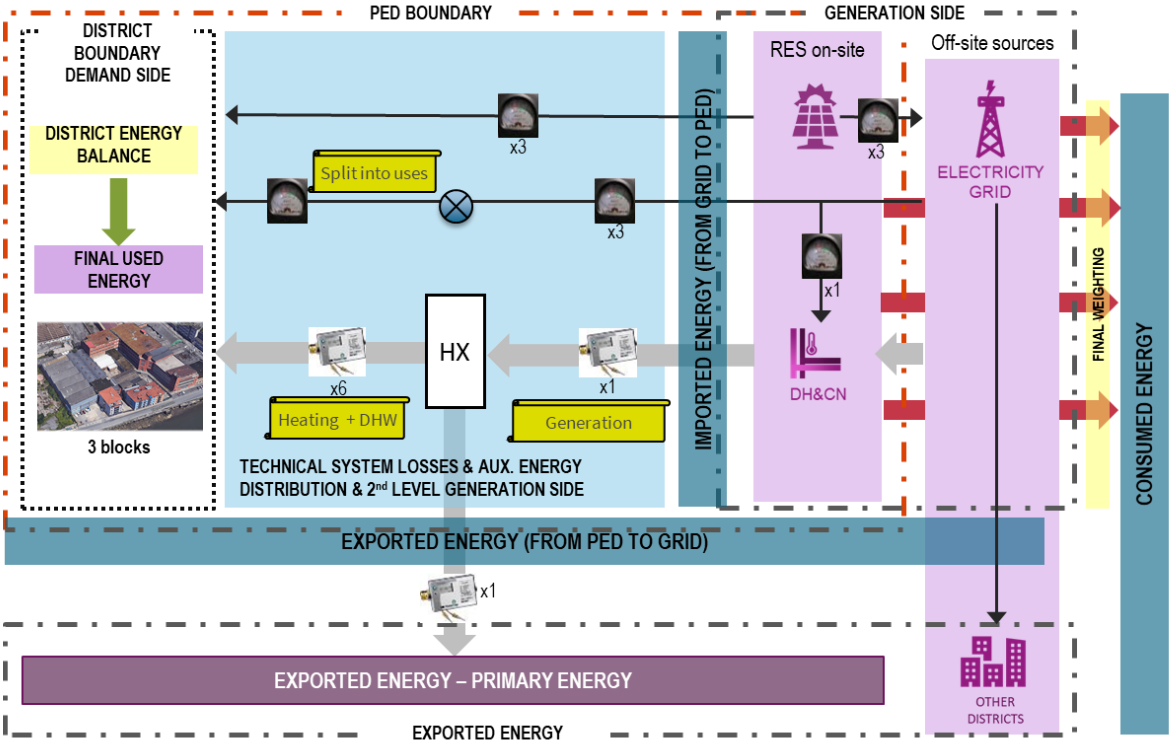


Figure 18. Poppies area boundaries definition in Amsterdam

1.2.2 Republica

The district area of Republica consists of a district heating network that is outside the district to provide heating and DHW. Then, in contrast to previous cases, the pumping elements are off-site sources. Basically, similar to Poppies, the generation of heat is in a single line that is split into the buildings and the two uses (heating and DHW). Moreover, for DHW, boosters (electrical heaters) are included to increase the temperature of the water coming from the district heating. In this case, the electricity needed for these boosters, as well as the thermal energy used for DHW are obtained.

In the specific case of the electricity, a PV system is included that is both connected to the grid and to the district battery to store energy. Each of the 5 buildings included in Figure 19 has its own PV installation, therefore, 5 measurements are obtained. The batter is single for the whole district (including the hotel that is in the schema of Figure 20), with the accounting of the energy provided by the battery as a whole as unique measurement. Furthermore, electricity used from grid both for pumping and buildings themselves are included.

Apart from these 5 buildings, the hotel is the sixth building in Republica. This is drawn in a different schema to simplify visualisation. It does not contain the previously mentioned boosters. In contrast it has two heat pumps connected to an inertia tank for water storage. In this sense, from the heat pumps, this tank is being fed in a single line, while the output of the tank is also supplied with district heating energy coming from the exchanger. Electricity is exactly the same than the other 5 building blocks.

