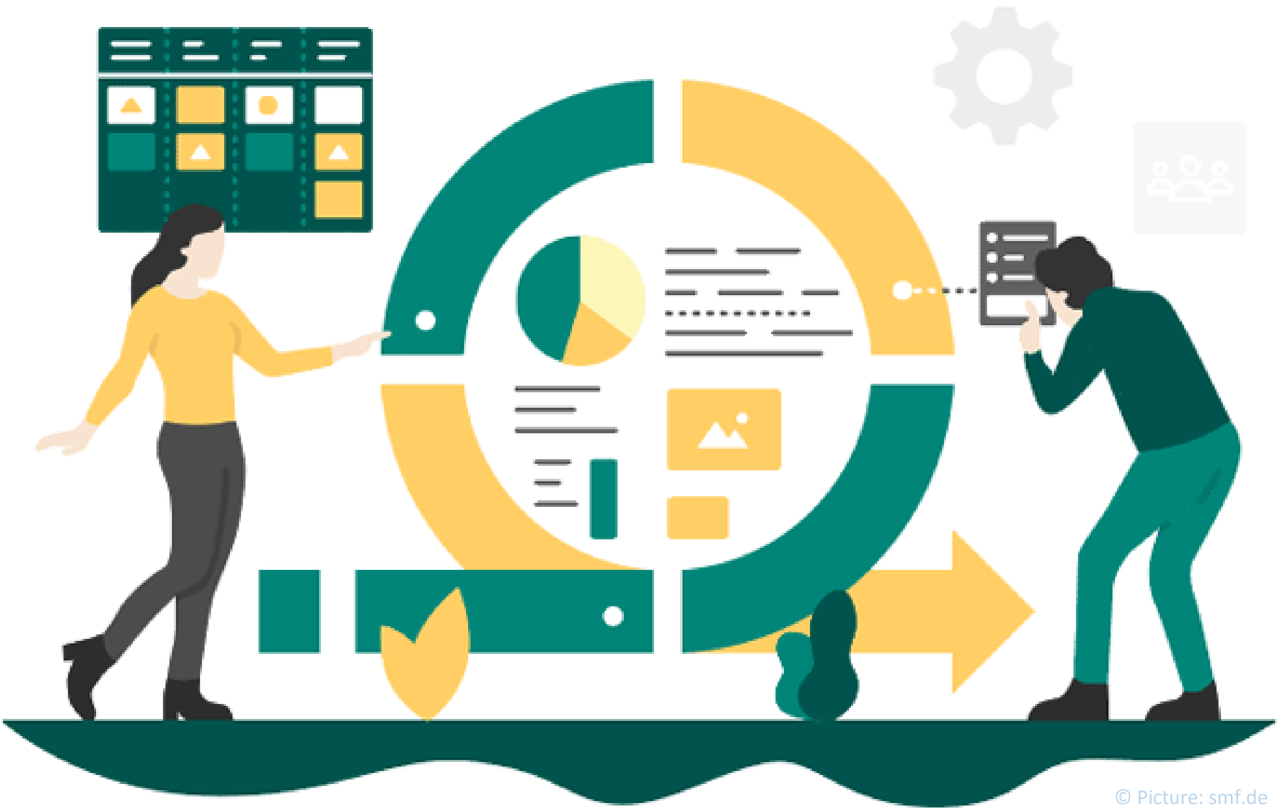
simply positive

D3.2. Gap analysis of Energy Balance Calculation Data

February 2024



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Dissemination Level

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History

Version	Description	Lead author	Date
V1	Table of Content	UASTW	August 2023
V2	First Template	UASTW	September 2023
V3	Continuous Data Improvement	UASTW, with Focus Districts	September 2023 to January 2024
V4	Visualization of Data Gaps	UASTW	November 2023
V5	Second Template	UASTW	December 2023
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V7	Third Template	UASTW	January 2024
V8	Second Review	SON	January 2024
V9	Fourth and final Template	UASTW	February 2024
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Disclaimer

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Executive Summary

The aim of the deliverable is to

- compilate and structure of available data of the different focus districts, to
- identify gaps in received data sets for each focus district, and to
- develop ways of gap elimination and list of necessary additions.

The final set of data consists of five groups, each of which is represented by subsets of data:

i. general characteristics,
ii. geometrical characteristics,
iii. physical characteristics,
iv. energy characteristics, and
v. climate data.

During the iterative process of the initial dataset forming interaction between experts and PED representatives allowed to collect required data. For each focus district data was collected by few steps with further increasing importance of the expert role. Significant changes were implemented for the Dutch focus district due to absence of the geometrical data and the high diversity of the area's-built environment, which could not be generalized.

The deliverable presents the overview of received data and the process of retrieving this information as of end of January 2024. Further received data will be described in a separate chapter within the following deliverable D3.3. Assessment Report on Focus Districts.

List of Figures

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List of Abbreviations and Acronyms

EMS	Energy Management System
FD	Focus district
GFA	Gross Floor Area
GIS	Geographic Information Systems
HER	Heat Energy Requirement
HVAC	Heating, ventilation, and air conditioning
LCA	Lifecycle-Assessment
PED	Positive Energy District
PV	Photovoltaic
UASTW	University of Applied Sciences Technikum Wien
WP	Work Package

Table of Contents

1 Introduction

1.1 Purpose and structure of the document

The aim of the deliverable is to

- collect and structure the available data of the Focus Districts.
- develop and define the minimum data required for Focus District assessment according to deliverable D3.1 PED framework definition status.
- perform a gap analysis of available data versus optional and required data for assessment.
- discuss possible approaches to bridging these gaps.

The document is structured in four main chapters: First giving an overview of possible methods of PED energy balance calculation and assessment which all have different requirements in terms of data types, formats, granularity, etc.

The second section provides an analysis of the data requirements of these different methods.

Third is a comparison to the actually available data for SimplyPositive's Focus Districts.

And finally, in Annexes A, B and C the optimal data set is described in detail.

1.2 Relation to other project activities

The document is connected to project activities in the following way:

Activity / deliverable	Relation
D1.1. Report on operation scenarios, technical characterization and identified stakeholders of Focus Districts	Existing data for the Energy Balance Calculation.
D1.2. Key performance indicators for PED/PEN implementation assessment	KPIs related to the Energy Balance Calculation.
D3.1. Framework definition status and Methodology description	Methodology description and required data for its usage.
D3.3. Assessment report on Focus District	Section: Data gaps and how to close them
WP 5. Monitoring, controlling and Digitalization of individual PED-Pathways	Section: Data gaps and how to close them

2 Overview of methods for Energy Balance Calculation

Energy balance calculation in positive energy districts (PEDs) involves assessing the energy demand and supply within a defined district or community to determine if it generates more energy than it consumes. Several existing methods and tools can be used for energy balance calculations in PEDs. Here are some of the commonly used approaches:

2.1 Hourly Energy Simulation Software

Tools like EnergyPlus [1], TRNSYS [2], IDA ICE [3] and DesignBuilder allow detailed hourly simulations of energy demand and supply within a district. They can model the energy performance of buildings, renewable energy systems, and district-wide energy distribution. These software tools typically require detailed information regarding geometry of the simulated buildings, realized heating and ventilation systems, physical properties of the building construction elements etc. (i.e. wide set of initial data), which mean that their usage requires additional modelling effort to create and or transform the available data into the required format. The main advantage of these approaches lies in their high accuracy, as well as temporal and spatial resolution. This type of methods could be called “3D methods” as simulation tools often require 3D model of buildings.

