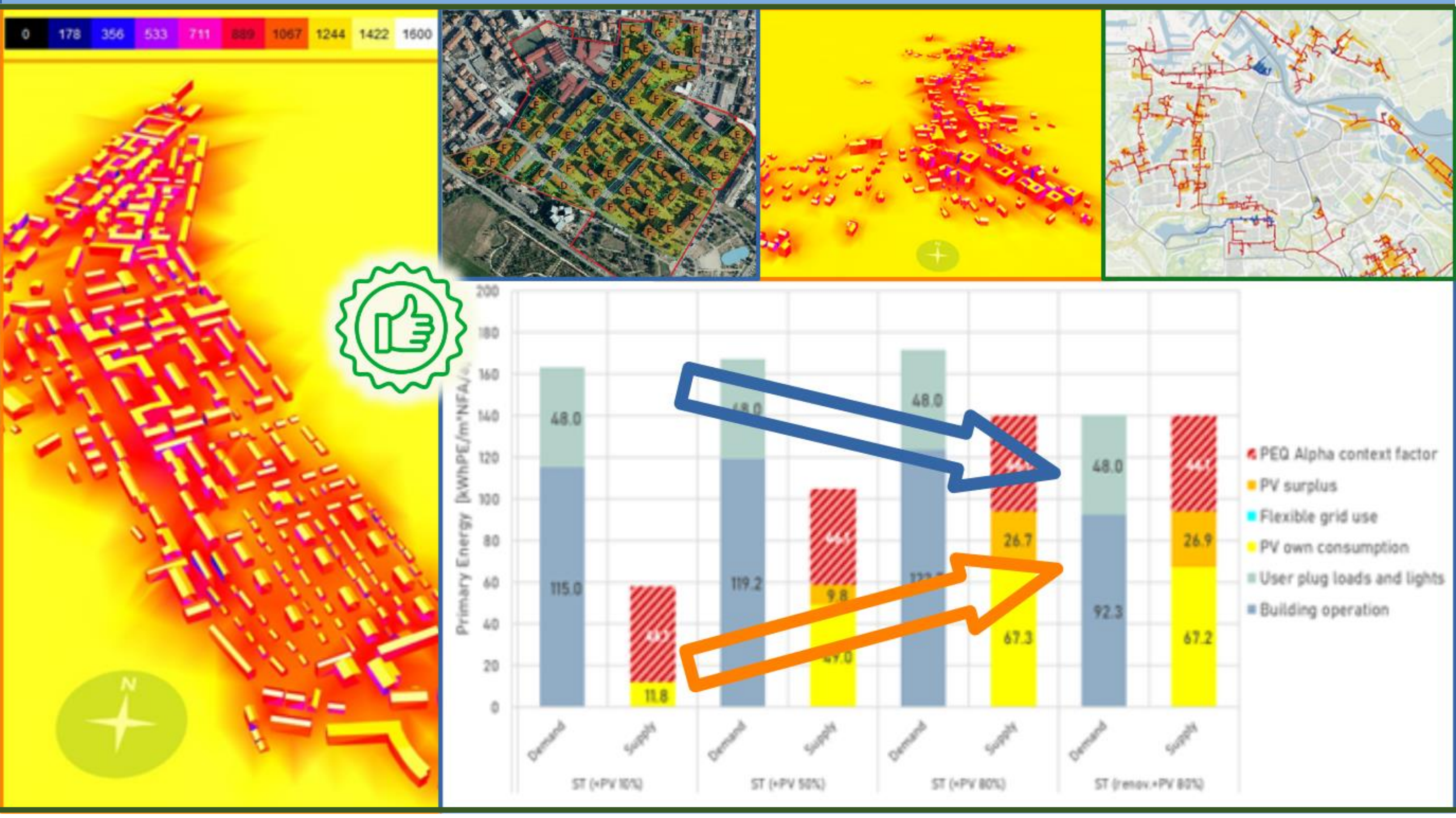
simply positive

D3.3 Assessment-Report on Focus Districts

June 2024



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History

Version	Description	Lead author	Date
V1	Table of Content	SON	December 2023
V2	Energy Balance of FD Amsterdam	UASTW	April 2024
V3	Review and Feedback	SON	April 2024
V4	Energy Balance of FD Settimo Torinese	UASTW	May 2024
V5	Energy Balance of FD Resita and Großschönau	UASTW	June 2024
V6	Internal Review	UASTW	June 2024
V7	Review and last formatting	SON	June 2024

Disclaimer

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Executive Summary

The aim of the deliverable is to

- highlight current understanding and goals of the focus district characterization and energy balance assessment;
- close gaps in existing datasets for energy balance calculations;
- calculate energy balances for the 4 focus districts considered in the Project.

This report presents a summary of the energy balance simulation for the four Focus Districts (FDs). The simulation was conducted using the methodology developed by UASTW and is based on a normative approach.

For all considered FDs, the development scenarios towards achieving Positive Energy Districts (PED) involve building renovations (insulating walls, roofs, basements; replacing windows) and installing photovoltaic (PV) panels. In regions with relatively cold climates, these measures play an important role in reducing heat losses during the winter period. Installing PV panels is more efficient in southern regions with high solar irradiation. However, in these regions, the energy loads for cooling also increase.

The most effective measures for development scenarios include a combination of all possible actions (e.g., including flexible grid usage) and the implementation of renewable energy technologies. The results obtained for the considered FDs highlight the directions for district development and can be used as a basis for district stakeholders towards PED implementation.

List of Figures

List of Tables

List of Abbreviations and Acronyms

CF	Context factor
DHW	Domestic hot water
DSM	Demand side management
EPBD	Energy Performance of Buildings directive
EU	European Union
FAR	Floor Area Ratio, this indicator of district density is the GFA over the PA
FD	Focus district investigated in the SimplyPositive Project
GHG	Greenhouse gas
GFA	Gross floor area, over ground
HVAC	Heating, ventilation, and air-conditioning
HP	Heat pump
ICT	Information and communications technology
IEA	International Energy Agency
JPI	Joint Programming Initiative
KPI	Key performance indicator
PA	Plot area, that can be built upon, does not include traffic areas, sidewalks, or parks
PED	Positive energy district
PEF	Primary energy factor
PEN	Positive energy neighborhood
PV	Photovoltaics
REC	Renewable Energy Community
RES	Renewable Energy Sources
WP	Work package

Table of Contents

1 Introduction

1.1 Purpose of the document

The purpose of this report is to comprehensively assess the Focus-Districts within the SIMPLY POSITIVE project, adhering to the methodology developed in task 3.2. The assessment concentrates on the goals established in task 3.1 and operationalizes the data compiled in task 3.3 and highlighted in D3.2. The results of the energy balance simulation will be presented to district and city stakeholders, providing a status quo analysis and establishing a baseline for innovative strategies and further improvements associated with WP4, WP5, and WP6.

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.
D3.2. Gap Analysis of Energy Balance Calculation Data	Section: Ways of gaps close for energy balance calculation
WP 5. Monitoring, controlling and Digitalization of individual PED-Pathways	Sections: Input data and assumptions
D5.3. Updated Framework definition and Methodology description for SIMPLYPositive	Methodology of the Framework definition and results of the energy balance simulation

1.3 Structure of the document

The document consists of 9 parts, including this Introduction and conclusions. Parts 2 – 4 briefly describe the theoretical background of the energy balance assessment, and parts 5– 8 describe the results of the energy balance simulation for each Focus District.

2 Understanding and Goals

2.1 PEDs as lighthouse areas to support reaching climate goals

Positive Energy Districts (PEDs) are emerging as critical models for urban sustainability and climate resilience. By generating more energy than they consume, PEDs serve as exemplary "lighthouse" areas, showcasing the integration of advanced energy technologies and sustainable urban planning. These districts demonstrate the feasibility and benefits of achieving net-positive energy status, thereby supporting broader climate goals.

PEDs contribute significantly to reducing greenhouse gas (GHG) emissions by incorporating renewable energy sources such as solar, wind, and geothermal systems. This local generation and consumption model minimizes reliance on fossil fuels, leading to a substantial decrease in carbon footprints. Moreover, PEDs promote energy efficiency through smart grid technologies, energy-efficient buildings, and advanced materials, further enhancing their sustainability profile.

One of the most significant advantages of PEDs is their potential for scalability and replication. By documenting best practices, performance data, and lessons learned, PEDs provide a blueprint for other urban areas to follow. This dissemination of knowledge accelerates the adoption of PED principles globally, contributing to a widespread reduction in urban GHG emissions. Under this Project, we are analyzing four focus districts, which have different parameters. Therefore the principle of scalability should be applied to the methodologies of the analysis, which was done and tested under energy balance simulation.

Both perspectives are important: With the Paris Agreement of 2015 and subsequent European and National climate goals, legally binding targets for decarbonization are in effect that have a **top-down** character.

On the ground, the feasibility and implementation of measures are limited by a myriad of technical, socioeconomic, legal, and regulatory factors. In light of these, the decarbonization potential of districts must be determined **bottom-up** on a case-by-case basis.

We aim to connect these two fundamentally different perspectives through the assessment of a Positive Energy Balance in the investigated focus districts.

2.2 Summary of Simply Positive PED Definition framework

The definition of Positive Energy Districts (PEDs) is intricately linked to their real-world objectives and implications. The primary goal of the definition is to find a balance between attainability and ambition, making it applicable to diverse urban and rural district types while aligning with the Paris 2050 climate goals. This is in line with the EU Commission's requirement that PEDs should "exceed the requirements of the Energy Performance of Buildings Directive," addressing both ambition and sufficiency.

To determine whether a configuration qualifies as a PED, a concrete criterion of a positive energy balance is necessary. The definition's goals include quantitative balance evaluation, categorized into three primary components: the district's system or balance boundaries, a weighting system for the balance, and balance objectives.

1. “District System or Balance Boundaries”: Define the physical, temporal, and functional limits within which energy flows are considered.
2. “Weighting System for the Balance”: Assigns importance to different energy flows to reflect their significance within the energy system.
3. “Balance Objectives”: Establishes the targets for achieving a positive energy balance.

System boundaries are approached from spatial, temporal, and functional perspectives:

1. “Spatial Boundaries”: Physical limits of included energy services and supplies.
2. “Temporal Boundaries”: Typically set to one operational year for balancing periods.
3. “Functional Boundaries”: Identify specific energy functions, uses, or demands to be included or excluded.

These boundaries define three variants or layers:

– “PED Alpha”: Focuses solely on operational energy.
– “PED Beta”: Incorporates private daily mobility.
– “PED Omega”: Includes embodied energy from construction, maintenance, repair, and mobility.

The PED definition considers energy demand for room conditioning, domestic hot water, lighting, building services, and user-specific demands like appliances and computers, etc.

The PED definition includes a coherent and transparent system for weighting and evaluating energy flows. The weighting objectives prioritize the district's contribution to national energy system's climate neutrality over physical self-sufficiency. Specific objectives include:

– Linking to planning practices and existing literature.
– Mapping seasonal differences in renewable feed-in and grid import.
– Evaluating energy flexible, grid-serving actions.
– Using biomass without implicit preference.

A quantitative PED definition is designed with a positive balance target using context factors for appropriate system boundaries.

One of the most important factors in the energy balance calculation is a factor that links the target value of the energy balance of a sustainable district to its building density, expressed by the floor area ratio (i.e. the gross floor area over the buildable plot area, constituting a “Density Context”). More about factor is explained in [1]. In this Project, regions with almost the same targets towards PEDs were analyzed, so as a conservative approach, the PED Alpha Context typical for Austria was chosen. For further work, the careful identification and study of this factor and influencing parameters for each region will be perspective direction.

Energy balance calculation is a critical part of PED assessment. The simulation method developed by UASTW includes transient simulation of energy flows, hourly load balancing with appropriate weighting factors, and inclusion of energy flexible control schemes and demand-side management (DSM). This approach was applied to the four FDs, described in detail in [17].

2.3 Roles of City Stakeholders in supporting PEDs

The development and implementation of Positive Energy Districts (PEDs) are critical components in the transition towards sustainable urban environments. City stakeholders, including local governments, private sector entities, community organizations, and residents, play pivotal roles in supporting and advancing PED initiatives. Their collective efforts can significantly influence the successful integration of energy-positive practices within urban settings.

There are a few groups of stakeholders that could be identified in the FD on its pathway toward PED: local governments, energy providers, urban planners, residents and local communities, etc.

Local governments are at the forefront of fostering Positive Energy Districts. They have the authority to implement policies, regulations, and incentives that promote energy efficiency and renewable energy adoption. By setting ambitious energy targets, providing financial incentives, and streamlining permitting processes, local governments can create an enabling environment for PEDs. Additionally, they can lead by example through the development of municipal buildings and infrastructure that adhere to PED principles, thereby setting a benchmark for private developments.

Energy providers and utility companies are essential stakeholders in the transition to positive energy districts. They are responsible for integrating renewable energy sources into the existing grid and ensuring a reliable supply of energy to residents and businesses. By investing in smart grid technologies and energy storage solutions, these providers can enhance grid stability and enable the effective management of energy supply and demand within PEDs. Additionally, energy providers can offer tailored services and incentives to encourage residents and businesses to adopt energy-efficient practices and technologies.

Urban planners and architects contribute by designing buildings and public spaces that maximize energy efficiency and support the integration of renewable energy systems. Their expertise in sustainable design principles helps reduce energy consumption and enhance the overall thermal performance of buildings. By adopting innovative construction materials and techniques, they can minimize the energy footprint of new and existing structures within PEDs. Moreover, urban planners can facilitate the development of smart grids and energy storage systems that enable the efficient distribution and use of locally generated renewable energy.

Residents and local communities also play a vital role in supporting PEDs. Their engagement and participation in energy-saving initiatives are crucial for the success of these districts.

Educational campaigns and community programs can raise awareness about the benefits of renewable energy and energy efficiency, motivating residents to reduce their energy consumption and participate in local energy generation projects. Community involvement in the planning and decision-making processes ensures that the development of PEDs aligns with local needs and preferences, fostering a sense of ownership and responsibility towards sustainable urban living.

The roles of city stakeholders in supporting Positive Energy Districts are multifaceted and interconnected. Local governments, private sector entities, community organizations, and residents each have unique contributions that are crucial for the development, implementation, and sustainability of PEDs. Their collaborative efforts can drive the transition towards more sustainable, energy-positive urban environments, ultimately contributing to broader climate goals and enhancing urban quality of life.

Under the SIMPLY Positive project, due to its specificity, the collaboration was mostly between district representatives who could be classified as urban planners (small enterprises, involved in technical work regarding FD development). Collaboration was led in the analysis of the energy characteristics of the district, parameters, and characteristics of FD buildings, residents' behavior, etc.

3 Resources and data availability for PED assessment

3.1 Ideal and Minimal requirements for data availability

Depending on the used method for energy balance simulation the ideal and minimal dataset can vary. In general, the Ideal Data Requirements could be divided for the next categories:

1. Detailed Building Information

– Architectural Plans: Detailed blueprints including dimensions, materials, and construction techniques.

– Energy Performance Certificates (EPCs): Information on the energy efficiency of each building.

– Occupancy Patterns: Detailed schedules of when and how buildings are used, including peak usage times.

– Appliance and Equipment Inventory: Types, numbers, and energy consumption profiles of all appliances and equipment.