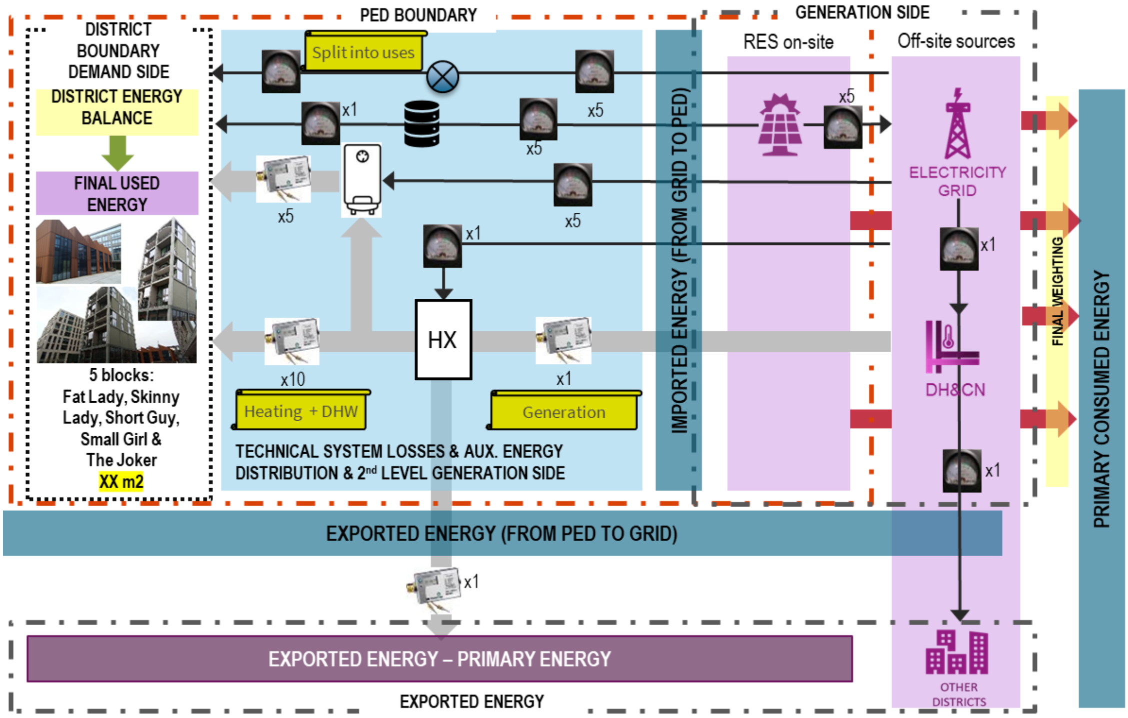


Figure 19. Republica area boundaries definition in Amsterdam for 5 building blocks