2.2 GIS-Based Analysis

Geographic Information Systems (GIS) are used to map and analyze the energy demand and supply across a geographic area. It can incorporate data on buildings, infrastructure, and renewable energy potential. This approach is described, for example, in [4], [5], etc... It typically involves the use and, in its absence, also the definition of building typologies to be used to map the available GIS building footprints to their energy related properties such as thermal insulation quality, HVAC system, etc. The undoubted advantage of these systems is the graphical representation of the energy characteristics of the region. However, at the same time, the data are quite generalized and its accuracy depends on the accurate modelling with suitable building typologies.

2.3 Balance Monitoring Approach

Real-time monitoring and metering of energy use within the district provide valuable data for calculating energy balance [6],[7], etc. Methods based on monitoring data derive the energy balance by comparing the measured energy supply (from renewables, such as solar panels or wind turbines) with the energy demand (from buildings and other users) at the district level. This approach can be considered a simplified assessment of energy regions, but its use becomes significantly more complex as the number of factors that need to be considered increases. Another main feature of this type of methods is impossibility to use on the stage of the PED planning because all calculations based on the already measured (actual) energy supply and consumption. Further we will call this type of methods “simplified”.

2.4 Energy Management Systems (EMS)

Advanced energy management systems integrate real-time data from various sources within the district, including buildings, renewable energy installations, and storage systems. These systems monitor and optimize energy use to maintain a positive energy balance and often incorporate optimization algorithms. This approach described, for example, in [8] etc. It is however, generally speaking, not suitable for PED energy balance calculations for two reasons. First, its high granularity is very suitable for monitoring purposes and identifying problems in building operation, but it becomes impractical when applied on district scale, which it typically is not due to economic considerations. Second, even if this detailed data were available on district scale, it is not necessarily available for all energy carriers and energy flows in the district, and crucially cannot easily be differentiated between different uses, making it difficult to assess the contribution types to the energy balance. This typically means that the EMS can only be used for certain energy carriers, such as electricity, as a source of validation for other methods, that are required anyway to fill the remainder of the energy balance not covered by the EMS.

2.5 Smart Grid and Demand Response Technologies

Smart grid technologies, including demand response and energy storage, can dynamically adjust energy supply and demand to maintain a surplus [9], [10], etc. It can be seen as a subset of the EMS system described in the previous section.

2.6 District Energy Modeling Platforms

Some platforms and software are specifically designed for modeling district-level energy systems, considering heating, cooling, electricity, and transportation [11], [12], etc. This approach is similar to the “3D methods” but extrapolated to the whole district. Thus, it requires a significant amount of data, including detailed information about buildings, infrastructure, energy consumption patterns, and climate conditions. Obtaining and managing this data can be challenging and time-consuming.

2.7 Life Cycle Assessment (LCA)

LCA methodologies assess the environmental impact of energy systems and can be used to evaluate the overall sustainability of PEDs, considering the energy balance and emissions associated with different energy sources [13], [14]. This type of methods has high dependence of system boundaries that often can be complex and, as a result, results are subject to uncertainties arising from data variations, model assumptions, and methodological choices.

2.8 Normative approaches

A normative approach in the context of Positive Energy District (PED) assessment involves establishing a set of norms, standards, or guidelines against which the sustainability and performance of a PED are evaluated. This approach aims to define a benchmark or ideal state for PEDs and assess the district's adherence to these predefined norms. This type of method includes the PED assessment approach developed at UASTW [15].

2.9 Comparison and selection approach for SimplyPositive

The temporal and spatial scale of the methods for various energy aspects were proposed by [16] and [17] and based on proposed scales the above-mentioned classification was described (Figure 1).

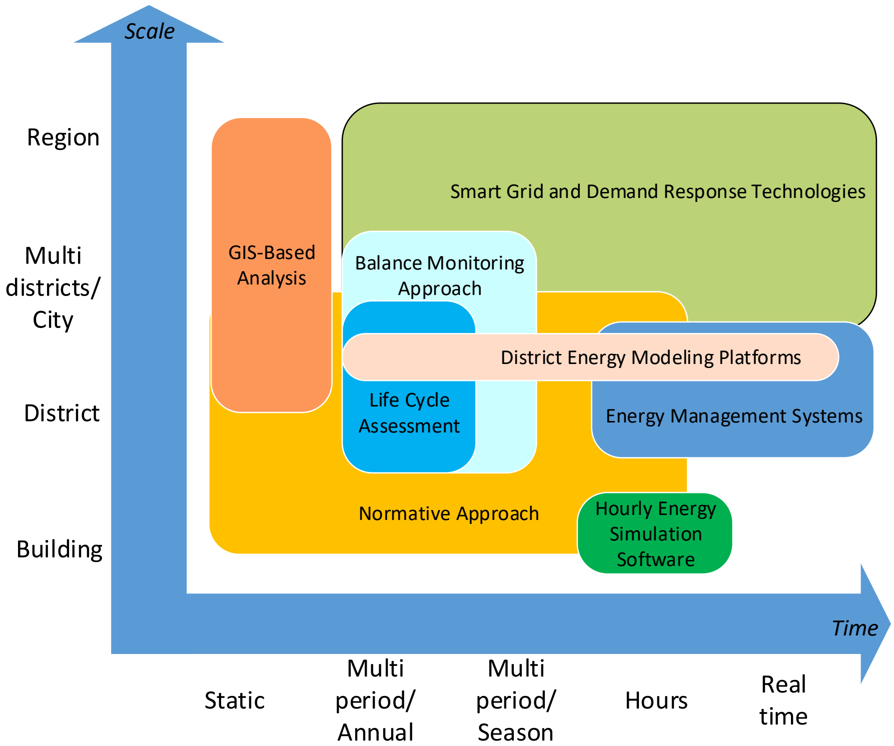

Figure 1. Temporal and spatial scales of PED assessment methods

PED assessment methods mainly center around analyzing districts at a multi-period time level. At the regional level, there are fewer methods, which can be explained by the complexity of analyzing a large number of parameters and source data.

If groups of methods analyze on the stage of application, three stages could be considered: planning, implementation, monitoring. All the described methods can be used to one way or another at the mentioned stages of PED development and implementation. Real-time methods are mostly used on the stage of monitoring; however, their results could be useful at the PED design. Static methods primarily serve to assess the main parameters of a PED at the stage of design and development of the main stages of implementation but can also be used when assessing an already implemented PED.

The choice of method or combination of methods depends on the specific KPIs defined for the PED, the availability of data, and the level of detail required for the analysis. Next, we consider the three main methods and the availability of data for each of them, which will determine their applicability for subsequent calculations in the context of PED.

Based on available methods and considering the SimplyPositive project goals only two methods were identified as potentially could be used for energy balance calculations. These are:

- UASTW methodology for energy balance calculations from the Normative approaches group and
- detailed 3D simulation method as realized in IDA ICE from the Hourly Energy Simulation Software group.