2. Comprehensive Energy Data

– Historical Consumption Data: Hourly, daily, and seasonal energy usage data over multiple years.

– Renewable Energy Generation Profiles: Detailed generation data from on-site renewable sources like solar PV, wind turbines, and biomass.

– Grid Interaction Data: Information on energy imported from and exported to the grid, including time-of-use tariffs and demand response events.

3. Environmental and Climatic Data

– Weather Data: High-resolution historical and forecasted weather data, including temperature, humidity, solar radiation, and wind speed.

– Microclimate Data: Localized climatic conditions affected by urban morphology, green spaces, and water bodies.

4. Infrastructure and Mobility Data (if these parameters are included in PED boundaries)

– Transport Patterns: Detailed data on commuting patterns, vehicle types, and usage frequencies.

– Energy Infrastructure: Information on local energy distribution networks, storage facilities, and charging stations for electric vehicles.

The minimal data have the same structure, although some of the sub-categories could be replaced by normative values or assumptions can be made.

More about the required and minimal data for energy balance assessment is described in [16].

3.2 Observations on data availability of the SIMPLY Positive focus districts

As was stated in [16] for the SIMPLY Positive project all FDs provided the basic sets of data, that are required for energy balance simulation. However, some data required proof or assumption due to the impossibility of their obtaining. A detailed description of assumptions made for each FD is provided in relevant sections of this Report.

4 PED assessment process and interpretation of results

In general, the whole process of PED assessment could be divided into three main stages:

1. Focus district characterization.
2. Dataset forming.
3. Energy balance assessment.

In the first stage "district characterization" the boundaries of the district are defined. It means that energy flows, geographic boundaries, district development goals, key performance indicators, etc. should be defined [1]. This process is quite well described in [2]. It is important to note that the characterization of the focus district primarily involves analytical work from experts, supported by stakeholders. Therefore, a formal representation of this process as a process flow chart is not necessary.

The second stage “Dataset forming” is the least formalized and practically not described in the open literature. However, it is the quality of preparation of the initial data set that will directly affect the quality of the results obtained in the third stage (e.g. [3]).

Thus, there is a need to formalize the process of preparing initial data for calculating the energy balance, and, as a result, improve the quality and efficiency of the calculation process. The process flow of dataset forming is presented in Figure 1.

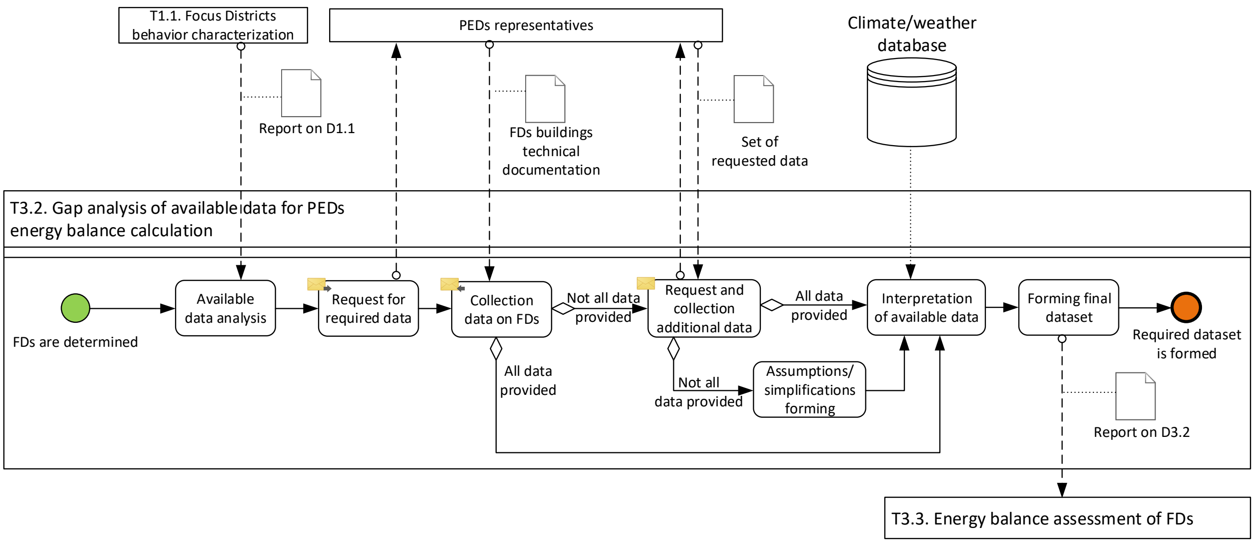


Figure 1. Process flow for dataset forming

The process of dataset forming starts after focus district characterization and requires a description of district boundaries [2]. This information is analyzed and requires information to be taken from outer databases (climate/weather (e.g. [4]), energy monitoring/statistical (e.g. [5]), building documentation databases (e.g. [6]) and GIS systems (e.g. [7])). District representatives are involved remotely only if required data cannot be approached directly by experts. In case data cannot be obtained assumptions are made. Before forming the final dataset, all collected information is interpreted to the required format to be transferred to the next task of energy balance calculation.

As was stated in [13] the Primary Energy conversion Factor (PEF) plays a crucial role in energy balance assessment in FD. This factor can vary during the year, season, day, etc., and depends on many factors such as weather, amount of renewable energy sources used for electricity production, etc.

For each FD in the Project SIMPLYPositive PEF was selected based on provided data in scientific literature and relative assumptions were made.

5 Assessment of Focus District in Settimo Torinese

5.1 Initial Goals and Setting

The FD is located in the southeast part of Settimo Torinese city. The main parameters of the district are provided in Table 1.

Table 1 – Parameters of Settimo Torinese FD

Parameter	Value	Unit
District Area	19	ha
Gross Floor Area	213 937	m² GFA
District Plot Area	146000	m²
Floor Area Ratio (FAR)	7.93	
Net to Gross Floor Area Ratio	80	%
Building storeys (avg)	5.6	
Residential usage	98.5%	%
Commercial usage	0.2%	%
Others (Retail)	1.4%	%

The focus district consists of 6 types of buildings and a few other buildings of different structures (see Figure 2). Those buildings are a church, two schools, and an institute. Unfortunately, FD representatives can not provide detailed data about those buildings' structures, areas, etc. Therefore, that part of FD was excluded from the analysis.

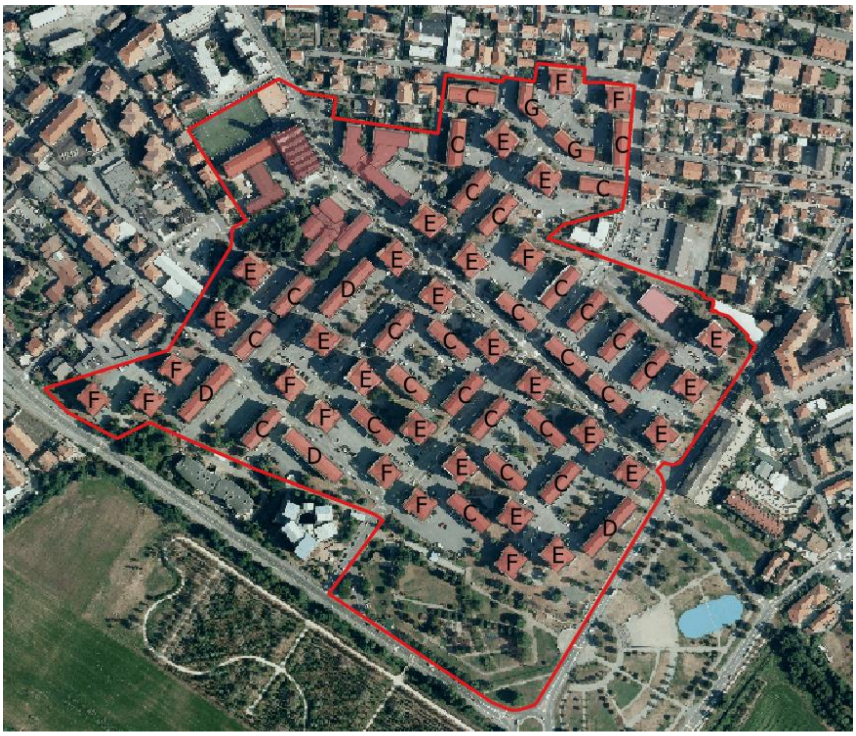


Figure 2. Settimo Torinese FD

For Settimo Torinese FD according to the provided information [17] there are no current goals towards the PED. However, potential scenarios for the FD development identified by district representatives could be presented as stated in Table 2.

Table 2 – Development goals for Settimo Torinese

No.	Description	Current state	Potential
1	Windows modernization	U-value 5.7 W/m²K 1-glass	U-value 0.6 W/m²K (2-glass)
2	Walls insulation	U-value 1.15 W/m²K (no insulation)	Insulate all walls using the air chamber present in the brick perimeter wall (external coat only if there is no alternative) U-value 0.6 W/m²K
3	PV installation	—	Install PV on 80% of roofs
4	Geothermal energy	—	Powered by geothermal energy

5.2 Input data and assumptions

FD has 5 types of buildings with a construction period of the later 60th. Thermal properties of their walls, windows, roofs, and basements were not provided directly by district representatives, so could be assumed as typical for that period accordingly [14]: 1.15 W/m²K for walls; 5.7 W/m²K for windows; 2 W/m²K for the base floor; 1.3 W/m²K for roof. G-value for 1-glass windows was taken as 0.85 according to [15].

District plot area was calculated with the usage Google Earth tool (Figure 3).

Figure 3. Settimo Torinese plot area

Yearly irradiation for Settimo Torinese was calculated with the usage program tool BIMSolar [10] (Figure 4).

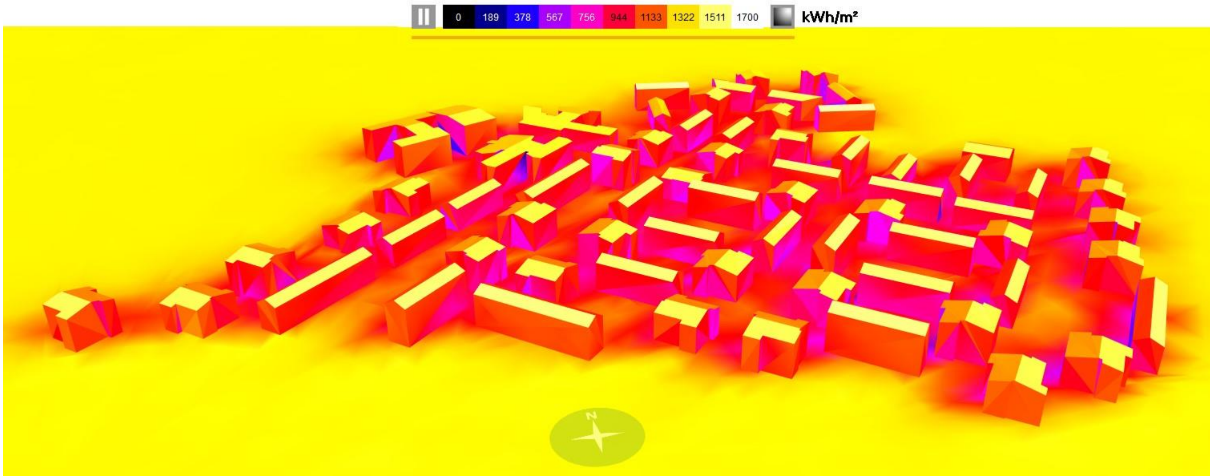


Figure 4. Yearly solar irradiation for Settimo Torinese FD.

5.2.1 Primary Energy conversion and availability of offsite RES

The primary energy factor for Italy is described in [9] (Figure 5, Figure 6). For Italy, the seasonal variations of PEF range from 1.5 to 2.36, with the higher share of renewables during the summer resulting in a median value as low as 1.8, while during winter, the PEF values rise to 2.1.

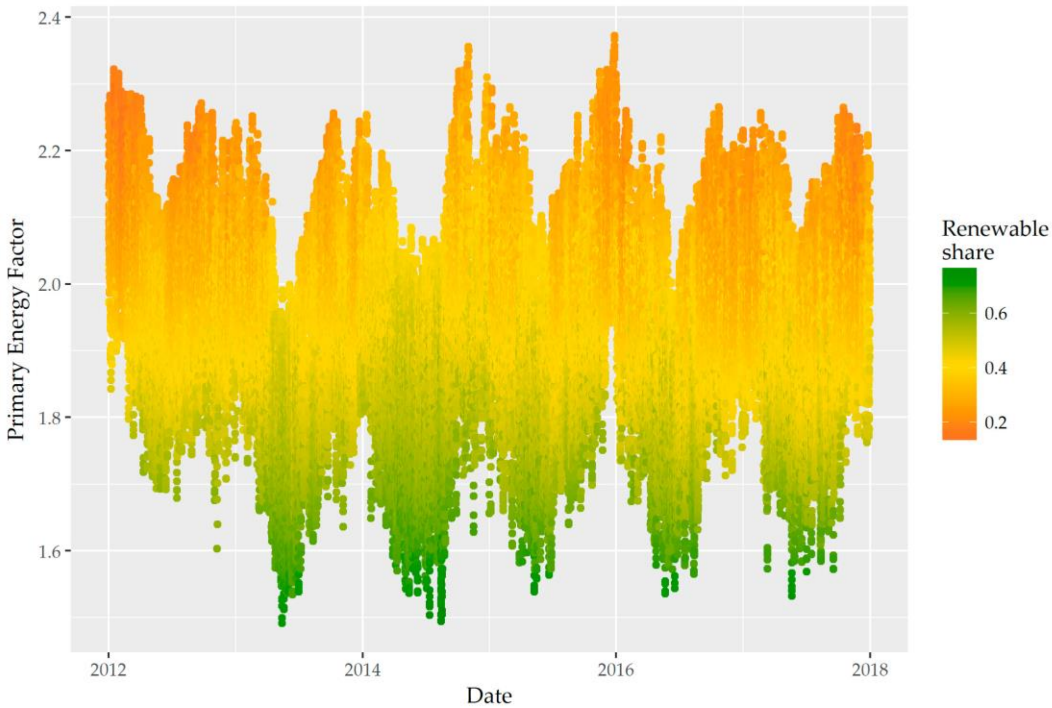


Figure 5. Primary Energy Factor for Italy [9]

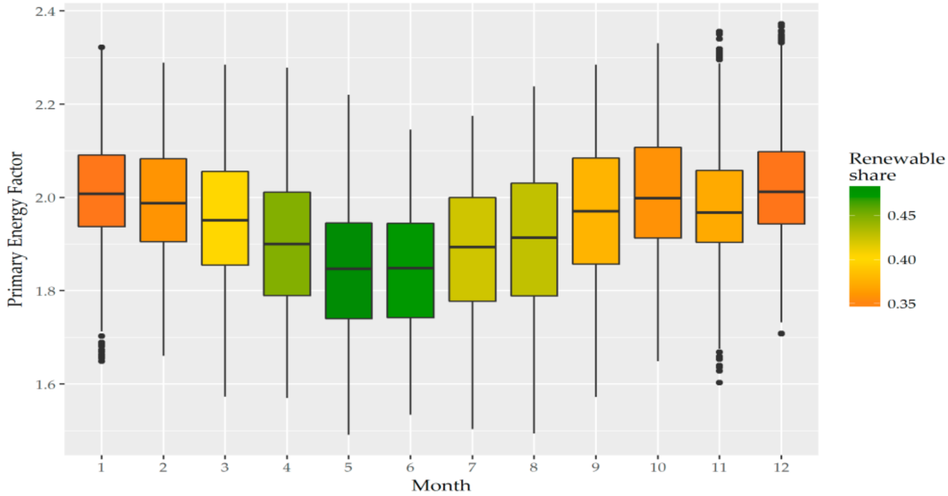


Figure 6. Monthly variation of Primary Energy Factor in Italy [9]

The average value of 1.95 was taken as a conservative approach for the next energy balance calculation.