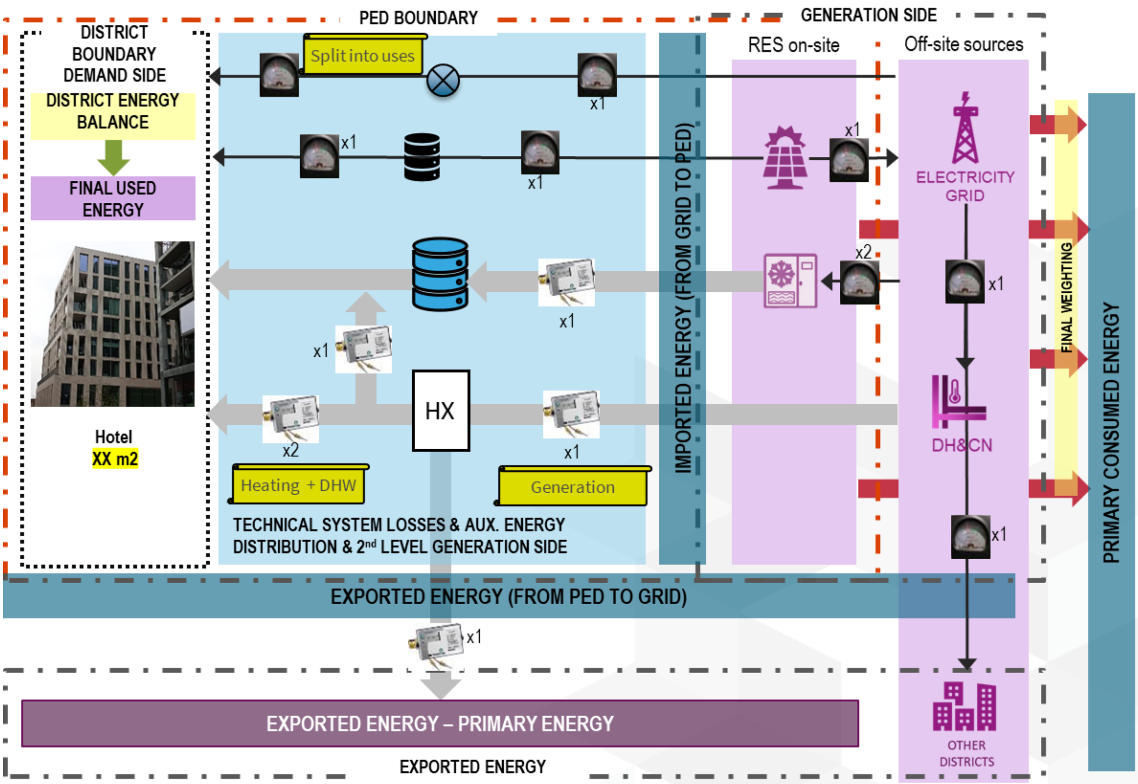


Figure 20. Republica area boundaries definition in Amsterdam for hotel building

Finally, the Republica side also considers electromobility as independent part. As observed in Figure 21, PV system installation from the previous buildings are connected to the grid and energy from the grid is used in the charging stations within the parking lots in the basement. A balance between the exported PV energy, the buildings electricity use and the charging station use would provide the renewable energy that is supplied by the charging station to the eV. Moreover, the connection between the eV and the charging station is bidirectional (V2G and G2V), whose energy flows are monitored. Last but not least, the eV elements are monitored (even by the onboard computed), although data could be not gathered due to privacy aspects.