Obviously, the required data (so-called "ideal dataset") for energy balance simulation strongly depends on the selected method. The following report on required data for energy balance simulation and gap analysis will be done based on data requirements for the two above mentioned methods.

3 Required and available data analysis

As was described above, two methods for the Energy balance calculation could be selected for the next consideration: UASTW's methodology and detailed 3D calculations. Generally, after analysis of the required data for the energy balance calculation, there are five groups of them (data sets) could be identified (Figure 2):

1. **General** characteristics.
2. **Energy** characteristics, including **Flexibility**
3. **Geometric** characteristics **including buildings location**.
4. **Climate**.
5. Building **Physical** characteristics.

It should be noted that mentioned data could be on the level of building, district or larger regions (e.g. village, town, city).

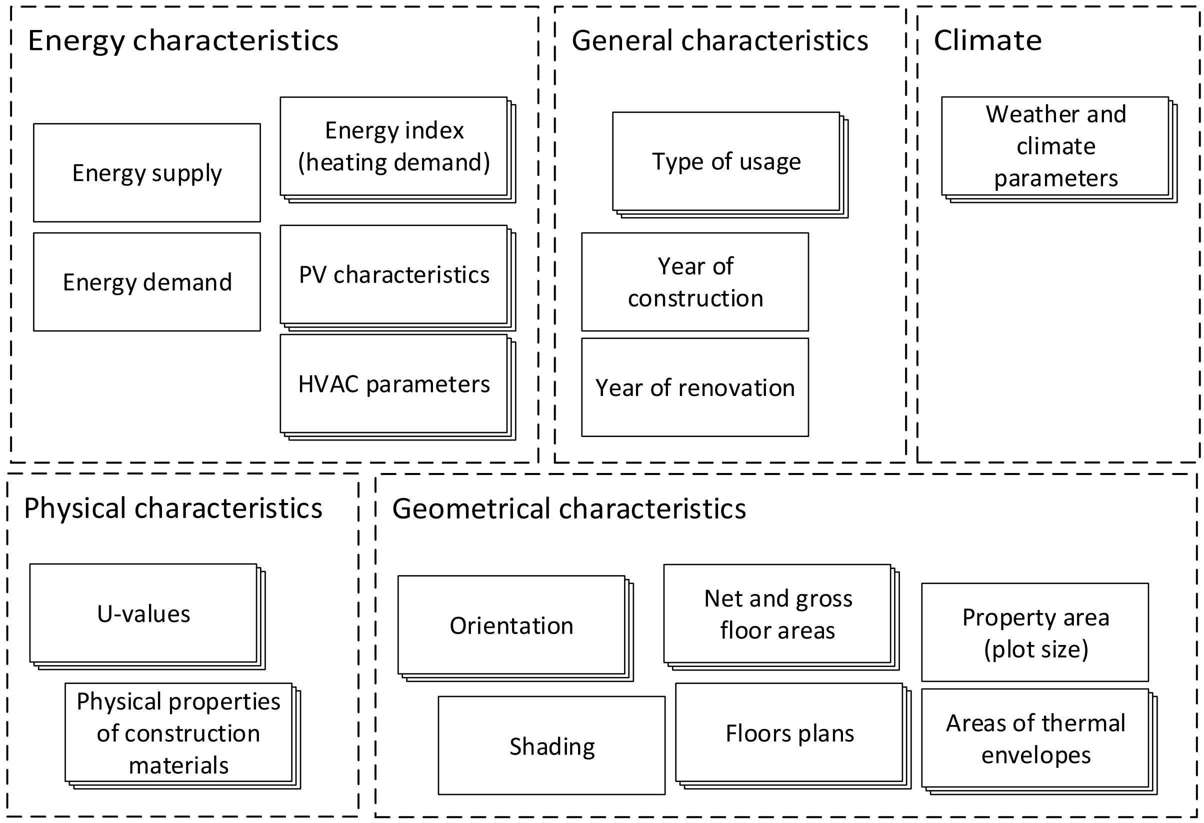

Figure 2. Required data sets for the methods of the energy balance calculation

The data set "**general characteristics**" consists of a few types of data: type of usage, year of construction; year of renovation. These data correlate with energy and physical characteristics. For example, buildings could be used for private and public purposes, which means different energy regimes: more energy supply during working hours and working days for public buildings and less energy supply for the private sector at the same time. Information regarding years of renovation and constructions correlates with physical characteristics of the used materials as were typical at those years as well as with energy characteristics of the HVAC systems realized or modernized accordingly standards, that was applied in appropriate years. All mentioned data under this data set could be easily collected and usually do not require additional preparation before usage.

Data set “**energy characteristics**” includes energy index, PV characteristics, HVAC parameters as well as energy supply and energy demand. Energy supply and energy demand are main parameters that, actually, characterize PED. Although, this information is difficult for collection as supply and demand consists of large number of energy flows in the FD. Energy index (i.e. heating demand) could be obtained by energy certificates provided for considered building, in the same time it could be difficult to obtain this parameter for the living district due to the different energy systems realized in each FD's element. Data regarding parameters of the PV and HVAC systems usually follows together with documentation supporting them and, generally, are not a problem. Another important aspect is that of Energy **Flexibility,** that is if and how the district is generating, dispatching and using energy flexibly and which data are required by possible predictive or other controllers.

Data set “**geometrical characteristics**” consists of floor plans, gross floor area, property area (plot size), areas of thermal envelope. All mentioned information is needed for evaluation real area that should be heated/cooled and to evaluate energy loses in the considered region. It should be noted that floor plans in some way could replace other geometrical characteristics through additional calculations. Data set includes orientation and shading, which are important for calculation solar influence on the buildings and PV effectiveness. This information is difficult to obtain; however, GIS systems could be helpful for this.

As working on this data set shown, collection of the buildings geometrical information is a difficult problem due to the access restrictions to the private data.

Data set “**climate**” includes year temperature, wind parameters, humidity for region, where FD is located. These data usually are obtained from global weather databases such as METEONORM [18] and it is not difficult to gain them.

Data set “**physical characteristics**” includes physical properties of construction materials and U-values. Physical properties include parameters, which are important for thermal calculations (thermal conductivity, heat capacity, etc.). Physical properties can be expressed through U-values. U-values are usually available in energy certificates or could be calculated based on heat conductivity coefficient and thickness of the wall.

This set of data is necessary for calculations and could be called “ideal set of data”. Although, it should be noted, that ideal set of data strongly depends on the method that is planned to be used for energy balance calculation of PED.

For each of the two main methods mentioned for calculating the PED energy balance, the initial data set will vary. For the simplest balance monitoring approach, the required dataset is minimal and includes only energy characteristics represented by energy supply and energy demand (Figure 3). This method will not be discussed further as it doesn’t give enough detailed results for PED assessment.