Flexible grid usage simulation is based on the availability of wind energy for power generation. Therefore the hourly capacity (or generation) profile is required. The hourly capacity profile for onshore and offshore wind power plants was set based on data from 2019 [21]. The total installed wind power capacity in Italy in 2023 according to [22] is 12.34 GW.

District representatives primarily consider the availability and potential use of renewable energy sources, particularly solar irradiation. Other sources are not considered.

5.3 Current state

For the FD of Settimo Torinese, where buildings are quite typical, it is interesting to calculate and compare primary energy use (Figure 7) and electricity end use (Figure 8) for each building type. As can be seen, buildings, where retail and offices are located, have higher user plug loads. This is because retail and office spaces typically have a higher density of equipment and appliances. These devices contribute to higher plug loads.

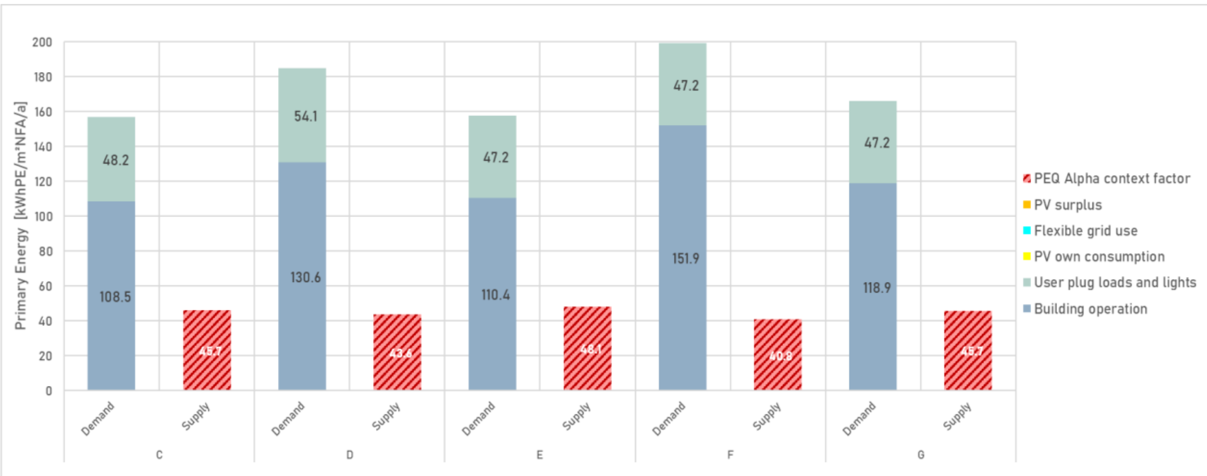


Figure 7. Primary energy for FD in Sttimo Torinese

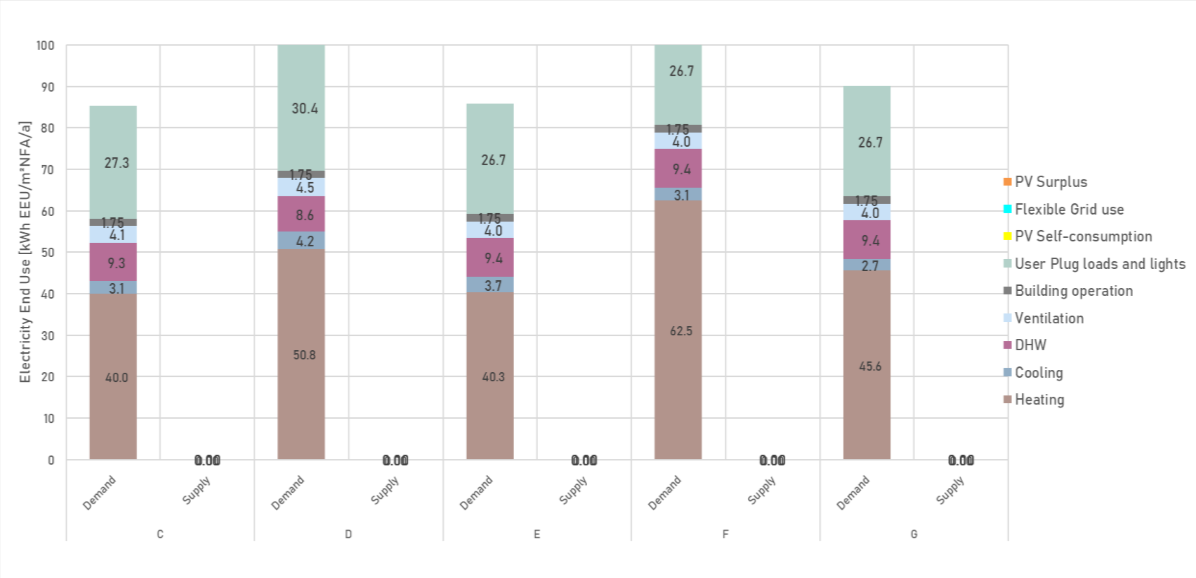


Figure 8. Electricity end use for each type of building in FD of Settimo Torinese

For the whole FD, annual electricity end uses (demand) are the following: heating – 43.06 kWh EE/m²NGF; cooling – 3.37 kWh EE/m²NGF; DHW – 9.29 kWh EE/m²NGF; Ventilation – 4.05 kWh EE/m²NGF; building operation – 1.75 kWh EE/m²NGF; User Plug loads and lights – 27.19 kWh EE/m²NGF.

5.4 Transition pathway towards a PED

There were analyzing transition pathways toward a PED by assessing energy balance after renovations, such as window replacements and wall insulation, and the introduction of PV systems. The comparison presented below evaluates the existing condition of FD against the outcomes of renovations and PV system installations, as well as the combined implementation of these measures (shown in Figure 9 and Figure 10) within the FD.

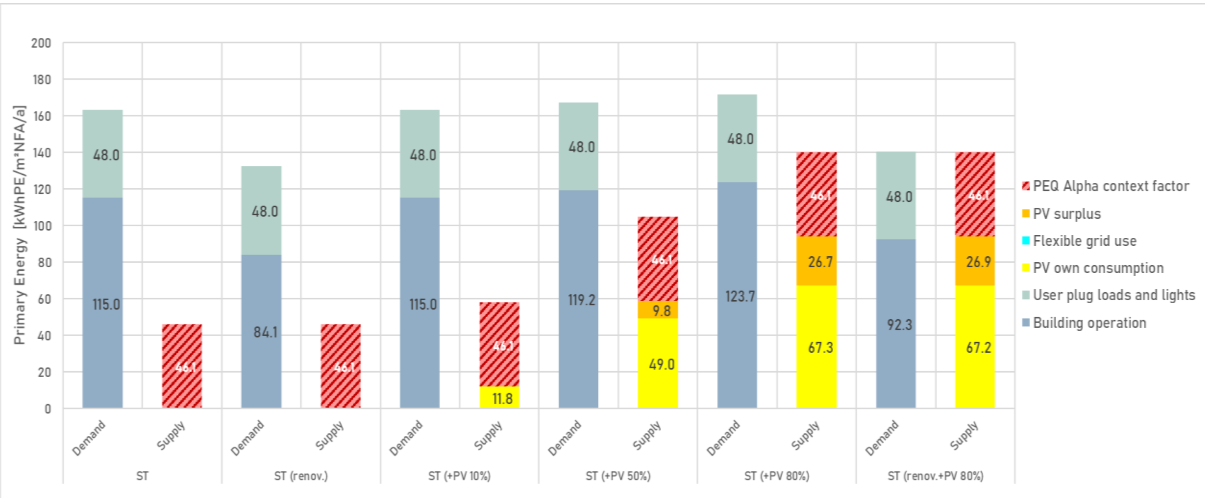


Figure 9. Primary energy in Settimo Torinese FD: current state vs potential FD development

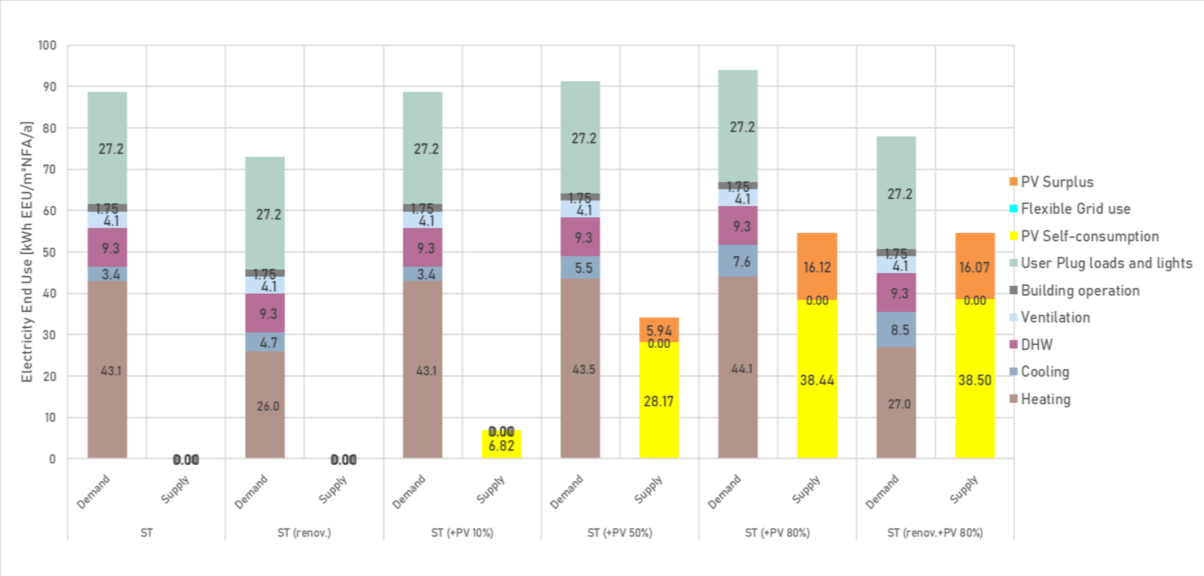


Figure 10. Electricity end use in Settimo Torinese FD: current state vs potential FD development

For the possible variants of FD modernization further considered the improvement of heat pumps (i.e. COP=4.5 for heating; COP=5.0 for cooling). In addition, the flexible grid usage was considered. Results are presented in Figure 11 and

Figure 12.

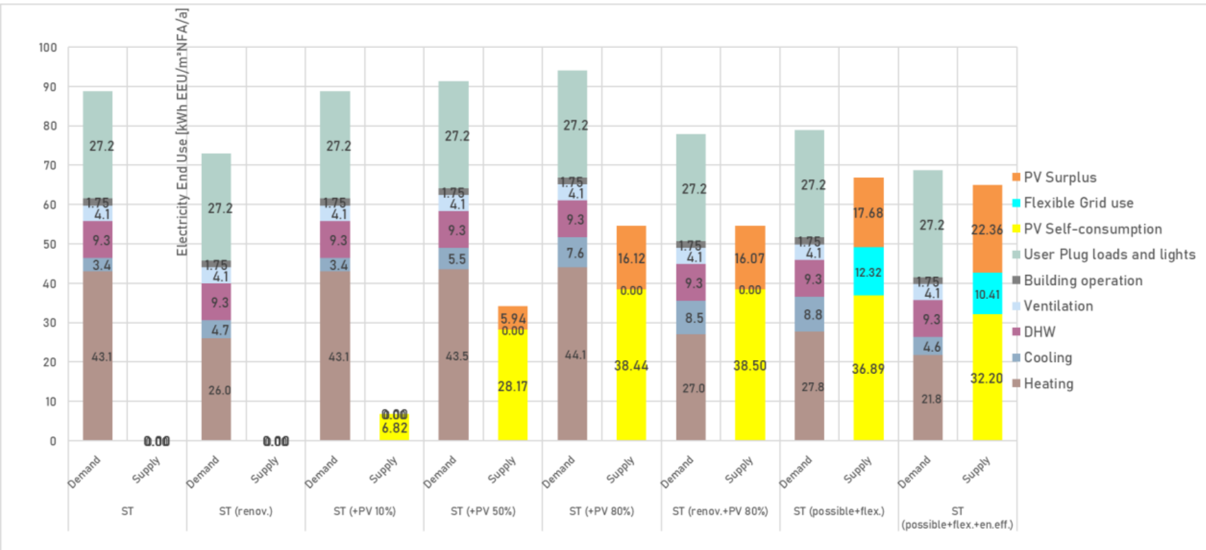


Figure 11. Electricity end use for further Settimo Torinese FD development

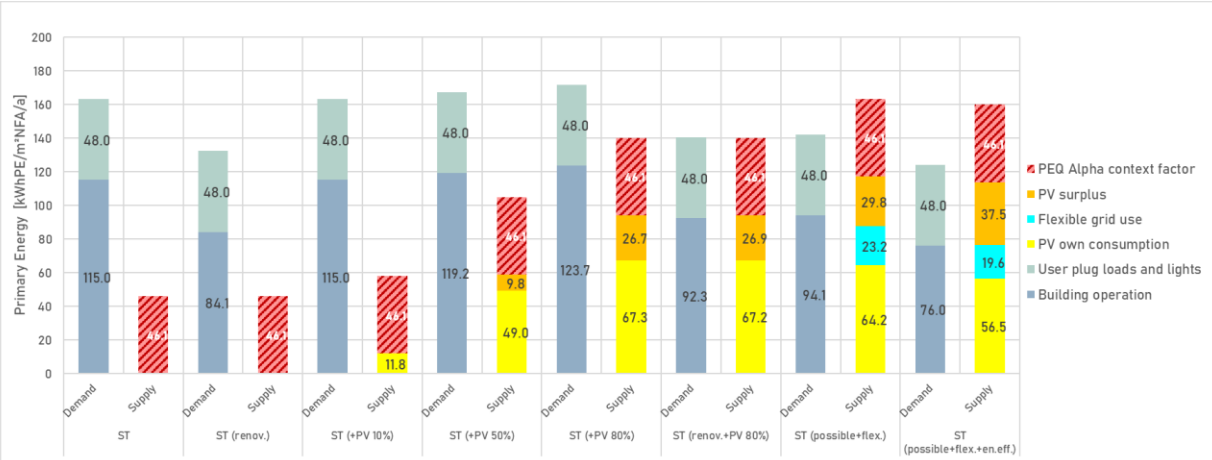


Figure 12. Primary energy for further Settimo Torinese FD development

Results of the energy balance analysis show that pathways toward PED for FD in Settimo Torinese mainly lie in the installation of PV panels, as the district is located in a region with high solar irradiation. Implementation of the flexible grid usage will allow for efficient integration of renewable energy sources. In this case, the general demand could be decreased with the same level of the energy supply.