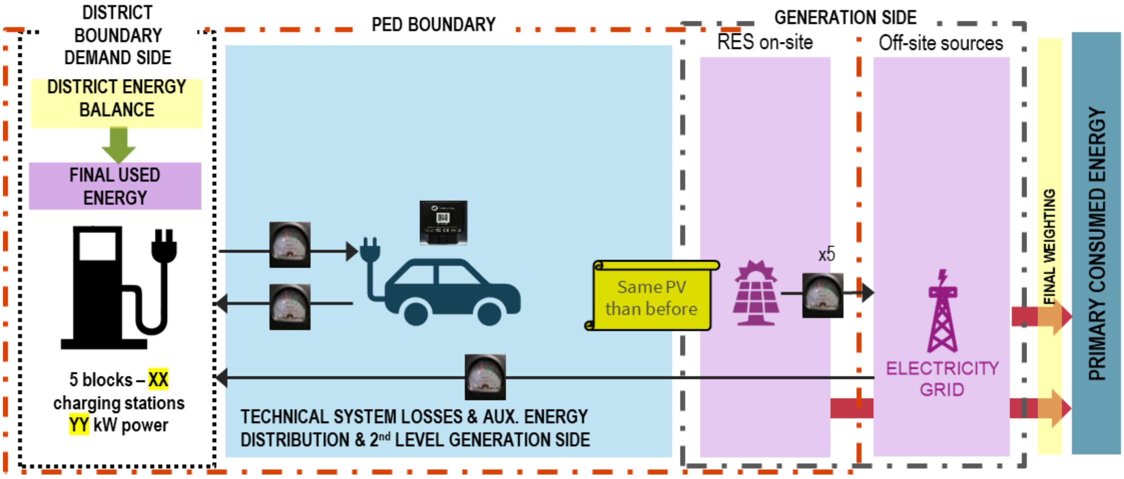


Figure 21. Republica area boundaries definition in Amsterdam for electromobility

Annex 2. Energy Tariff Information

2.1 Bilbao

2.1.1 Electricity

For **small consumers** (individual households): PVPC (Regulated tariff in the Spanish Market)[28]. The following subtariff will be considered: "Término De Facturación De Energía Activa Del PVPC 2.0TD Península" Data is available from ESIOS[29]

The following figure presents this information for year 2023.

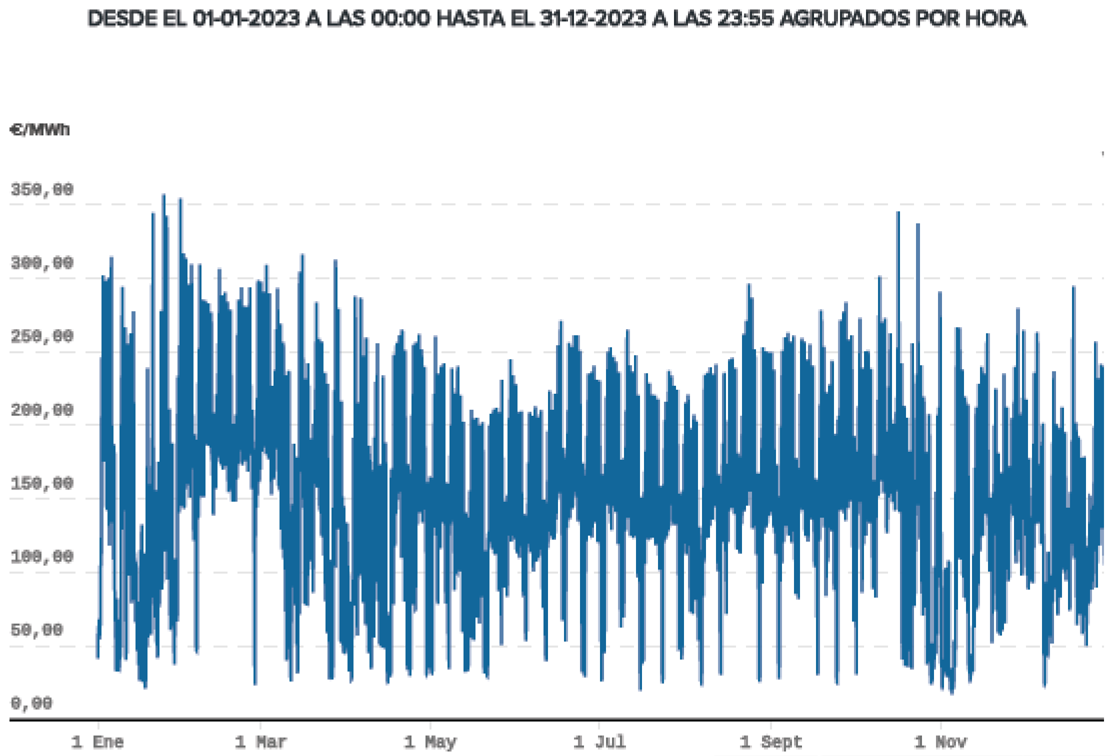


Figure 22 Hourly PVPC data for 2023[30]