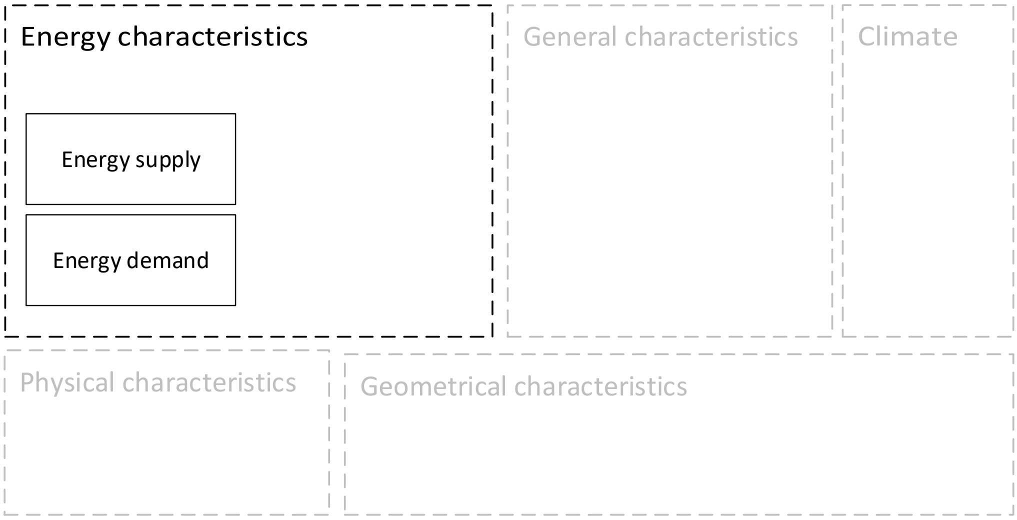

Figure 3. Data set for balance monitoring approach

Detailed 3D calculation requires a wider set of data (Figure 4) and already includes four groups from the above-mentioned classification of source data. Among the energy characteristics, the initial data are now PV characteristics and HVAC parameters, which, in turn, are specified comprehensively by sub-set of data. The physical and climate data included in the initial data set required for the 3D calculation are represented by only one subset of data each: the physical properties of the structural materials and the regional climate data, respectively. Geometrical characteristics have three subsets of data: floor plans of the buildings in the region, their orientations and shading.

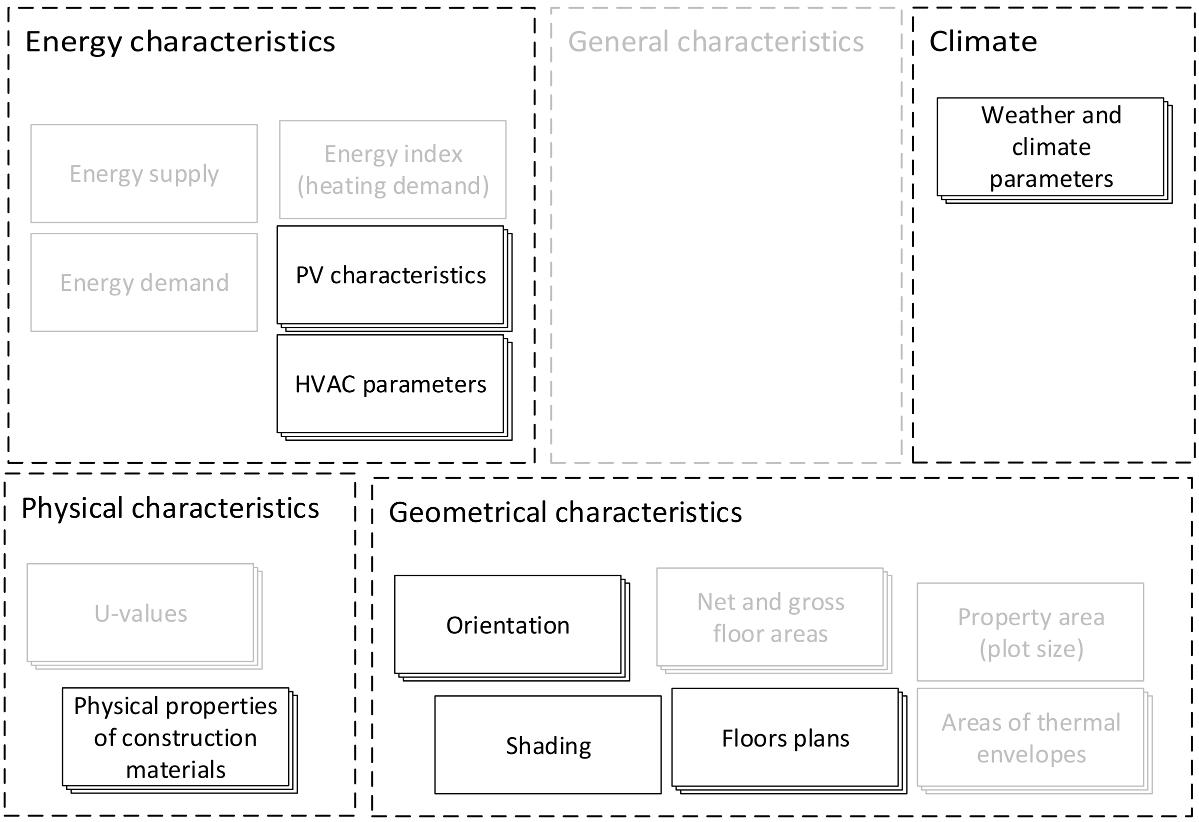

Figure 4. Data set for detailed 3D calculation

Thus, for the method under consideration, only seven subsets of data from four classification groups are sufficient. However, as mentioned above, the formation of these subsets usually requires significant effort and poses a number of difficulties for both PED representatives and the experts conducting the calculation.

When using UASTW's methodology, the initial dataset has the greatest detail and requires thirteen subsets of data from all 5 classification groups (Figure 5). The inclusion of new data subsets is due to the need to reduce the complexity of generating the initial dataset for calculations. Thus, in the group of geometric characteristics, floor plans can be replaced by estimated calculations of areas of thermal envelopes, gross floor area, and plot size.