6 Assessment of Focus District Großschönau

6.1 Initial Goals and Setting

Focus district is located in the northern part of Austria and consists mainly of private residential houses, see Figure 13.

Figure 13. Großschönau FD

More parameters of the FD are presented in Table 3.

Table 3 – Parameters of Großschönau

Parameter	Value	Unit
District Area	705	ha
Gross Floor Area	40161	m^2 GFA
District Plot Area	391000	m^2
Share of plot area built	3.245	%
Net to Gross Floor Area Ratio	70	%
Building storeys (avg)	1.5	
Residential usage	82.2	%
Commercial usage	11.7	%
Primary School (incl. Kindergarden)	5	%
Others (Retail)	1.1	%

In general goals toward PED for Großschönau cover insulation walls and roofs, windows replacement (from 1-glass to 2-glass), installing PVs, and improving the heating system (decreasing its energy usage). District representatives provided planned and possible scenarios of the FD development, which were set as follows (Table 4).

Table 4 – Großschönau FD development scenarios

No.	Description	Planned	Possible
1	Windows modernization	100% of building types 1-4 replaced from 1-gl. to 2-gl. 75% of building types 5-6 from 1-gl. to 2-gl.	100% of building types 1-6 replaced from 1-gl. to 2-gl.
2	Walls insulation	25% of building types 1-4: with 12 cm EPS* 15% of building types 5-6: with 8 cm EPS*	100% of building types 1-6: with 16 cm EPS*
3	Roofs insulation	50% of building types 1-4: with 15 cm EPS* 25% of building types 5-6: with 12 cm EPS*	100% of building types 1-6: with 20 cm EPS*
4	Ground/basement insulation	Not possible	
5	PV installation	25% of all roofs	60% of all roofs
6	Renovation of heating system	15% of building types 1-4: with 30% reduction 10% of building types 5-6: with 25% reduction	50% of building types 1-6: with 30/25% reduction 15% of building types 7-8: with 15% reduction

* EPS – expanded polystyrene material (thermal conductivity about 0.035 W/(m·K)

6.2 Input data and assumptions

All buildings in FD were divided into 9 categories based on typologies provided in [18]. Based on their typical parameters the total areas of walls, windows, roofs, and floors for FD were calculated. Physical parameters (U-values) were taken based on typical values provided in [18]. It should be noted, that such buildings' classification and their parameters generalization make additional uncertainty for initial data. However, the used approach for assumptions could be considered conservative, i.e. leads to increasing energy usage.

Yearly irradiation for Großschönau was calculated with the usage program tool BIMSolar [10] (Figure 14).

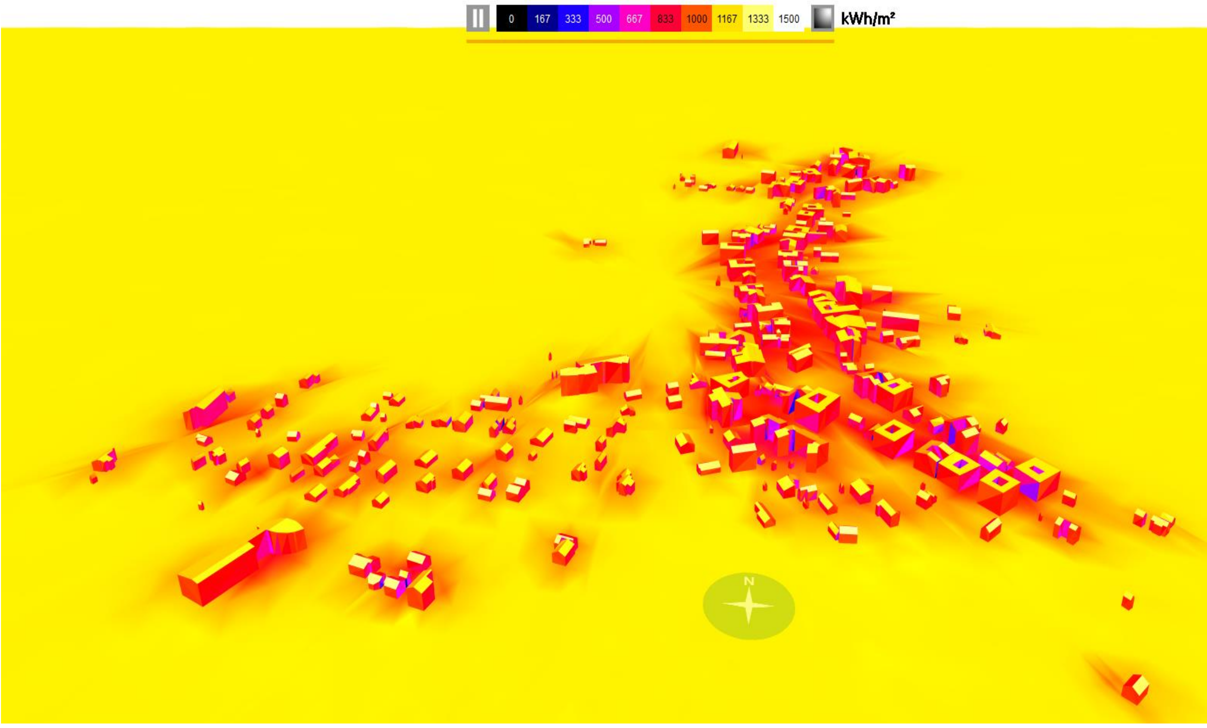


Figure 14. Yearly irradiation for Großschönau FD

Totally in FD installed 550.84 kWp PV panels (according to the provided data from the district representatives), which covers approximately 20% of roofs. This profile was used for current state calculation and proportionally increased for other variants.

The next U-values were set for the calculations of FD's current state and development scenarios (Table 5).

Table 5 – U-values for Großschönau FD simulation

No.	Description	Current state	Planned	Possible
1	Windows	1.843 W/m²K	1.684 W/m²K	1.516 W/m²K
2	Walls	0.925 W/m²K	0.786 W/m²K	0.243 W/m²K
3	Roofs	0.686 W/m²K	0.465 W/m²K	0.187 W/m²K
4	Ground/basement		0.752 W/m²K	

As each type of building has its parameters, the U-values were calculated as average-weighted values based on the number of buildings in the district. The thermal conductivity of the materials was taken as the average provided in the scientific literature. U-values were calculated as described in [20].

Goals, related to the renovation of the heating systems are simulated by changing PEF for the whole district up to 0.33, which is typical for very efficient energy generation equipment.

6.2.1 Primary Energy conversion and availability of offsite RES

Energy conversion factors for Großschönau FD energy balance analysis were taken according to [19] (Table 6).

Table 6 – Energy conversion factors for Austria [19]

	Energy source	f_{PE}	$f_{PE,n.ern.}$	$f_{PE,ern.}$
1	Coal	1.46	1.46	0.00
2	Heating oil	1.2	1.2	0.00
3	Natural gas	1.1	1.1	0.00
4	Biomass (solid biofuels)	1.13	0.10	1.03
5	Liquid biofuels (isolated operation) (1)	1.5	0.5	1.00
6	Gaseous biofuels (isolated operation) (1,2)	1.4	0.4	1.00
7	Electricity (supply mix)	1.63	1.02	0.61
8	District heating from heating plant (renewable) (3)	1.6	0.28	1.32
9	District heating from heating plant (non-renewable) (3)	1.51	1.37	0.14
10	District heating from highly efficient cogeneration (3,4)	0.88	0.00	0.88
11	Waste heat (3)	1.00	1.00	0.00

(1) ... Isolated operation here exclusively refers to systems in which the production of fuel also takes place in the building or near the building.
(2) ... Values for green gas and synthesis gas can be found in the explanatory notes.
(3) ... In the case of an individual proof, the boundary conditions can be found in the explanatory notes.
(4) ... All those that comply with Directive 2004/8/EC are considered highly efficient combined heat and power (CHP).

The average PEF for Austria, according to the source [11] is 1.33, which was used for the calculations as others were not provided by district representatives.

In the district, the interest in the usage of renewable energy sources mostly lies in solar irradiation usage. The usage of ground heat pumps and groundwater heat pumps is not considered by district representatives. It could be due to a few reasons such as high initial costs, geological conditions, etc.

6.3 Current state

Based on energy balance simulation for the whole FD annual electricity end use (demand) follows: heating – 44.93 kWh EE/m²NGF/a; cooling – 1.84 kWh EE/m²NGF; DHW – 8.08 kWh EE/m²NGF; Ventilation – 4.45 kWh EE/m²NGF/a; building operation – 1.71 kWh EE/m²NGF; User Plug loads and lights – 26.27 kWh EE/m²NGF. Supply PV Self-consumption 14.21 kWh EE/m²NGF, PV surplus 1.23 kWh EE/m²NGF. The gap between demand and supply is 71.84 kWh EE/m²NGF.

The total annual primary energy demand for the whole FD is 148.33 kWh PE/m²NFA (105.5 kWh PE/m²NFA for building operation and 42.8 kWh PE/m²NFA for user plug loads and lights); supply is 24.1 kWh PE/m²NFA (22.2 kWh PE/m²NFA is PV own consumption and 1.9 kWh PE/m²NFA PV surplus). The gap between demand and supply is 124.23 kWh PE/m²NFA.

6.4 Transition pathway towards a PED

Traditionally pathways toward the PED are lying in decreasing energy demand for heating, increasing PV generation, flexible grid usage, and using more efficient energy equipment. All these variants are considered further.

The goals fixed by district representatives are in additional building insulation and installing PV leads to the next electricity end use (Figure 15) and primary energy (Figure 16) for the Großschönau FD.

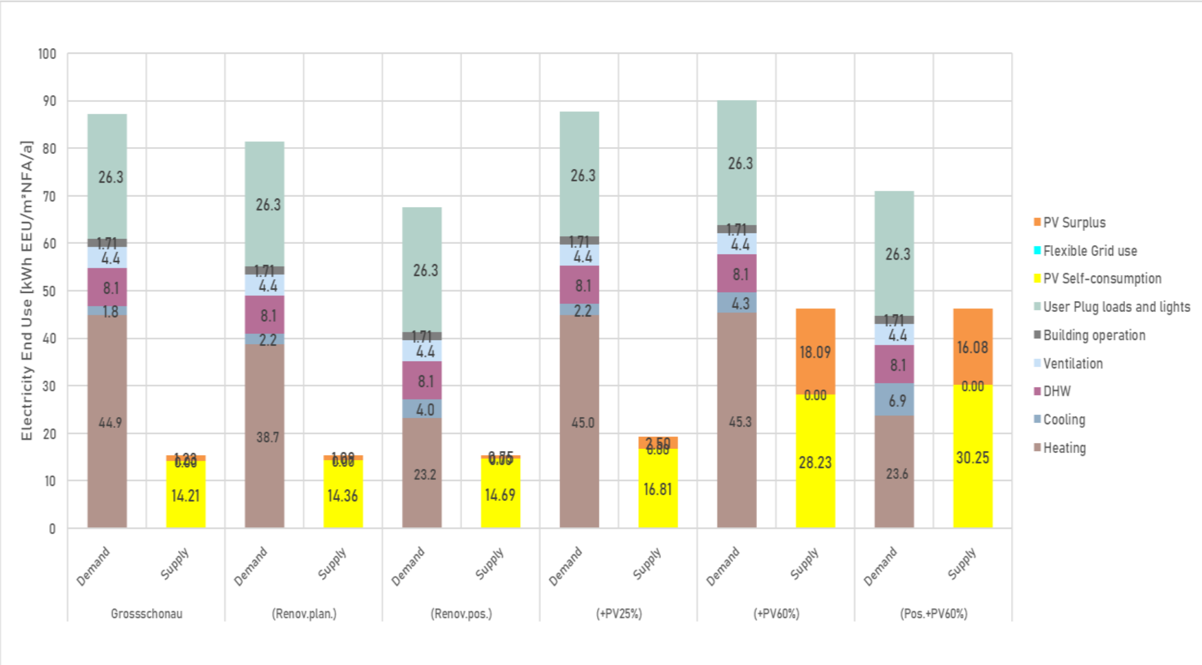


Figure 15. Electricity end use for Großschönau FD: current state vs planned and possible goals

Figure 16. Primary energy for Großschönau FD: current state vs planned and possible goals

As for other FDs, the variants of flexible grid usage and installation of more effective energy equipment (COP=4.5 for heating; COP=5.0 for cooling) were considered (Figure 17,

Figure **18**). It allowed to reduce the difference between demand and supply of electricity end-use. In the first case, this value is 13.27 kWh EE/m²NGF, and in the second case, it is 6.17 kWh EE/m²NGF. When assessing primary energy, the difference between demand and supply was 80.4 kWh EE/m²NGF and 45.7 kWh EE/m²NGF, respectively.