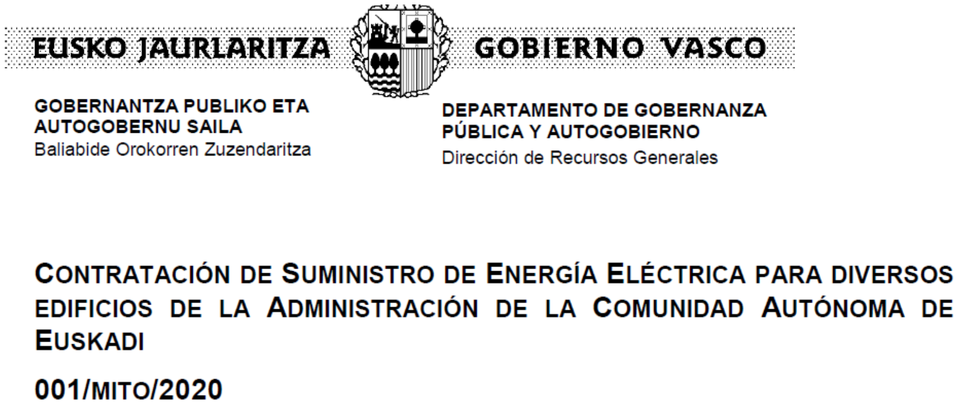
28 https://www.ree.es/es/actividades/operacion-del-sistema-electrico/precio-voluntario-pequeno-consumidor-pvpc

29 https://www.esios.ree.es/

30 Data exportation from ESIOS: https://www.esios.ree.es/es/analisis/1001?vis=1&start_date=01-01-2023T00%3A00&end_date=31-12-2023T23%3A55&geoids=8741&compare_start_date=31-12-2022T00%3A00&groupby=hour

For **large consumers** (Beta I and II; and Papelera): Public procurement for energy supplies in the basque country. Public information of the following tender will be used:

Basque Government, Department of Public Government. Tender reference: 001/MITO/2020



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GOBERNANTZA PUBLIKO ETA AUTOGOBERNU SAILA
Baliabide Orokorren Zuzendaritza

DEPARTAMENTO DE GOBERNANZA PÚBLICA Y AUTOGOBIERNO
Dirección de Recursos Generales

TÍTULO:	CONTRATACIÓN DE SUMINISTRO DE ENERGÍA ELÉCTRICA PARA DIVERSOS EDIFICIOS DE LA ADMINISTRACIÓN DE LA COMUNIDAD AUTÓNOMA DE EUSKADI
EXPEDIENTE:	001/MITO/2020

Figure 23 Information file on public tender for electricity purchase in the Basque Country. 2020

Within this tender, prices for supplies of 10<P<50kW will be used (Lot 3).

This lot is structured in agreement with the following price structure:

$$PE_t = C1_t + (OMIE_m * C2_t)$$

Where:

PE is the price for electricity

C1t is an independent term

C2t is an indexation term with regards to OMIE prices

OMIEm is the average price for each tariff period (P1 to P6) for the marginal price of the Spanish Electric System. Published daily by OMIE[31]

C1 and C2 are specific for each period (P1 to P6)

For all the preceding cases, net **PV deliveries to the network** will be rewarded at 70% of the purchase cost.

[31] Operador del Mercado Iberico de Energia

Cost for the use of electricity networks will be added to the regulated costs for the use of electric network (Peaje de accceso).

The following figure presents this information for year 2023.