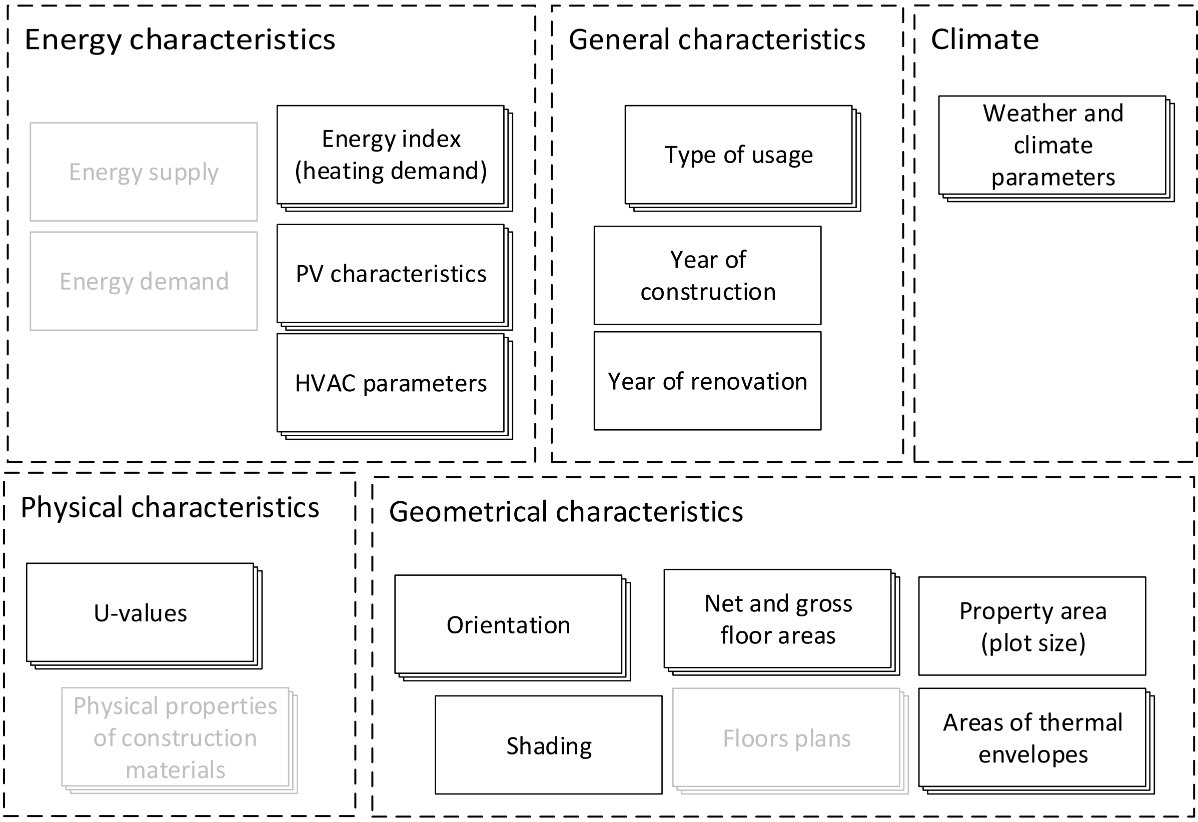

Figure 5. Data set for UASTW's methodology

It should be noted that adding a building energy index feature also reduces the level of uncertainty in PV and HVAC parameters. This characteristic is often present in building energy certificates and partially replaces the energy parameters required in PV and HVAC characterization.

Detailed structures of each subset of data could be found in Annexes A-C.

When generating the initial dataset for energy balance calculations, the key issue lies in the ability to provide the required data. The solution to this issue will ultimately form the basis for selecting the PED energy balance modeling method.

In general, when implementing a PED, two types of stakeholders can be identified: direct representatives of the future PED (for example, municipality, building company, etc.) and external experts (specialists in the analysis of positive energy districts). Implementation of the

PED is the goal for both parties, but the roles and responsibilities of the parties are separated when collecting data.

Based on the data classification proposed above (Figure 2), in general, the pathway of obtaining the final set of data required to conduct a PED energy analysis, with the division of responsibilities of the main stakeholders, can be represented as follows (Figure 6).

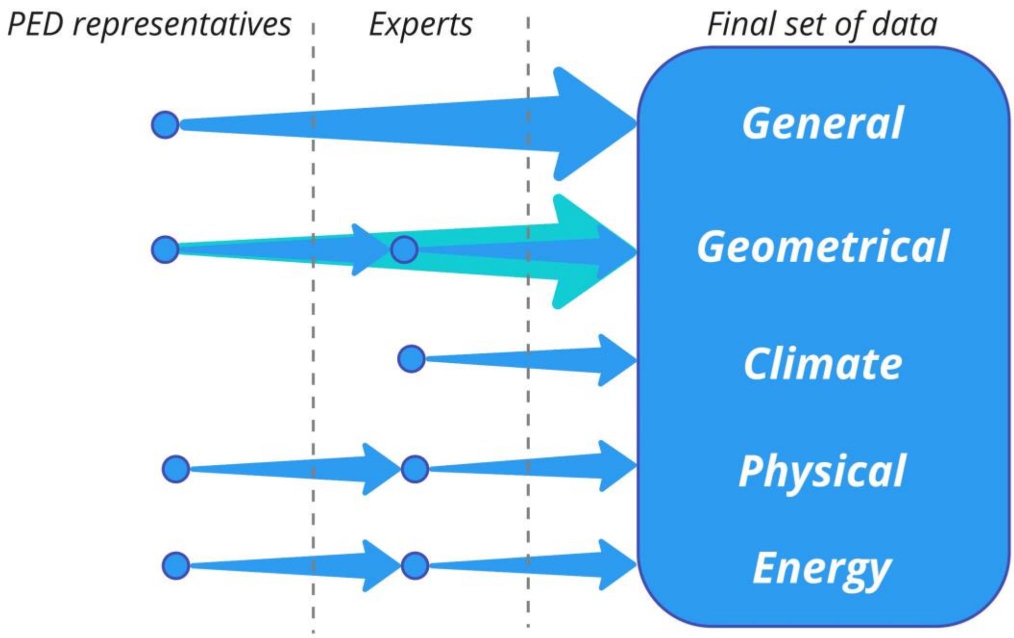

Figure 6. Final dataset forming

According to this data pathway, some information from the PED representatives could directly be included in the final set of data and do not require additional data from the experts. This is true for general information and could be true for some parts of geometrical data set (depending on planned methods for PED analysis). Climate data are not required PED representative's involvement as their format is formed by experts depending on used methods.

Physical, energy and, in some cases, geometric data arrays require additional processing, and their formation occurs in two stages. Thus, in the category of energy characteristics, the data necessary for modeling PV and HVAC in PED is generated by experts on the basis of characteristic (technical) data provided by PED representatives about equipment already in use or planned for installation. The building energy index is also typically calculated by experts based on provided data on the size of the county and its energy consumption. Energy demand and supply of districts are also formed with the participation of experts, who determine which parameters will be included in one category or another.

In the category of physical characteristics, the formation of the final data set usually begins with the collection of structural parameters of buildings (materials used and their spatial characteristics) by PED representatives. And on their basis, using regulatory documentation, the physical characteristics necessary for modeling (U-values, g-values, etc.) are formed.

The geometric characteristics of the PED in the final data set can be generated in two ways: with and without the participation of experts. In the first case, the participation of experts is required if it is necessary to present data in a special format. Thus, shading data is generated using special calculation programs (e.g. BIMsolar [19]), which transform the insolation profile for a specific modeled area. Data that does not require the participation of experts include floors plans, orientation. Areas of thermal envelopes can be specified both by experts (calculated based on the provided floor plans) and directly by PED representatives. Which way of forming a group of geometric data will be chosen depends on the chosen method for analyzing the PED energy balance.

4 Data Gaps and how to close them

In the Project concept and based on the proposed data structure (see Figure 2) available information regarding each FD was analyzed. Data was analyzed for two selected methods (see chapter 2 "Overview of methods for Energy Balance Calculation"). Dataset “climate” is not considered as a gap because of various numbers of the open climate databases from which information for considered FDs could be extracted.

All work under D3.2 was done iteratively and based on the pathway for final dataset forming (see Figure 6). The number of data request iterations for each FD varied depending on provided answers on the previous stage.

4.1 Großschönau (AT)

Round 1. Requested data from ideal dataset (Figure 2):

- general characteristics;
- energy characteristics;
- geometric characteristics including buildings location;
- building physical characteristics.

Provided data for each category:

- General characteristics: type of usage; year of construction; year of renovation.
- Energy characteristics: type of heating; availability of energy certificates.
- Geometric characteristics: gross floor areas (under D1.1), pictures of the typical houses in FD; dimensions of typical buildings in FD; link to the FD’s cadaster [20].
- Building physical characteristics: typical materials used in main buildings type and their thickness.