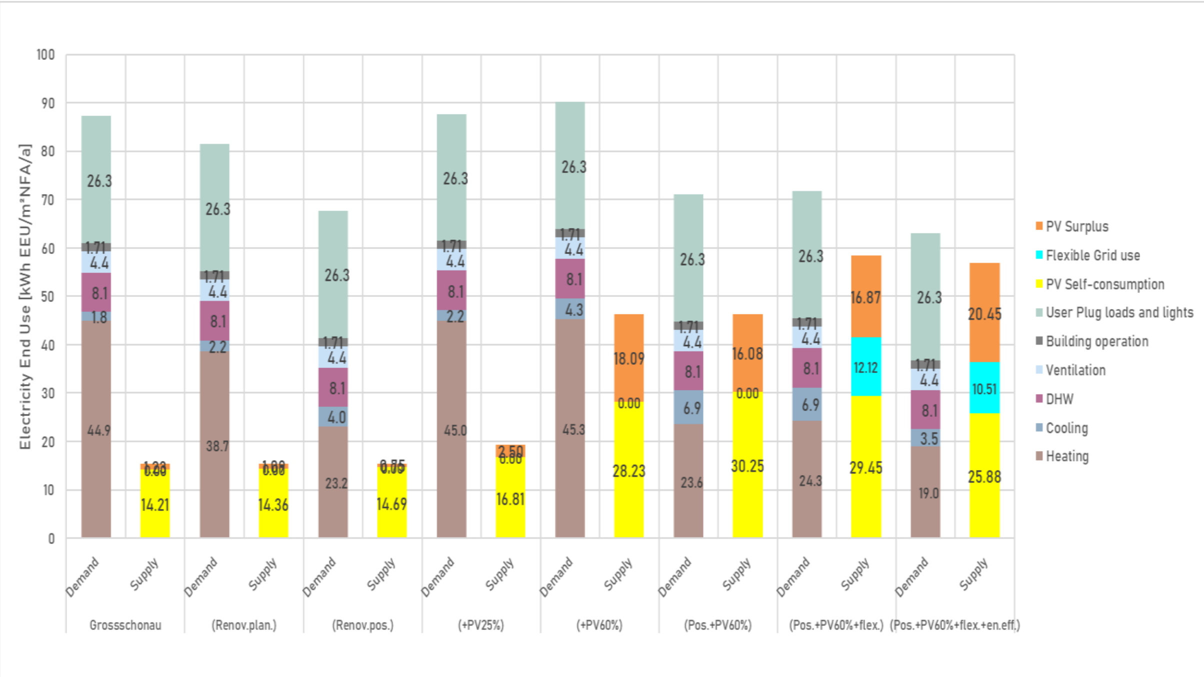


Figure 17. Electricity end use for Großschönau FD

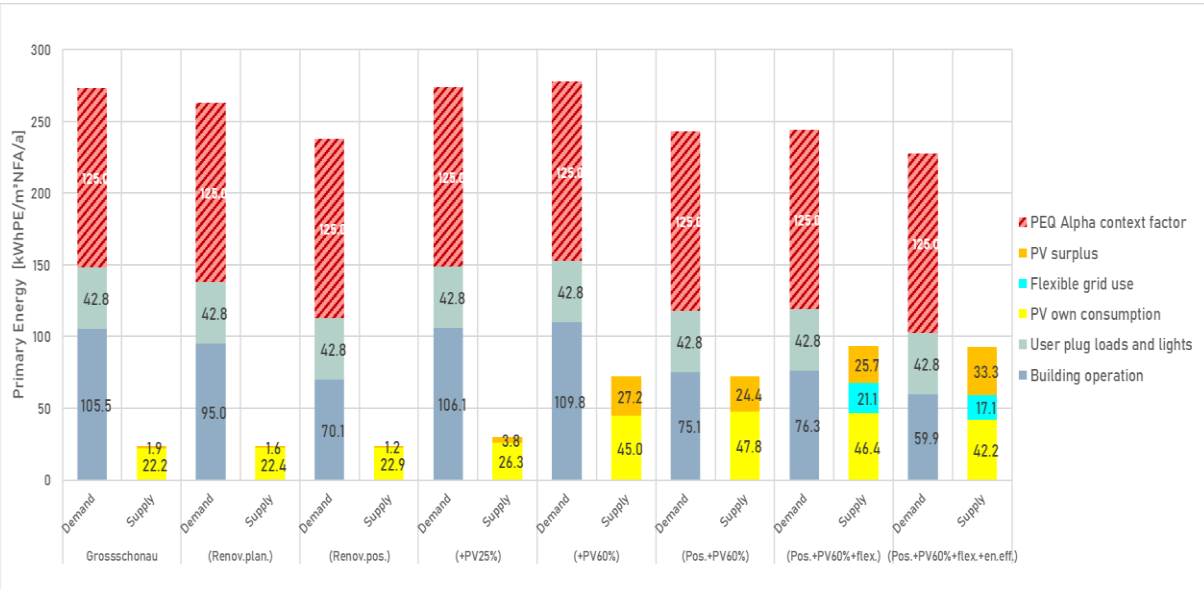


Figure 18. Primary energy for Großschönau FD

Based on the results of the energy balance calculations and considering the above-mentioned assumptions, FD cannot currently be considered a PED. Implementing the planned and possible building renovations in FD will bring the district closer to PED status more effectively than solely installing PV panels. A comprehensive approach of installing PV panels along with possible renovations will reduce the difference between demand and supply to 6.17 kWh EE/m²NGF (electricity end use) and 45.7 kWh EE/m²NGF (primary energy).

Another potential development option for the district is the implementation of flexible grid usage and energy-efficient equipment. Therefore, implementing the most widely adopted PED development strategies will bring Großschönau FD as close as possible to becoming a positive energy district.

7 Assessment of Focus District in Amsterdam

As was stated in Report on D3.2 “Gap analysis of Energy Balance Calculation Data” [16] due to the unavailability of all required data for the whole of Amsterdam city only a small part of it was chosen as FD. The next assumption, calculations, and analysis were done for this FD.

7.1 Initial Goals and Setting

Two goals were identified for the Amsterdam FD: planned and possible. Planned goals mean fixed actions, that could be implemented in the nearest future. Possible goals mean actions that technically could be implemented but not planned now or could not be realized in the nearest future due to some limitations (e.g. architecture and monument protection).

The FD is presented in Figure 19 and consists of five parts: Bijenkorf (1), Euronext (2), Canal Houses (3), Beurs van Berlage (4), and Beursplein (5). Parts 1-4 are built territory and part 5 is a square, which will not be considered at PED analysis.

The Focus District in Amsterdam represents a small part of the city's historical center (Table 7). Part 3 of the FD (Canal Houses) could be considered as a typical living area for Amsterdam. Other parts of FD represent public areas. The further results and pathways toward a PED will be presented for each type of building (it will allow to interpolate them for typical areas in Amsterdam) and for the whole district.

Table 7 – Parameters of FD in Amsterdam

Parameter	Value	Unit
District Area	3	ha
Gross Floor Area	98 941	m^2 GFA
District Plot Area	30035	m^2
Floor Area Ratio (FAR)	3.29	
Share of plot area built	79	%
Net to Gross Floor Area Ratio	80	%
Building storeys (avg)	4.2	
Residential usage	19.1	%
Commercial usage	29	%
Others (Retail)	51.9	%

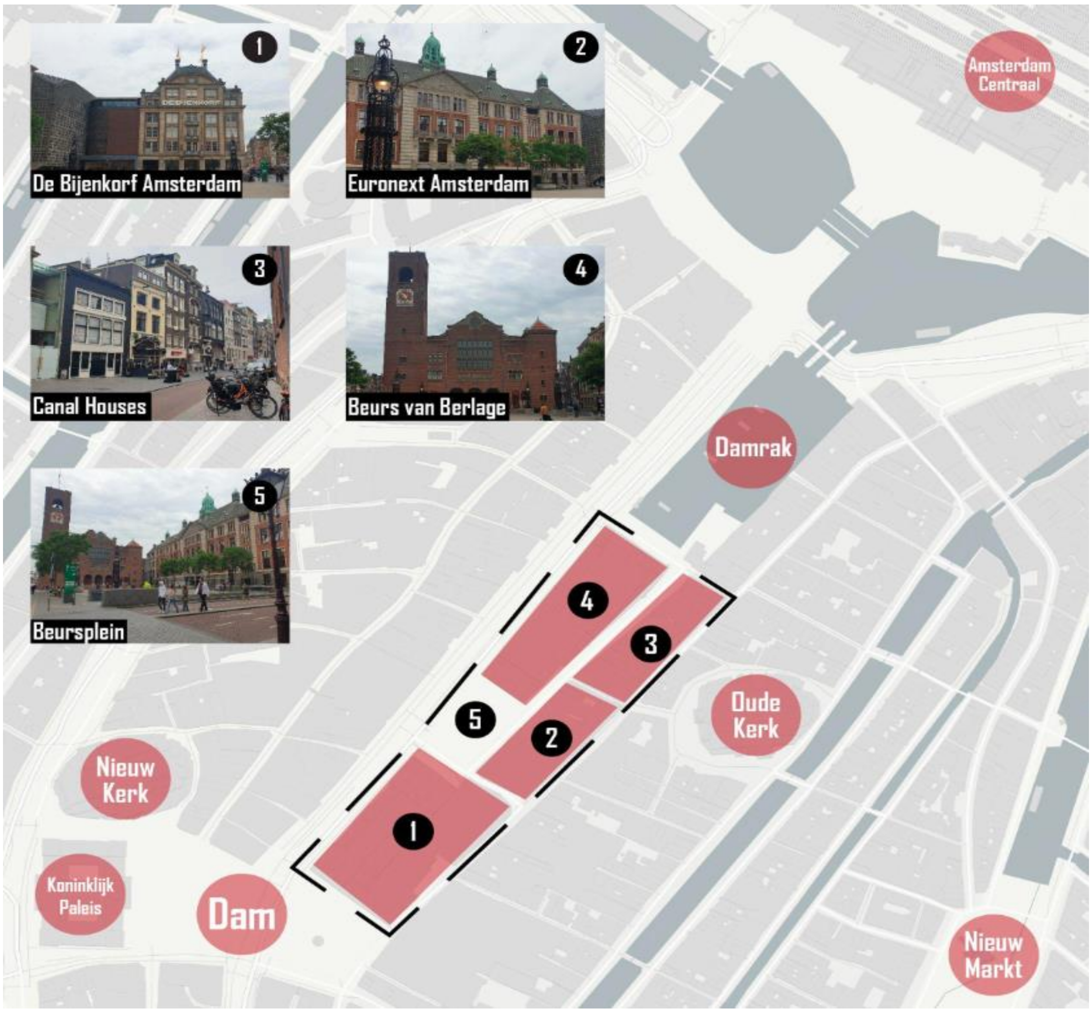


Figure 19. Schematic representation of the FD in Amsterdam

7.2 Input data and assumptions

In the central part of Amsterdam, many buildings have a traditional Dutch style with tall, narrow facades, which limits window space. However, windows usually occupy a significant portion of the façade to maximize natural light and provide visibility to the street. As it is not possible to evaluate the exact percentage of the windows in the considered buildings the value of 40% of windows in the total buildings' facades area was assumed.

Planned and possible goals for each part of the FD are presented in Table 8 – Table 11 on the base of conversations with district representatives. However, it should be noted, that all changes in the built area of Amsterdam (especially in the historical part of the city) are regulated by heritage protection laws. For example, installing PVs is possible only on the invisible from the street parts of roofs. This point in some way regulates planned and possible goals for FD toward PED.

Table 8 – Development goals for the FD in Amsterdam (Bijenkorf)

No.	Description	Current state	Planned	Possible
1	Windows modernization	U-value 5.8 W/m²K	U-value 1.1 W/m²K	U-value 0.6 W/m²K (triple glazing)
2	Walls insulation	U-value 1.25 W/m²K	U-value 0.588 W/m²K	U-value 0.4 W/m²K
3	Roofs insulation	U-value 2.857 W/m²K	U-value 0.4 W/m²K	U-value 0.25 W/m²K
4	Ground/basement insulation	U-value 6.67 W/m²K	U-value 0.588 W/m²K	U-value 0.4 W/m²K
5	PV installation	45 kW (137 panels)	100 kW	220 kW (50% of roof area)
6	Active cooling system	6 kWh/m²	7.6 kWh/m²	—
7	Implement ground heat pumps	—		
8	Implement air-air heat pumps	—	70% of building heating through (Hybrid) heat pump	100% of building heating through (Hybrid) heat pump
9	Implement groundwater heat pumps	—		
10	Implement air conditioning	—	100%	—

Table 9 – Development goals for the FD in Amsterdam (Euronext)

No.	Description	Current state	Planned	Possible
1	Windows modernization	U-value 5.8 W/m²K	U-value 1.1 W/m²K	U-value 0.6 W/m²K (triple glazing)
2	Walls insulation	U-value 1.25 W/m²K	U-value 0.588 W/m²K	U-value 0.4 W/m²K
3	Roofs insulation	U-value 2.857 W/m²K	U-value 0.4 W/m²K	U-value 0.25 W/m²K
4	Ground/basement insulation	U-value 6.67 W/m²K	U-value 0.588 W/m²K	U-value 0.4 W/m²K
5	PV installation	—	90 kW	180 kW (50% of roof area)
6	Active cooling system	6 kWh/m²	7.6 kWh/m²	—
7	Implement ground heat pumps	—		
8	Implement air-air heat pumps	—	70% of building heating through (Hybrid) heat pump	100% of building heating through (Hybrid) heat pump
9	Implement groundwater heat pumps	—		
10	Implement air conditioning	—	100%	—

Table 10 – Development goals for the FD in Amsterdam (Canal Houses)

No.	Description	Current state	Planned	Possible
1	Windows modernization	U-value 5.2 W/m²K	U-value 1.1 W/m²K	U-value 0.7 W/m²K (vacuum glass)
2	Walls insulation	U-value 1.25 W/m²K	U-value 0.588 W/m²K	U-value 0.5 W/m²K
3	Roofs insulation	U-value 4.55 W/m²K	U-value 0.4 W/m²K	U-value 0.25 W/m²K
4	Ground/basement insulation	U-value 6.67 W/m²K	U-value 0.588 W/m²K	U-value 0.286 W/m²K
5	PV installation	56 kW (176 panels)	80 kW	100 kW (40% of roof area)
6	Active cooling system	—	individual split air conditioning	cooling via air-source or ground-source HP

7	Implement ground heat pumps	—	70% of building heating through (Hybrid) heat pump	100% of building heating through (Hybrid) heat pump
8	Implement air-air heat pumps	—		
9	Implement air conditioning	—	100%	—

Table 11 – Development goals for the FD in Amsterdam (Beurs van Berlage)

No.	Description	Current state	Planned	Possible
1	Windows modernization	U-value 5.8 W/m²K	U-value 1.1 W/m²K	U-value 0.6 W/m²K (triple glazing)
2	Walls insulation	U-value 1.25 W/m²K	U-value 0.588 W/m²K	U-value 0.4 W/m²K
3	Roofs insulation	U-value 2.857 W/m²K	U-value 0.4 W/m²K	U-value 0.25 W/m²K
4	Ground/basement insulation	U-value 6.67 W/m²K	U-value 0.588 W/m²K	U-value 0.4 W/m²K
5	PV installation	—	150 kW	310 kW (60% of roof area)
6	Active cooling system	6 kWh/m²	7.6 kWh/m²	—
7	Implement ground heat pumps	—	70% of building heating through (Hybrid) heat pump	100% of building heating through (Hybrid) heat pump
8	Implement air-air heat pumps	—		
9	Implement groundwater heat pumps	—		
10	Implement air conditioning	—	100%	—

For those buildings where PVs are already installed, the profile of the hourly PV generation was calculated based on the yearly irradiation (see example in Figure 20 for Canal Houses) with the BIMsolar program tool [10]. For calculations of hourly PV generation for buildings currently without PVs the planned capacity of PVs was modeled and a possible variant was calculated by scaling of existing profile.

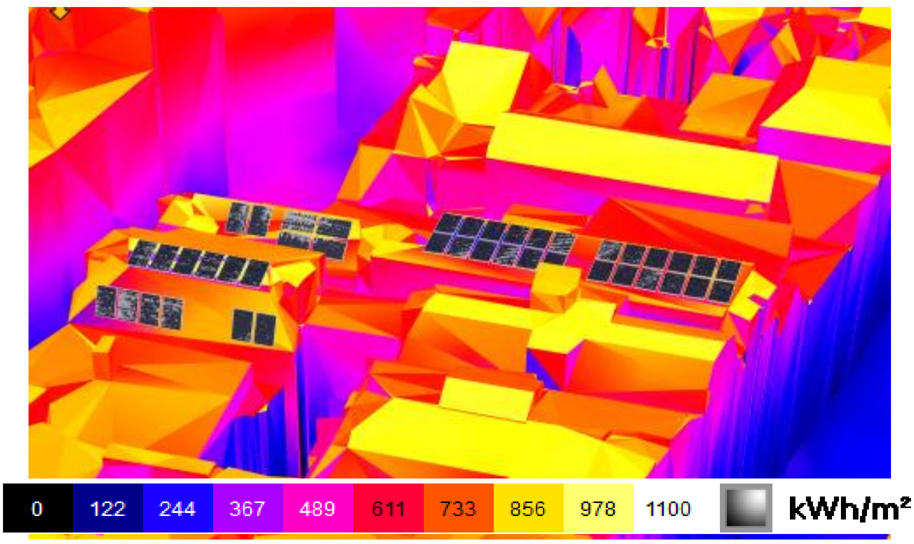


Figure 20. Annual solar irradiation for Canal Houses

7.2.1 Primary Energy Conversion and availability of offsite RES

The primary energy conversion factor is one of the important values in energy balance calculations. However, its definition is a complex problem with a wide spectrum of approaches. For, example, the changes at the winter season for the Netherlands is shown on Figure 21. Based on the literature research the primary energy conversion factors for the Netherlands were chosen as 1.39 (general yearly average value), 1.93 (gas), 2.58 (coal) accordingly to [11] and the general value could be reached 1.2 [12] or 1.02 [11] in some cases.