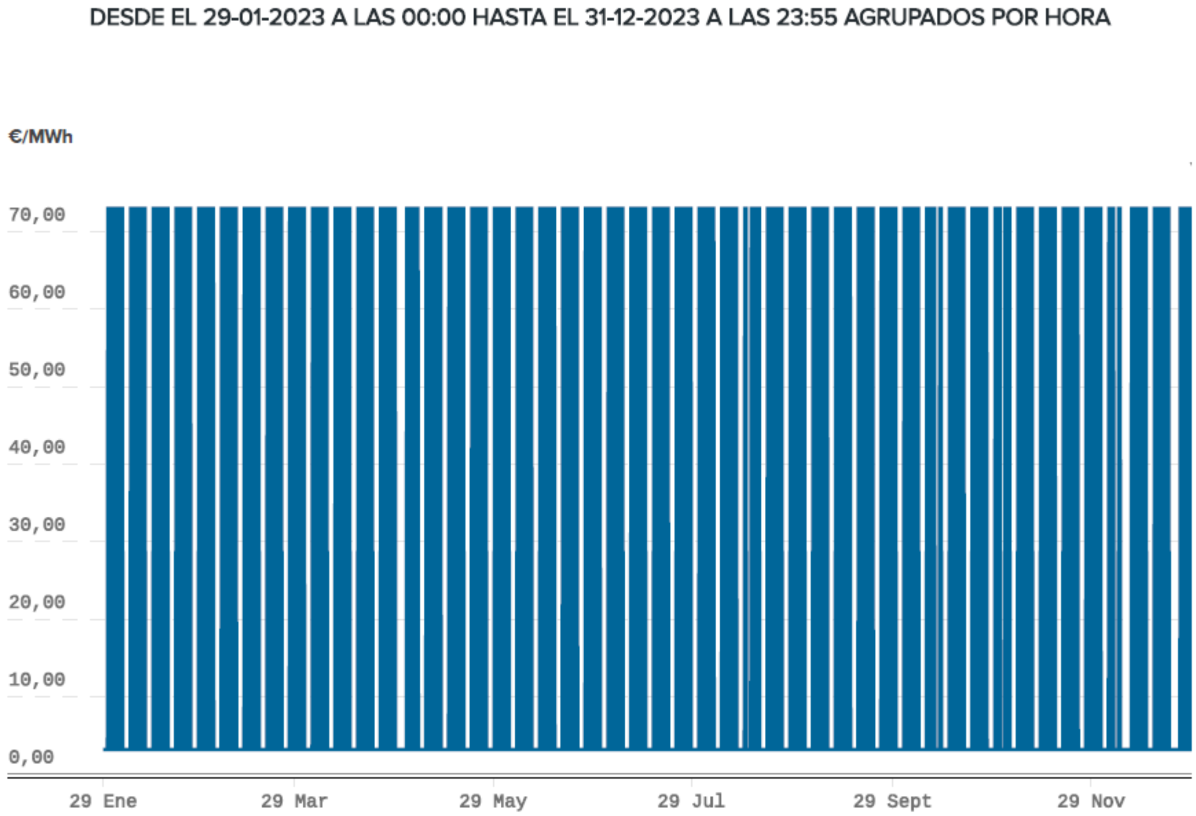

Figure 24 Hourly regulated costs for the use of electric networks for 2023[32]

[32] Data exportation from ESIOS: https://www.esios.ree.es/es/analisis/1876?vis=1&start_date=29-01-2023T00%3A00&end_date=31-12-2023T23%3A55&geoids=8741&compare_start_date=28-01-2023T00%3A00&groupby=hour

2.1.2 Natural Gas

For **small consumers** (individual households): TUR (Regulated tariff in the Spanish Market)[33]. The reference tariff is T.RL2 (Energy supplies in between 5000kWh/year and 15000kWh/year).

This tariff is updated quarterly by the Spanish government. In the latest update[34], prices for this supply are 0.04095€/kWh.

For **large consumers** (Beta I and II; and Papelera): Public procurement for energy supplies in the basque country. Public information of the following tender will be used:

Basque Government, Department of Public Government. Tender reference: KM/2022/028

Expediente nº: KM/2022/018

Objeto: Suministro de gas natural, para la Administración General de la Comunidad Autónoma de Euskadi, así como para diversas entidades de su sector público y del resto del sector público

Figure 25 Information file on public tender for natural purchase in the Basque Country. 2022

Within this tender, prices for supplies of Bizkaia will be used (Lot 3).

2.1.3 Capacity and fixed terms

In this work we assume that all customers are connected to the relevant grids, and that capacity costs as well as fixed items in the energy supply bills are not modified.

2.1.4 Taxation

In all cases, applicable taxes will be considered. Particularly:

- Tax for the generation of electricty[35]
- Value Added Tax. This tax impacts differently to individual households and large consumers. In order to provide a consistent methodology. This tax will not be considered.