Identified gaps after 1st round:

1. The provided geometrical data are not suitable for 3D simulation methods or UASTW methodology due to absence main required parameters: floor plans, area of thermal envelopes, orientation, shading. Required data could not be provided due to the private data protection issues.
2. Physical characteristics partially suitable for simulation due to absence of the exact thermal physical properties of construction materials and U-values could not be calculated due to absence information about detailed buildings structure, which is considered as private data.
3. Energy characteristics are too general and do not contain technical parameters that are necessary at the energy balance simulation; energy indexes for buildings are not provided.

Identified gaps do not allow to use 3D methods of energy balance simulation due to large number of buildings in the FD with different geometrical structure. The absence of the floor plans will not allow to build 3D models; therefore, Hourly Energy Simulation Software are not suitable for the considered FD. However, more simplified normative approach developed by UASTW could be solution in considered case. So, the second round of data request was done.

Table 1 - Overview of directly useable data for energy balance calculation after 1st round - Austria

Focus District	3D method				UASTW method			
	Energy	Geometrical	Position	Physical	Energy	Position	Physical	Geometrical
Großschönau (AT)	–	–	~	–	~	~	~	~

For the identified gaps the next ways of their elimination were developed (numbers of gaps corelated with numbers of "ways"):

1. Experts will calculate areas of buildings envelopes based on available information for each type of buildings. Orientation will be identified by PED representatives on base of open GIS systems. Experts will interpret and generalize provided information forming required datasets.
2. U-values will be calculated by experts based on typical values and available standards. PED representatives will provide energy certificates for some buildings after obtaining permissions regarding personal data.
3. PED representatives will calculate energy indexes for main types of buildings in FD keeping personal data safety. Energy certificates will be provided for some types of buildings after obtaining permissions regarding personal data.

Round 2. Requested data:

- Geometric characteristics: buildings orientation.
- Energy characteristics: energy certificates; energy indexes.

Provided data: all requested.

Table 2 - Overview of updated data for energy balance calculation after 2nd round - Austria

Focus District	3D method				UASTW method			
	Energy	Geometrical	Position	Physical	Energy	Position	Physical	Geometrical
Großschönau (AT)	+	–	~	–	+	~	+	+

Next steps will be done by experts under Task 3.4 “Assessment of SimplyPositive Focus Districts”. These steps contain interpretation of obtained data and energy balance simulation for different scenarios of FD development.

4.2 Settimo Torinese (IT)

Round 1. Requested data from ideal dataset (Figure 2):

- general characteristics;
- energy characteristics;
- geometric characteristics including buildings location;
- building physical characteristics.

Provided data for each category:

- General characteristics: type of usage; year of construction.
- Geometric characteristics: floor plans for all types of buildings.
- Physical characteristics: construction materials of all buildings and their thickness.

Identified gaps after 1st round:

1. Geometric characteristics are available in the form of floor plans, which is suitable for 3D simulation but not in the format required for UASTW methodology (see Annex A).
2. Physical characteristics are specified indirectly and not in the form required for UASTW methodology (see Annex B).
3. Energy characteristics are not directly available for PED representatives and could not be provided in requested form.

Table 3 - Overview of directly useable data for energy balance calculation after 1st round - Italy

Focus District	3D method				UASTW method			
	Energy	Geometrical	Position	Physical	Energy	Position	Physical	Geometrical
Settimo Torinese (IT)	~	+	~	~	~	–	~	+

For the identified gaps the next ways of their elimination were developed (numbers of gaps corelated with numbers of “ways”):

1. Floor plans and building drawings provide all required data for areas calculation, so it could be done by experts on the stage of data preparation before simulation.
2. Based on provided data U-values and other physical characteristics could be calculated by experts using open databases of materials properties (e.g. [27], [28]) and standard methods [29].

3. Request energy certificates where required data could be presented in direct or indirect form.

Round 2. Requested data:

– Energy characteristics: energy certificates for main types of buildings.

Provided data: energy information for each type of building, which will allow calculate or assume with high accuracy required initial data.

Table 4 - Overview of updated data for energy balance calculation after 2nd round - Italy

Focus District	3D method				UASTW method			
	Energy	Geometrical	Position	Physical	Energy	Position	Physical	Geometrical
Settimo Torinese (IT)	~	+	~	~	~	~	~	+

Next steps will be done by experts under Task 3.4 "Assessment of SimplyPositive Focus Districts". These steps contain interpretation of obtained data and energy balance simulation for different scenarios of FD development.

4.3 Resita (RO)

Round 1. Requested data from ideal dataset (Figure 2):

– general characteristics;

– energy characteristics;

– geometric characteristics including buildings location;

– building physical characteristics.

Provided data for each category:

– General characteristics: type of usage; year of construction.

– Geometrical characteristics: general plan of a territory with non-standard buildings, their photos and main parameters.

– Physical characteristics: description of construction materials for some buildings in FD.

Identified gaps after 1st round:

1. Geometrical characteristics for the most of buildings are absent or provided in general form, which is not enough for energy balance simulation.
2. Physical characteristics provided in general description but not in required form (see Annex B), so can't be used directly at simulation.
3. Energy characteristics (see Annex C) are absent due to impossibility to obtain them in required form.

Table 5 - Overview of directly useable data for energy balance calculation after 1st round - Romania

Focus District	3D method				UASTW method			
	Energy	Geometrical	Position	Physical	Energy	Position	Physical	Geometrical
Resita (RO)	–	–	~	~	–	–	~	~

For the identified gaps the next ways of their elimination were developed (numbers of gaps corelated with numbers of "ways"):

1. Request floor plans and building drawings, which can be obtained from city's archive.
2. Request U-values, which could be stated in energy certificates. Otherwise, based on provided data U-values and other physical characteristics could be calculated by experts using open databases of materials properties (e.g. [27], [28]) and standard methods [29].
3. Request energy certificates, which contain additional information regarding energy characteristics of buildings.

Round 2. Requested data:

- Building drawings and floor plans.
- Energy certificates.

Provided data:

- Drawings of main types of buildings in FD.
- Average U-values for each type of building in FD.

Table 6 - Overview of updated data for energy balance calculation after 2nd round - Romania

Focus District	3D method				UASTW method			
	Energy	Geometrical	Position	Physical	Energy	Position	Physical	Geometrical
Resita (RO)	+	+	~	~	+	~	+	+

Next steps will be done by experts under Task 3.4 "Assessment of SimplyPositive Focus Districts". These steps contain interpretation of obtained data and energy balance simulation for different scenarios of FD development.

4.4 Amsterdam (NL)

Round 1. Requested data from ideal dataset (Figure 2):

– general characteristics;

– energy characteristics;

– geometric characteristics including buildings location;

– building physical characteristics.

Provided data: link to the maps of Amsterdam [21]; link to the 3D maps of Amsterdam [22]; link to WKO soil energy tool [23]; interactive map of water sources [24]; infographic of Amsterdam [25]; information about population density in Amsterdam.