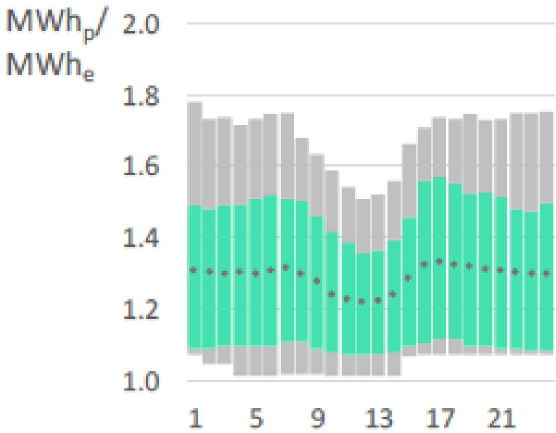


Figure 21. Distribution of hourly conversion factor in winter across the 24h daily cycle (black dots – average value) [12]

A possible variant of FD development was expanded not only by considering values provided in Table 8 – Table 11 but also by improving other parameters: COP for heat pump 4.5 for heating, 5.0 for cooling, 2.5 for warm water; and switched on flexible network usage.

The Nederlands has a high wind potential. According to [24] the Netherlands has 10749 MW of installed wind power capacity till the end of 2023 and this value is growing. Conversion factors are taken according to [21].

7.3 Current state

Energy balance calculations for the FD were made for each building (see Figure 19) separately. Results are presented in Figure 22, and Figure 23.

As can be seen in the current state, the primary energy demand for each building in FD consists, in general, of building operation and users plug loads.

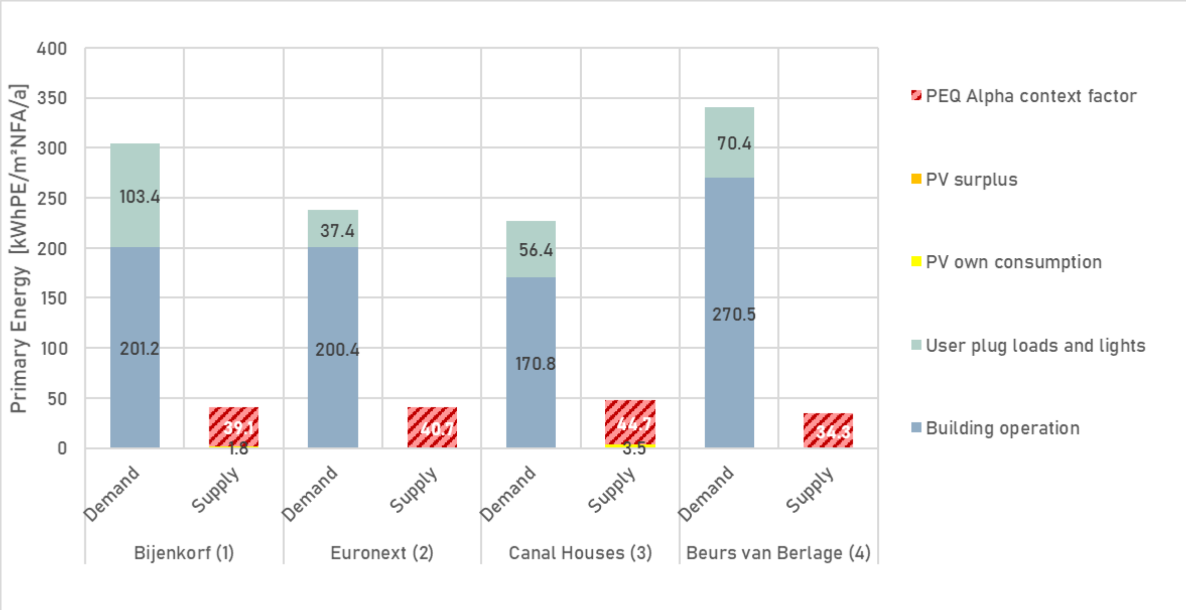


Figure 22. Current primary energy in Amsterdam FD

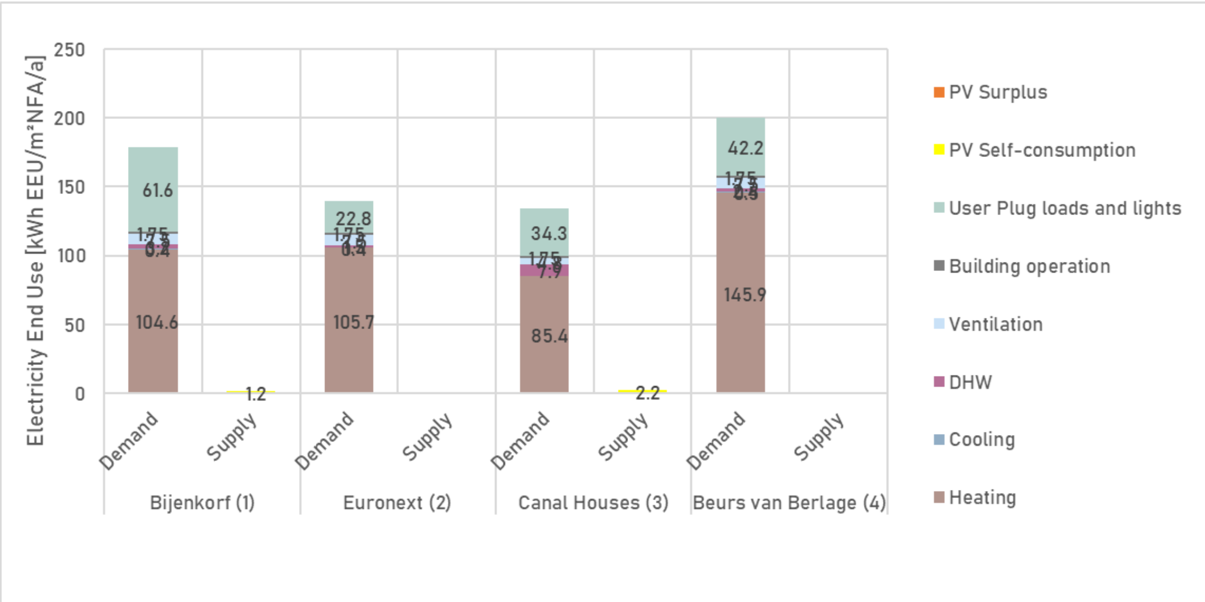


Figure 23. Current electricity end use for Amsterdam FD

For whole annual FD electricity end use (demand) follows: heating – 107.86 kWh EE/m²NGF/a; cooling – 0.37 kWh EE/m²NGF; DHW – 3.91 kWh EE/m²NGF; Ventilation – 6.83 kWh EE/m²NGF; building operation – 1.75 kWh EE/m²NGF; User Plug loads and lights – 43.66 kWh EE/m²NGF. Supply PV Self-consumption 1.00 kWh EE/m²NGF per year.

7.4 Transition pathway towards a PED

When developing possible steps for the PED implementation, special consideration is given to the impact of renovations (windows replacement, walls insulation, etc.) and the installation of PV systems. Below is a comparison of the current state of FD vs. the carried-out renovation (Figure 24, Figure 25) and the installation of PV systems (Figure 26, Figure 27), as well as the simultaneous implementation of these measures (Figure 28, Figure 29) for each building in FD.