[33] Ley 12/2007, de 2 de julio, por la que se modifica la Ley 34/1998, de 7 de octubre, del Sector de Hidrocarburos, con el fin de adaptarla a lo dispuesto en la Directiva 2003/55/CE del Parlamento Europeo y del Consejo, de 26 de junio de 2003, sobre normas comunes para el mercado interior del gas natural, https://www.boe.es/eli/es/l/2007/07/02/12

[34] Resolución de 26 de marzo de 2024, de la Dirección General de Política Energética y Minas, por la que se publica la tarifa de último recurso de gas natural. https://www.boe.es/eli/es/res/2024/03/26/(1)

[35] Ley 15/2012, de 27 de diciembre, de medidas fiscales para la sostenibilidad energética. https://www.boe.es/eli/es/l/2012/12/27/15

2.1.5 List of PEDs

City	Area	Building	Type	Technologies
Bilbao	North	RZ13.1	Residential	Ground source heat pump(GHSP), Air source heat pump (AHSP), Electricity, EV
Bilbao	North	RZ13.2	Residential	GHSP, AHSP, Electricity, EV
Bilbao	North	RZ13.3	Residential	GHSP, AHSP, Electricity, EV
Bilbao	Centre	Beta 1 (DIGIPEN)	Tertiary	GHSP, AHSP, Electricity, EV
Bilbao	Centre	Beta 2 (MU)	Tertiary	GHSP, AHSP, Electricity, EV
Bilbao	South	Papelera	Tertiary	GHSP, AHSP, Electricity, EV
Amsterdam	Schoonschip	Building 1	NA	NA
Amsterdam	Republica	District	Technical	District heating (DH), District cooling (DC), Electricity
Amsterdam	Republica	Fat Lady	Residential	DH, DC, Electricity, Boosters
Amsterdam	Republica	Skinny Lad	Residential	DH, DC, Electricity, Boosters
Amsterdam	Republica	Short Guy	Residential	DH, DC, Electricity, Boosters
Amsterdam	Republica	Hotel	Hotel	DH, DC, Electricity
Amsterdam	Republica	Small Girl	Commercial	DH, DC, Electricity
Amsterdam	Republica	The Joker	Commercial	DH, DC, Electricity
Amsterdam	Republica	PV	Technical	Electricity
Amsterdam	Republica	Heat Pump	Technical	DH, DC, GSHP, Electricity
Amsterdam	Republica	Battery	Technical	Electricity
Amsterdam	Republica	Garage	Technical	EV
Amsterdam	Poppies	Building 1		Electricity
Amsterdam	Poppies	Building 2		Electricity
Amsterdam	Poppies	Building 3		Electricity
Amsterdam	Poppies	Building 4		Electricity
Amsterdam	Poppies	Building 5		Electricity
Amsterdam	Poppies	Building 6		Electricity
Amsterdam	Poppies	Building 7		Electricity
Amsterdam	Poppies	Building 8		Electricity