Identified gaps after 1st round:

1. Geometrical data for the entire city is represented as 3D outlines of buildings without detailing on windows, and sometimes on buildings. Thus, the calculation of required areas of roofs, facades, and windows can only be done manually, which, in turn, is impossible for the FD due to the large number of buildings in it.
2. Based on 3D maps it is not possible to calculate gross and net floors areas, and floor numbers for all types of buildings in the FD as maps provide only outlines of buildings.
3. None of the provided data give information about the physical characteristics of building materials that are necessary to calculate heat losses (see Annex B).
4. Information regarding heating and cooling systems is presented in general way and do not correlate with required data (see Annex C).

Despite high numbers of maps, which interactively covered various living aspects of the Amsterdam city, it is not possible to obtain required data. This due to limitation of the export and summarizing/analyzing functions of the maps or absence of the required information.

Table 7 - Overview of directly useable data for energy balance calculation after 1st round - Netherlands

Focus District	3D method				UASTW method			
	Energy	Geometrical	Position	Physical	Energy	Position	Physical	Geometrical
Amsterdam (NL)	–	–	–	–	–	–	–	–

simply positive

The way to eliminate identified gaps: reduce area of the FD, which will allow to calculate or assume with high accuracy missing parameters. This decision was made during General Assembly meeting on 20-21 November 2023. The selected, reduced FD as a typical part of the Amsterdam is shown on Figure 7.

Figure 7. Updated Focus District Beursplain in Amsterdam

Together with boundaries of new focus district NL partners provided information regarding physical characteristics of the buildings and their main energy parameters [26].

Identified gaps for new FD:

1. Geometric characteristics: buildings net and gross floor areas, areas of thermal envelopes, orientation, shading.
2. PV characteristics.

Table 8 - Overview of updated data for energy balance calculation after 2nd round - Netherlands

Focus District	3D method				UASTW method			
	Energy	Geometrical	Position	Physical	Energy	Position	Physical	Geometrical
Amsterdam (NL)	+	–	~	+	+	~	+	~

For the identified gaps the next ways of their elimination were developed (numbers of gaps corelated with numbers of "ways"):

1. Required buildings areas could be calculated with adequate assumption based on 3D map of region. 3D model of the district could be obtained through export function from [22]. This 3D model could be used at orientation and shading calculations by BIMSolar software [19].

2. Based on 3D model and available information regarding installed PV in FD the required parameters will be calculated by BIMSolar software [19].

For the new FD in Amsterdam the key role in data preparation have experts (see Figure 6), which are based on open data will calculate and form required set of data for further simulations.

4.5 Generic process summary

A typical sequence of steps in data collection is shown on Figure 8. The most important data is provided by PED representatives based on construction documents and includes general data sets, geometric and physical data. For these types of data, significant simplifications and assumptions are not advisable, since they can lead to distortion or misinterpretation of the features of the focus district and, as a result, incorrect results, which will ultimately lead to a lack of correlation between the real and modeled objects. In other words, if it is not possible to obtain the specified data sets, then the need to carry out modeling within the established framework should be reconsidered.

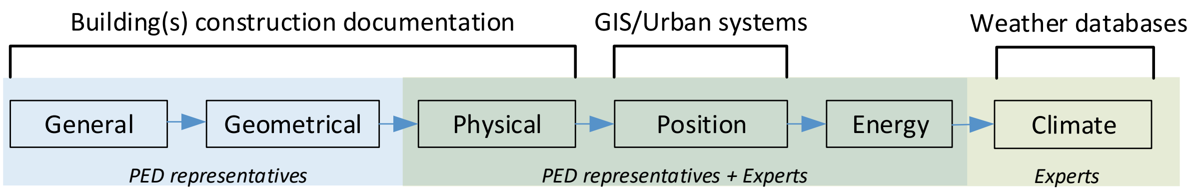

Figure 8. Stages of collecting data for energy simulation

Energy data is the least sensitive to assumptions. There are more sources for obtaining from; they can be obtained indirectly or represented as a space of variables. In the last case, the data moves from the category of initial constants to the category of variable boundary conditions and can serve as an object of study.

5 Conclusions

Based on available data for each FD and possible final results the method, developed in UASTW [15], was selected as a main for the next evaluation.

The impossibility to collect detailed geometrical data was led to impossibility to use 3D methods. The balance monitoring approach shortcomings and its limitations in simulation of different developing scenarios for FDs were leading to the avoiding this type of methods in the Project.

Significant changes were agreed for Amsterdam FD due to the absence of the required construction documentation.

Main gaps were closed during close collaborative work with partners through requests of main buildings' documents. Other gaps are possible to close within next collaboration work with partners or during simulation process by experts.

Iterative process on the data collection was carried out and required data were collected for the next calculations.

Sources

[1] Crawley, D. B., Lawrie, L. K., Winkelmann, F. C., Buhl, W. F., Huang, Y. J., Pedersen, C. O., ... & Glazer, J. (2001). EnergyPlus: creating a new-generation building energy simulation program. *Energy and buildings*, *33*(4), 319-331.

[2] McDowell, T. P., Bradley, D. E., Hiller, M., Lam, J., Merk, J., & Keilholz, W. (2017, August). TRNSYS 18: the continued evolution of the software. In *Proceedings of the 15th IBPSA Conference, San Francisco, CA, USA* (pp. 7-9).

[3] IDA ICE Simulation Software. https://www.equa.se/en/ida-ice

[4] Alpagut, B., Lopez Romo, A., Hernández, P., Tabanoğlu, O., & Hermoso Martinez, N. (2021). A GIS-Based Multicriteria Assessment for Identification of Positive Energy Districts Boundary in Cities. *Energies*, *14*(22), 7517. MDPI AG. Retrieved from http://dx.doi.org/10.3390/en14227517

[5] Girardin, L. (2012). A GIS-based Methodology for the Evaluation of Integrated Energy Systems in Urban Area. DOI: 10.5075/EPFL-THESIS-5287

[6] Coelho, A., Iria, J., Soares, F., & Lopes, J. P. (2023). Real-time management of distributed multi-energy resources in multi-energy networks. *Sustainable Energy, Grids and Networks*, *34*, 101022.

[7] Magrini, A., Marenco, L., & Bodrato, A. (2022). Energy smart management and performance monitoring of a NZEB: Analysis of an application. *Energy Reports*, *8*, 8896-8906.

[8] Sánchez, V. F., & Marijuan, A. G. (2021). Integrated model concept for district energy management optimisation platforms. *Applied Thermal Engineering*, *196*, 117233.

[9] Gharbi, A., Ayari, M., & Yahya, A. E. (2023). Demand-Response Control in Smart Grids. *Applied Sciences*, *13*(4), 2355.

[10] Assad, U., Hassan, M. A. S., Farooq, U., Kabir, A., Khan, M. Z., Bukhari, S. S. H., ... & Popp, J. (2022). Smart grid, demand response and optimization: A critical review of computational methods. *Energies*, *15*(6), 2003.

[11] Wehkamp, S., Schmeling, L., Vorspel, L., Roelcke, F., & Windmeier, K. L. (2020). District energy systems: Challenges and new tools for planning and evaluation. *Energies*, *13*(11), 2967.

[12] Klemm, C., & Vennemann, P. (2021). Modeling and optimization of multi-energy systems in mixed-use districts: A review of existing methods and approaches. *Renewable and Sustainable Energy Reviews*, *135*, 110206.