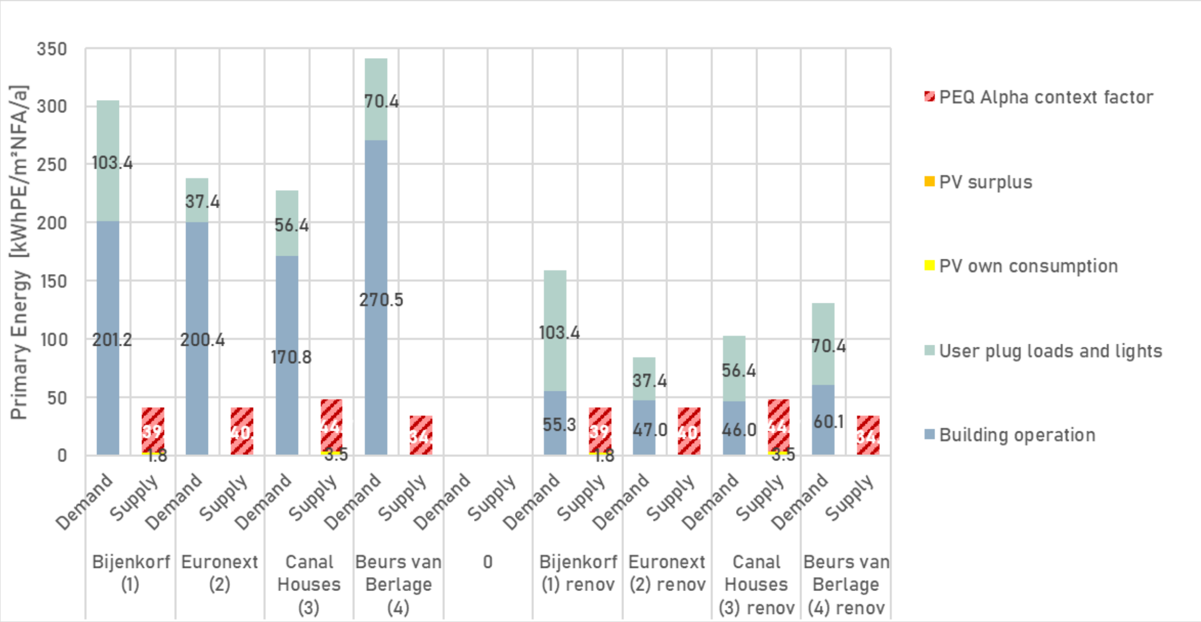


Figure 24. Primary energy: current state vs planned renovation

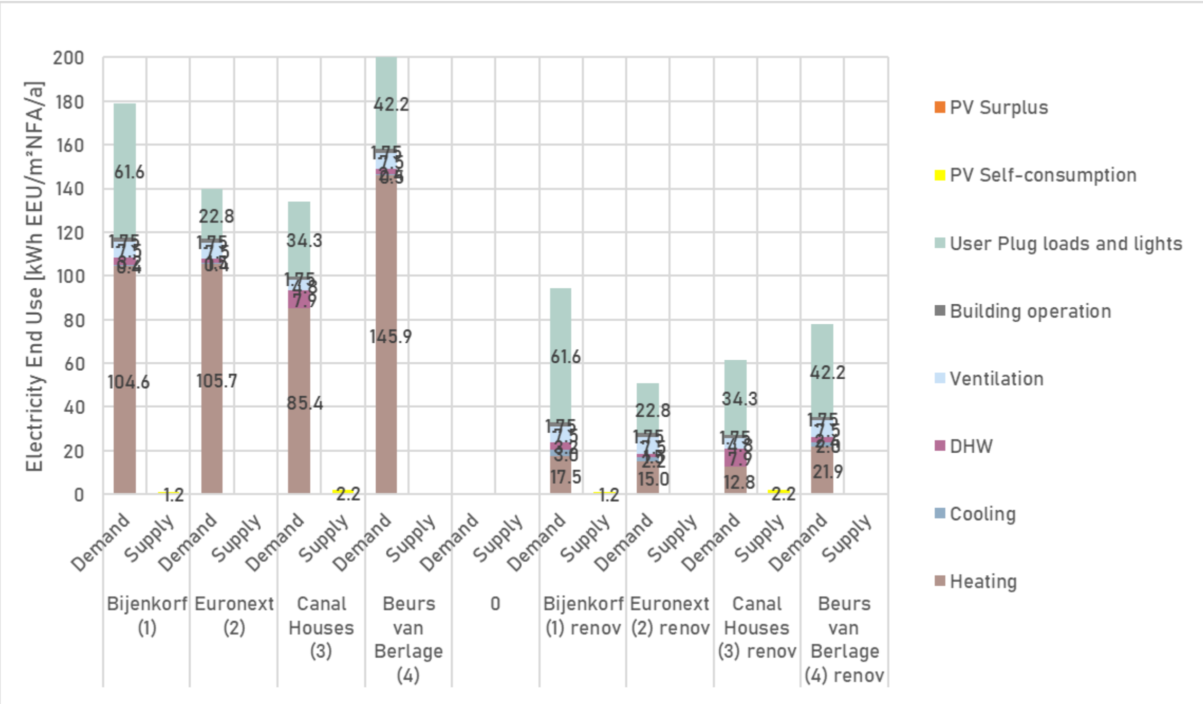


Figure 25. Electricity end use: current state vs planned renovation

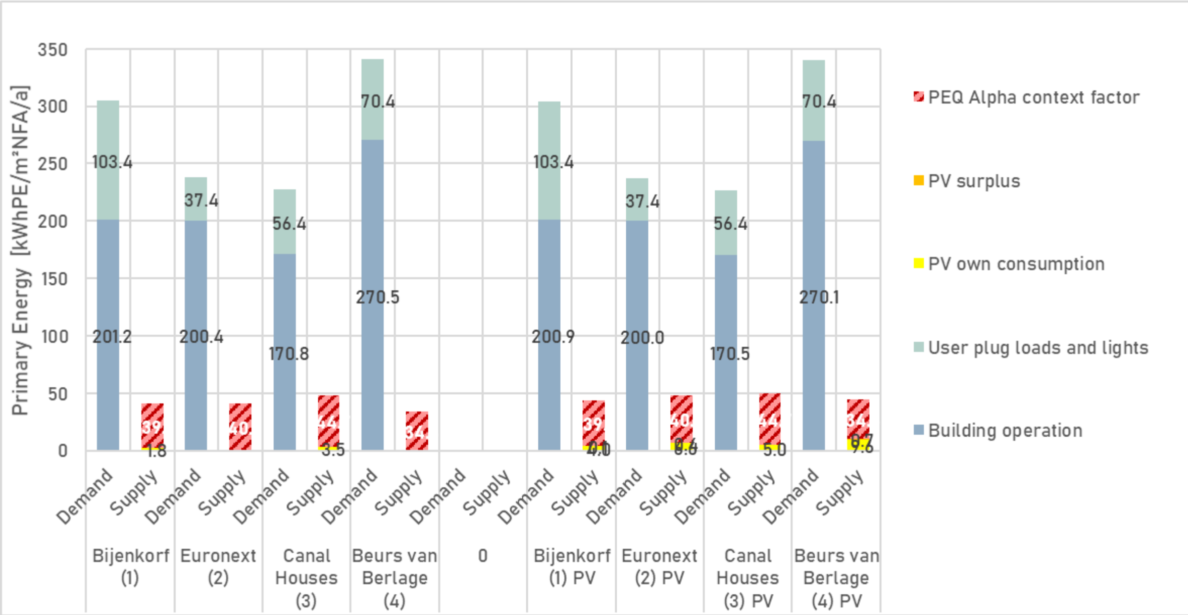


Figure 26. Primary energy: current state vs PV installation

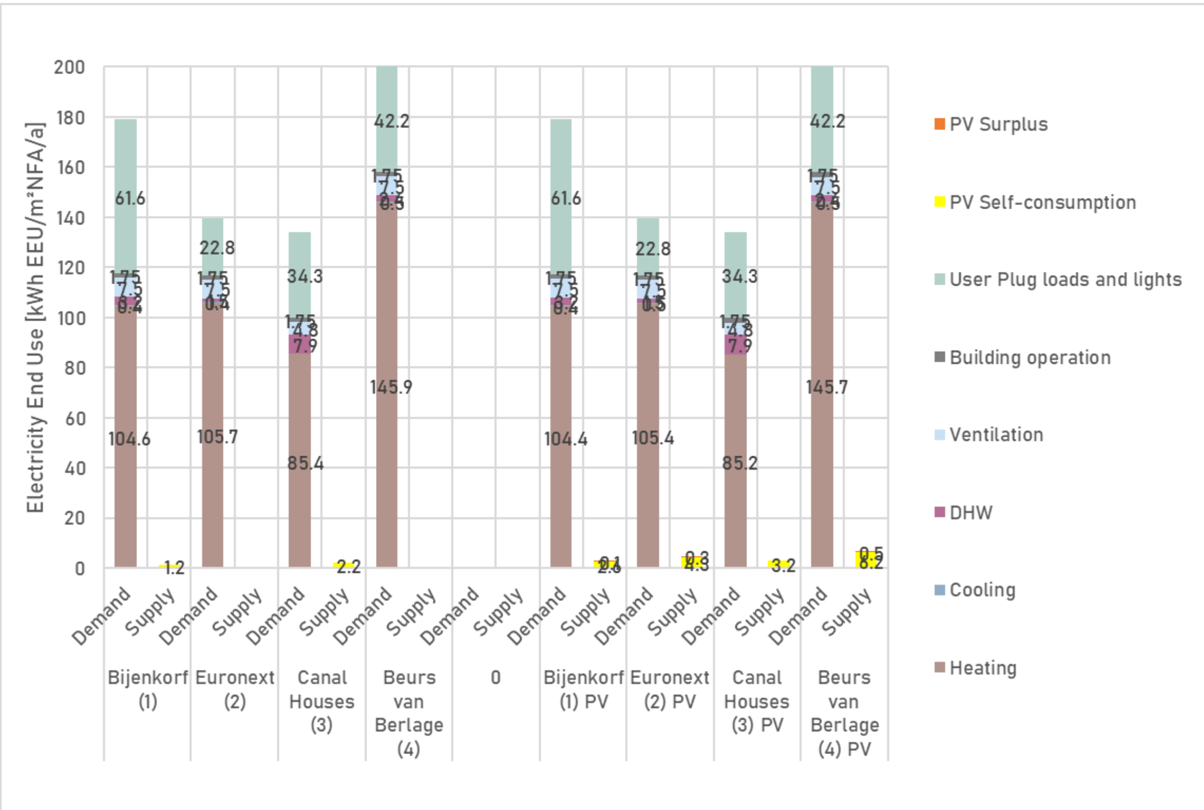


Figure 27. Electricity end use: current state vs PV installation

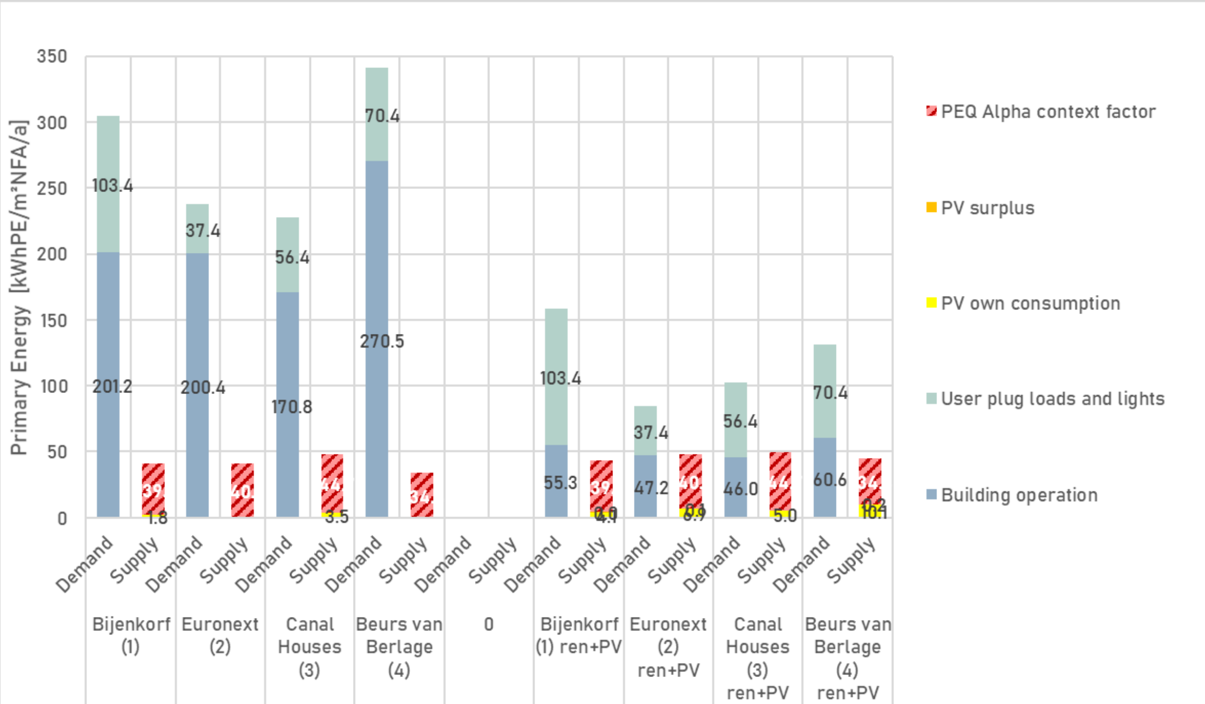


Figure 28. Primary energy: current state vs renovation and PV installation

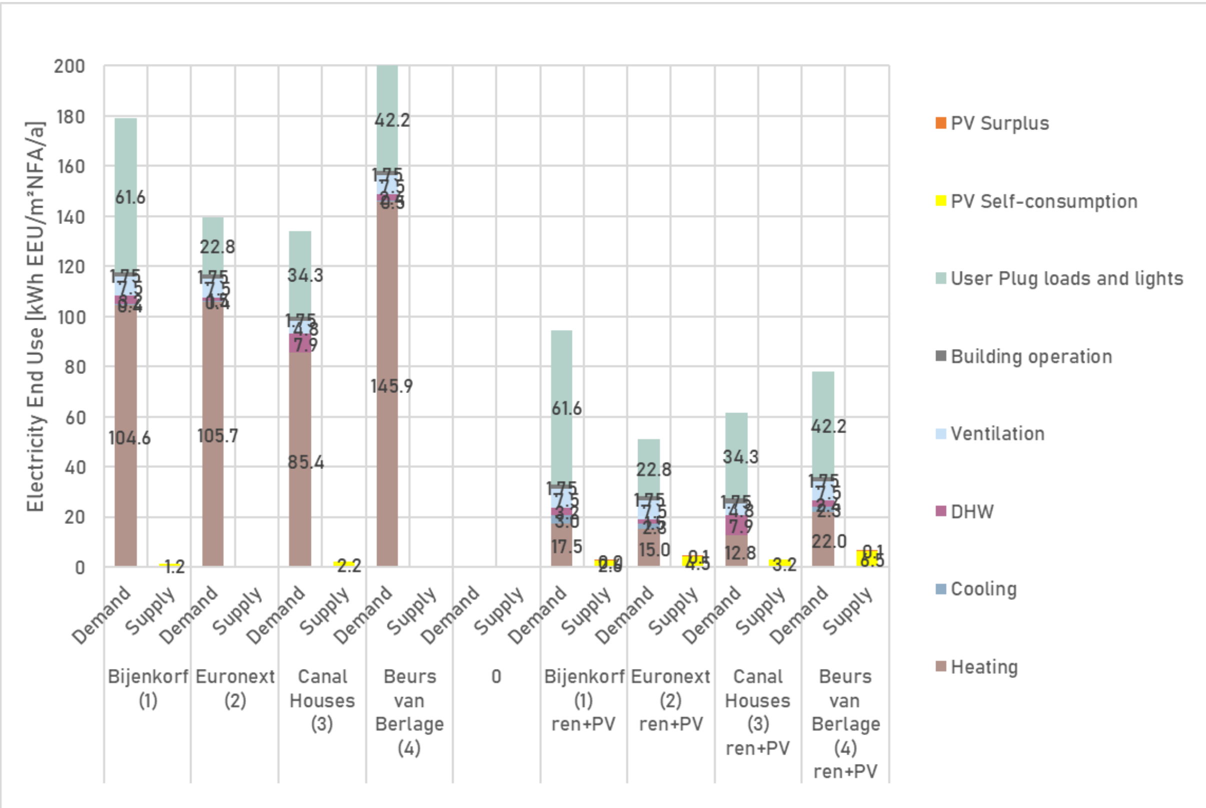


Figure 29. Electricity end use: current state vs renovation and PV installation

For the possible variants of FD modernization further considered improvement of heat pumps (i.e. COP=4,5 for heating; COP=5,0 for cooling). In addition, the flexible grid usage was considered. Other possible improvements according to the Table 8 - Table 11. Results are presented in Figure 30 and Figure 31.

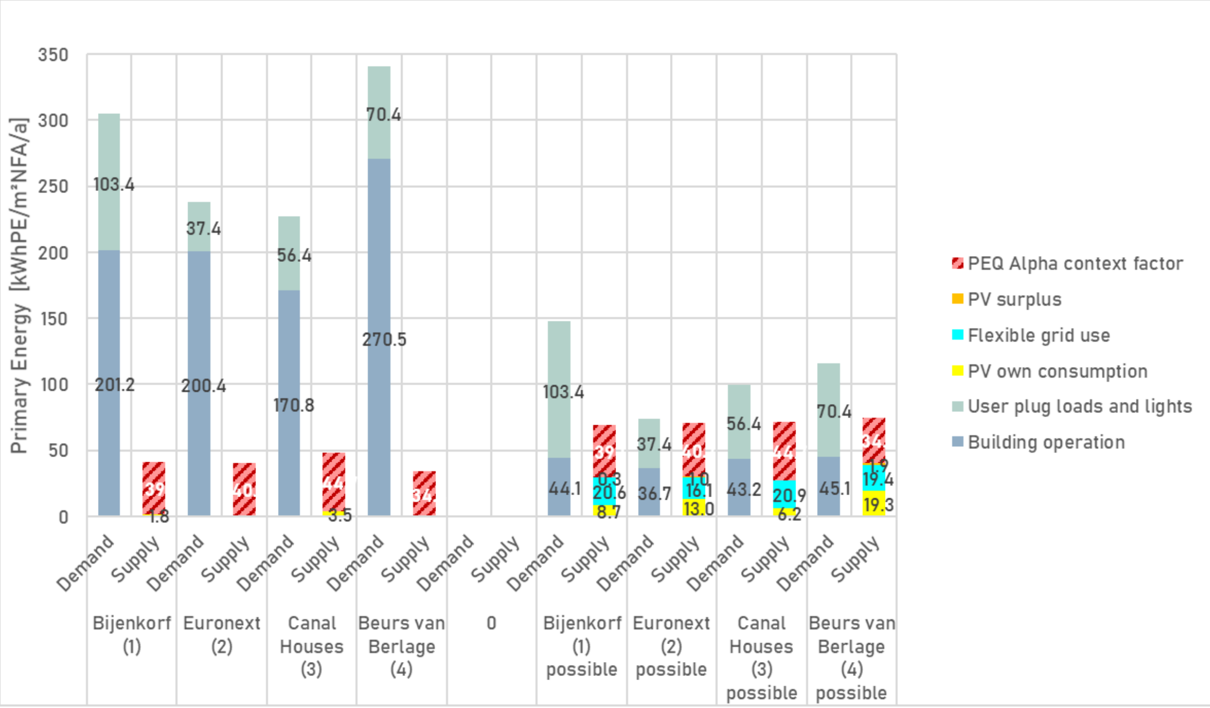


Figure 30. Primary energy: current state vs possible renovation and maximum PV installation

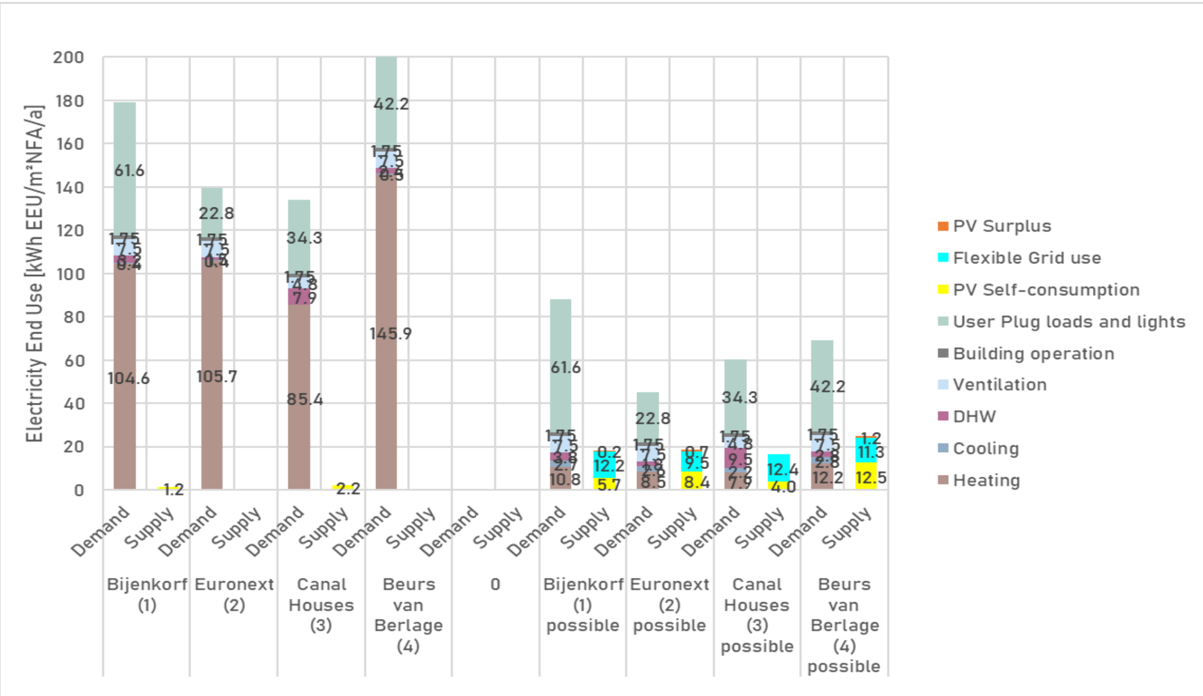


Figure 31. Electricity end use: current state vs possible renovation and maximum PV installation

simply positive

If the district is considered as a whole the planned and possible variants of its development are presented on Figure 32 and Figure 33.