Annex 3. KPI list

Table 4 KPI List

KPI Name	REF	Cate-gory	Formula	Units	Periodicity
Thermal energy delivered to PED (imported)	ENE_01	Energy	ENE_01 = ENE_01_n_1 + ENE_01_n_2 + ENE_01_n_3 + ENE_01_c_b1 + ENE_01_c_b2 + ENE_01_s	MWh (MWh/m2)	Yearly, Monthly, Daily
Electrical energy delivered to PED (imported)	ENE_02	Energy	ENE_02 = ENE_02_n_1 + ENE_02_n_2 + ENE_02_n_3 + ENE_02_c_b1 + ENE_02_c_b2 + ENE_02_s	MWh (MWh/m2)	Yearly, Monthly, Daily
Thermal energy consumption in the PED	ENE_03	Energy	ENE_03 = ENE_03_n_1 + ENE_03_n_2 + ENE_03_n_3 + ENE_03_c_b1 + ENE_03_c_b2 + ENE_03_s	MWh (MWh/m2)	Yearly, Monthly, Daily
Electrical energy consumption in the PED	ENE_04	Energy	ENE_04 = ENE_04_n_1 + ENE_04_n_2 + ENE_04_n_3 + ENE_04_c_b1 + ENE_04_c_b2 + ENE_04_s	MWh (MWh/m2)	Yearly, Monthly, Daily
Thermal energy demand (energy needs)	ENE_05	Energy	ENE_05 = ENE_05_n_1 + ENE_05_n_2 + ENE_05_n_3 + ENE_05_c_b1 + ENE_05_c_b2 + ENE_05_s	MW (MW/m2)	Yearly, Monthly, Daily
Electrical energy demand (energy needs)	ENE_06	Energy	ENE_06 = ENE_06_n_1 + ENE_06_n_2 + ENE_06_n_3 + ENE_06_c_b1 + ENE_06_c_b2 + ENE_06_s	MW (MW/m2)	Yearly, Monthly, Daily
Primary total energy consumption	ENE_07	Energy	see KPI ATELIER - Energy	MWh (MWh/m2)	Yearly, Monthly, Daily
Primary thermal energy consumption	ENE_08	Energy	see KPI ATELIER - Energy	MWh (MWh/m2)	Yearly, Monthly, Daily
Primary electricity energy consumption	ENE_09	Energy	see KPI ATELIER - Energy	MWh (MWh/m2)	Yearly, Monthly, Daily
Energy efficiency improvement (Energy savings)	ENE_10	Energy	see KPI ATELIER - Energy	MWh (MWh/m2)	Yearly, Monthly

Renewable electricity production	ENE_11	Energy	see KPI ATELIER - Energy	MWh (MWh/m2)	Yearly, Monthly, Daily
Renewable thermal energy production	ENE_12	Energy	see KPI ATELIER - Energy	MWh (MWh/m2)	Yearly, Monthly, Daily
Surplus thermal energy (exported energy)	ENE_13	Energy	see KPI ATELIER - Energy	MWh (MWh/m2)	Yearly, Monthly, Daily
Surplus electricity (exported energy)	ENE_14	Energy	see KPI ATELIER - Energy	MWh (MWh/m2)	Yearly, Monthly, Daily
PED energy balance (energy exports – energy imports)	ENE_15	Energy	see KPI ATELIER - Energy	MWh (MWh/m2)	Yearly, Monthly
Surplus electricity delivered out of the PED at peak time	FLE_01	Flexibility	FLE_01 = Ñpeak_hours ENE_14 ** Filter at peak hours	MWh (MWh/m2)	Yearly, Monthly, Daily
Energy-related greenhouse gas emissions	ENV_01	Environment	ENV_01 = ENV_02 + ENV_03	tCO2 (tCO/m2)	Yearly, Monthly, Daily
Thermal energy-related greenhouse gas emissions	ENV_02	Environment	ENV_02 = Scarrier & bulding ENE_01 * GHGCFth	tCO2 (tCO/m2)	Yearly, Monthly, Daily
Electricity related greenhouse gas emissions	ENV_03	Environment	ENV_03 = Sbuilding (ENE_02 - ENE_11) * GHGCFel	tCO2 (tCO/m2)	Yearly, Monthly, Daily
Particulate matter emissions (PM 2.5)	ENV_04	Environment	ENV_04 = ENV_01 * PMCF	tPM (tPM/m2)	Yearly, Monthly, Daily
Nitrogen oxides emissions (NOx)	ENV_05	Environment	ENV_05 = ENV_01 * NOxCF	tNOx (tNOx/m2)	Yearly, Monthly, Daily

Life cycle greenhouse gas emissions	ENV_06	Environment	ENV_06 = LCA tool	tCO2eq (tCO2eq/m2)	Once
Life cycle primary energy demand (non-renewable)	ENV_07	Environment	ENV_07 = LCA tool	kWh oil eq	Once
Life cycle total environmental footprint	ENV_08	Environment	ENV_08 = LCA tool	points	Once
Annual energy delivered by charging infrastructure	MOB_01	Mobility	MOB_01 = Scharging_station Energy_delivered_by_charging_point	kWh	Yearly, Monthly, Daily
Level of self-consumption of total energy					
Level of self-consumption of thermal energy					
Level of self-consumption of electricity production					