[13] Fnais, A., Rezgui, Y., Petri, I., Beach, T., Yeung, J., Ghoroghi, A., & Kubicki, S. (2022). The application of life cycle assessment in buildings: challenges, and directions for future research. *The International Journal of Life Cycle Assessment*, *27*(5), 627-654.

[14] Hussien, A., Saleem, A. A., Mushtaha, E., Jannat, N., Al-Shammaa, A., Ali, S. B., ... & Al-Jumeily, D. (2023). A statistical analysis of life cycle assessment for buildings and buildings' refurbishment research. *Ain Shams Engineering Journal*, 102143.

[15] Schneider, S., Zelger, T., Sengl, D., & Baptista, J. (2023). A Quantitative Positive Energy District Definition with Contextual Targets. *Buildings*, *13*(5), 1210

[16] Mancarella, P., Andersson, G., Peças-Lopes, J. A., & Bell, K. R. (2016, June). Modelling of integrated multi-energy systems: Drivers, requirements, and opportunities. In *2016 power systems computation conference (PSCC)* (pp. 1-22). IEEE.

[17] Kriechbaum, L., Scheiber, G., & Kienberger, T. (2018). Grid-based multi-energy systems—modelling, assessment, open source modelling frameworks and challenges. *Energy, Sustainability and Society*, *8*(1), 1-19.

[18] Meteonorm Software. https://meteonorm.com/en/

[19] BIMsolar – The Solar Architecture & Digital Community. https://www.bim-solar.com/

[20] Österreichischer Kataster. https://kataster.bev.gv.at/#/center/14.9426,48.6536/zoom/14.9

[21] Maps Amsterdam. https://maps.amsterdam.nl/

[22] 3D Amsterdam. https://3d.amsterdam.nl

[23] WKO-bodemenergietool. Ontdek de mogelijkheden van bodemenergie. https://wkotool.nl/

[24] Waternet. https://waternet.omgevingswarmte.nl/waternet#c9eaed99-a69e-48eb-9642-61c0e0b77078

[25] Warmtebronnen van nu en straks: het Amsterdamse bronnenboek. https://issuu.com/gemeenteamsterdam/docs/het_amsterdamse_bronnenboek_online_versie

[26] Ayaz, M. F. (2022). *No gas all local: Developing a renewable-based and decentralised energy system for the historic centre of Amsterdam.* [Master's thesis, Delft University of Technology].

[27] Materials Database - Thermal Properties. https://thermtest.com/thermal-resources/materials-database

[28] Materials Thermal Properties Database https://hvac-eng.com/materials-thermal-properties-database/

[29] ISO 6946 - Building components and building elements – Thermal resistance and thermal transmittance.

Annex A. Geometrical characteristics

No.	Name of characteristic	Units	Description/Comment
		Net and gross floor areas	
1.	Net Floor Area (NFA) for each building type	m^2	NFA (area of all floors without walls) of every Building of type (living, office, school, KiGa, retail)
2.	Share of Non-Food Retail	%	Ratio between trading of type Food to NonFood - retail is per definition regarded as "food" (supermarket, etc.) which means assuming high demands. Non-Food are other kinds of retail with lower demands
3.	NFA/GFA	—	Ratio between net floor area and gross floor area to determine the floor space ratio
4.	Room height	m	Typical room height of a regular floor to calculate the building volume
5.	Number of floors	—	Number of floors including cellar and ground floor to calculate the volume
6.	Personal density	m^2/Person	Ratio between NFA and persons. Higher density means higher internal gains and therefore higher cooling demand. But they also improve the rating in the FutureDistrict assessment system
		Areas of thermal envelopes	
7.	Area of external walls (excl. windows)	m^2	Area of all external walls without windows
8.	Area of windows	m^2	Area of all windows
9.	Area of roof	m^2	Area of the roof facing outside air
10.	Area of ground floor	m^2	Area of the floor facing the ground (or cellar)
		Property area	
11.	Area of property	m^2	Area of property on which the Project will be Built. This value needs to be entered to calculate the FSR (Floor Space Ratio) in order to determine the needed Plus Energy Concept
		Orientation	
12.	Gross area of window	m^2	The gross area for the windows facing North, East, South, West.
		Shading	
13.	Reduction factor for solar radiation heating	—	Composes by dirt, shading and glass to frame ratio of the Window

Annex B. Physical characteristics

No.	Name of characteristic	Units	Description/Comment
U-values			
1.	U-value	W/m²K	U-values walls, windows, roofs, floors
Physical properties of construction materials			
2.	Thermal bridge surcharge	W/mK	This value refers to the quality and losses of the thermal envelope and will be added to the U-values of the building structures
3.	Gains through opaque surfaces	—	This value refers to the solar gains of opaque surfaces
4.	Mobile summer shading	—	This value contributes to the solar gains through windows (z-value)
5.	Reference g-value	—	This value contributes to the solar gains through windows (g-Value)
6.	Specific heat capacity	Wh/m²K	The specific heat capacity defines an average value for every construction including walls, roof and floor

Annex C. Energy characteristics

No.	Name of characteristic	Units	Description/Comment
1	2	3	4
HVAC parameters			
1.	Heating and Cooling season	—	The heating and Cooling Season defines in which Month of the year the building has to be heated or cooled in order to keep a comfortable climate inside. Normally the heating Period (1) is in Winter. The cooling Period (-1) is in Summer and no Heating or Cooling (0) is required during the transitional period
2.	Room temperature minimum	°C	This Value defines the set-point temperature in which the heating/cooling system shall be turned on
3.	Room temperature maximum	°C	This value can be defined to stop heating/cooling the building if the temperature is higher/lower than necessary
4.	Efficiency heating/cooling (Distribution)	—	This Value defines the efficiency of the heat/cold distribution system and includes mechanic losses for Pumps and thermal Losses
5.	Power Heat Pump	W/m^2	This Value defines the specific power of the Heat Pump in use to calculate the needed energy and convert it into the primary Energy demand and the CO_2-Emissions for the HVAC System
6.	Water temperature minimum and maximum	°C	These values define the minimum and maximum temperatures to which hot water should be heated
7.	Storage Losses	W	This Value defines the thermal losses by storing Energy in a Tank (hourly temperature drop of 0,5°C by 60°C storage temperature)
8.	Water Tank Volume	l/Person*day	Default 50 l/Person*day assuming simultaneity of 0,1
9.	Share of the Volume Flow without HR	—	The share of the ventilation system which has no heat recovery included in the system (per default all Ventilation has heat recovery)
10.	Efficiency heat/cooling Recovery	—	Refers to the whole air change rate in winter/summer

1	2	3	4
PV characteristics			
11.	Hourly PV-generation on roof; on facade 90°; on roof & facade	W/kWp	These values refer to the PV-Production for a PV-System with 1 kWp. These Profiles can be scaled in order to cover the electric energy
Energy index			
12.	Maximum and minimum Internal gains	kWh/m²a	The simulation uses timeseries for each usage and load/air change
13.	Hot water usage	kWh/m²a	
14.	Electric energy for ventilation	kWh/m²a	
15.	Elevators, HVAC control, building electricity	kWh/m²a	
16.	Lighting	kWh/m²a	
17.	Ventilation ACH	1/h	
18.	Infiltration ACH	1/h	

simply positive

simply positive