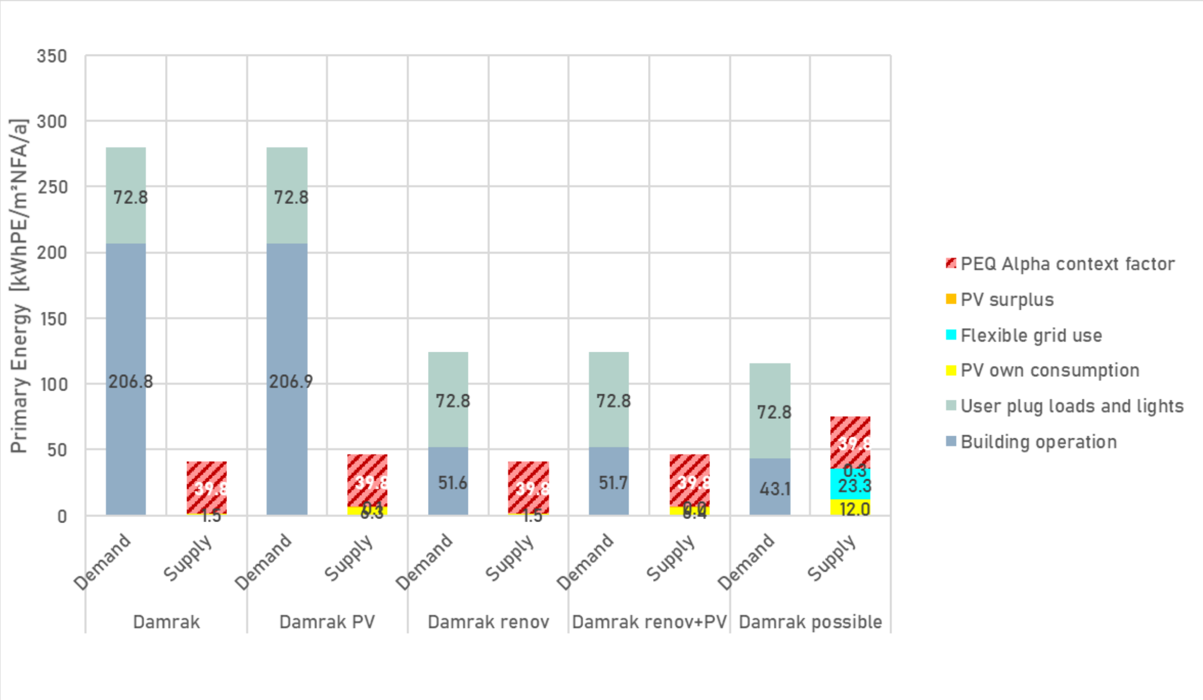


Figure 32. Primary energy for Amsterdam FD

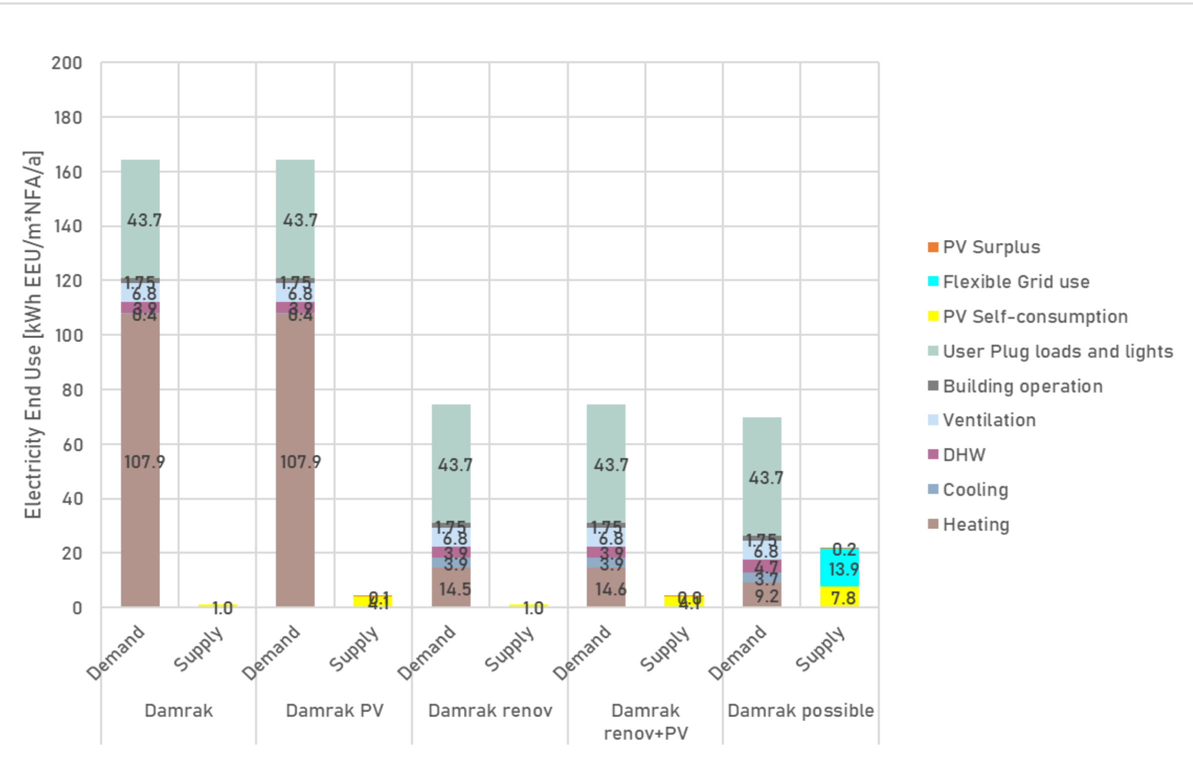


Figure 33. Electricity end use for Amsterdam FD

Different energy conversion factors can change primary energy balance (Figure 34) and could be one of the ways towards PED. Decreasing of the energy conversion factor will decrease energy demand.

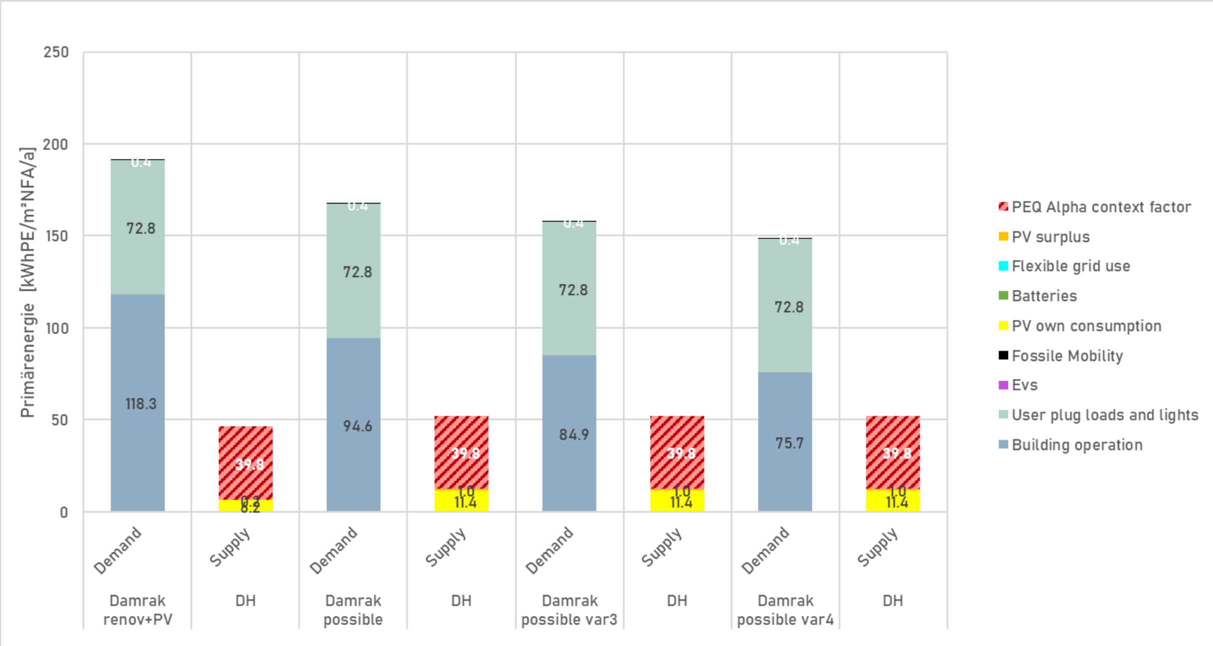


Figure 34. Primary energy for Amsterdam FD with changing energy conversion factors

8 Assessment of Focus District in Resita

8.1 Initial Goals and Setting

FD is located in the south-west part of Resita town. The main parameters of the district are presented in Table 12.

Table 12 – Parameters of Lunca Pomostului FD in Resita

Parameter	Value	Unit
District Area	46.98	ha
Gross Floor Area	130,700	m² GFA
District Plot Area	420 859	m²
Floor Area Ratio (FAR)	0,9	
Share of plot area built	27,45	%
Net to Gross Floor Area Ratio	80	%
Building storeys (avg)	4.9	
Residential usage	76.5%	%
Secondary School (incl. Uni)	9.8	%
Commercial usage	3.9	%
Others (Retail)	9.8	%

Within the Resita focus district, „Lunca Pomostului”, there are :

- No. of residential buildings – 241 (of which rehabilitated – about 30%, including 35 houses);
- No. of educational buildings – 3 (of which rehabilitated – 3);
- No. of municipality buildings (similar in structure to the "girls' block") – 6 (of which rehabilitated – 1)
- No. of tertiary buildings (similar in structure to residential buildings) – 11 (of which rehabilitated – 4).

Currently, FD does not have goals toward PED, however, district representatives developed the next possible goals towards PED:

- modernize 20% of buildings by installing double-glazed windows (approximately 80% have already been modernized);
- 80% of buildings may be insulated with exterior wall insulation;
- roofs of 80% of buildings may be insulated;
- ground/basement insulation of 80% of buildings.

All potential goals for FD are in insulation.

8.2 Remarks on input data and assumptions

As was stated in [16] the geometrical parameters play a crucial role in energy balance calculation. Information regarding gross floor area, areas of envelope/roofs/windows, plot area, etc. was provided by district representatives only for 3 educational buildings and 15 types of residential buildings. Parameters for the provided types of buildings were calculated according to the documentation. For other building types, they were measured in Google Earth.

The plot area of FD was not provided by district representatives, so it was measured and calculated based on Google Earth maps (Figure 35).

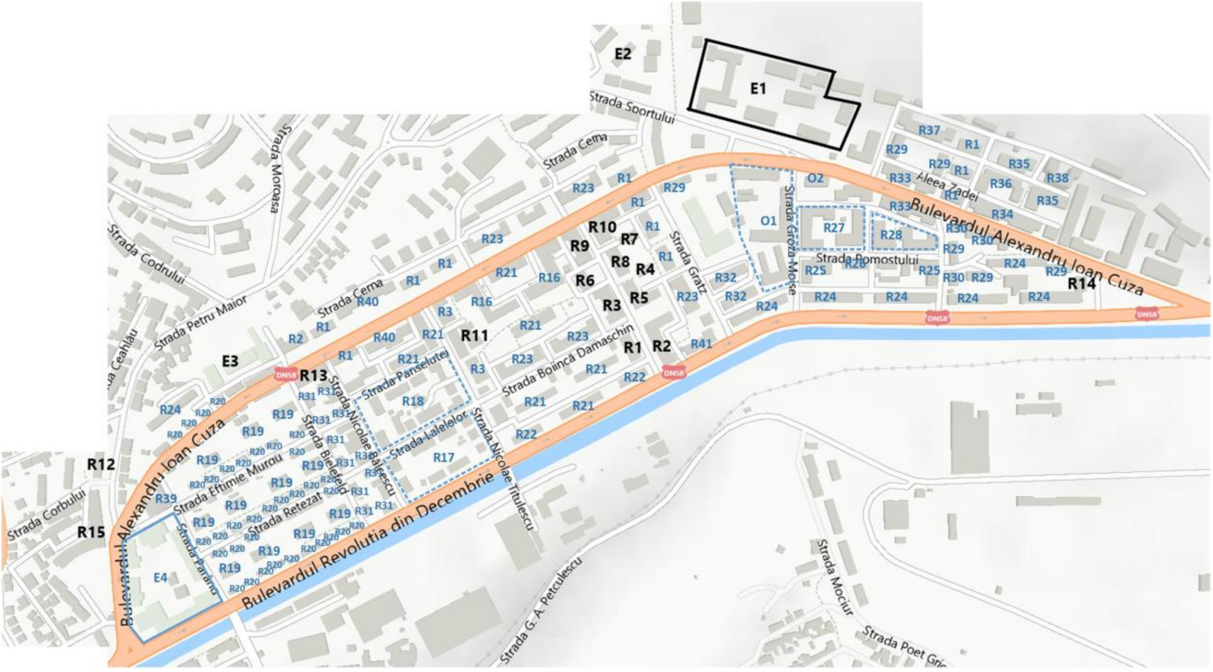


Figure 35. Plot area of FD Lunca Pomostului (Resita)

FD has quite different types of buildings, mostly residential. There are 41 types of buildings recognized in the FD (Figure 36). Residential buildings are marked by R, educational – by E, and office – O. Buildings with available floor plans are marked in black, without floor plans – in blue. Unfortunately, it was not possible to get floor plans for each type of building. So, measurements by Google Earth and Google Maps were done.

Figure 36. Types of buildings in FD Lunca Pomostului (Resita)

simply positive

For the Focus District in Resita, the simulation of flexible grid usage relies on the availability of wind energy for power generation. Thus, an hourly capacity (or generation) profile is necessary. This profile for wind power plants was determined using data about conversion factors from [21]. According to [23], the total installed wind power capacity in Romania in 2022 is 3015 MW (remark: this capacity has almost not changed during the last 7 years).

Yearly Resita FD irradiation was calculated using the tool BIMSolar [10] (Figure 37). As can be seen, the region has relatively (compared to other FDs) high potential for PV installation. Despite the district currently not considering PV installation, at the energy balance calculation, a few variants have been simulated to evaluate potential scenarios of district development.

Figure 37. Yearly irradiation for Resita FD

PV generation profile was made based on identified by Google Earth PV modules with average capacity. Currently, their total capacity is about 50 kWp and they cover about 0.76% of the roof area in the FD. For the next simulation of possible ways towards the PED, the variants of 20%, 50%, and 80% of roofs covered by PV were considered.

8.3 Current state

Annual Electricity End Use for the current state of the FD is the next: heating – 63.6 kWh EE/m²NGF; cooling – 3.07 kWh EE/m²NGF; DHW – 7.89 kWh EE/m²NGF; ventilation – 4.48 kWh EE/m²NGF; building operation – 1.67 kWh EE/m²NGF; user plug loads and lights – 30.04 kWh EE/m²NGF; PV self-consumption – 0.18 kWh EE/m²NGF.

Current values of the annual primary energy are the next: building operation – 152.04 PE/m²NGF; user plug loads and lights – 53.49 PE/m²NGF. As FD is now in the beginning stage of the implementation of renewable energy technologies the PV generation is quite low and equal to about 0.2 kWh PE/m²NGF.

8.4 Transition pathway towards a PED

As for other FDs potential pathways toward PED were considered and include: renovation activities and installing PV (20%, 50%, and 80% of roofs in FD). Electricity end use and primary energy are presented in Figure 38 and Figure 39 respectively.

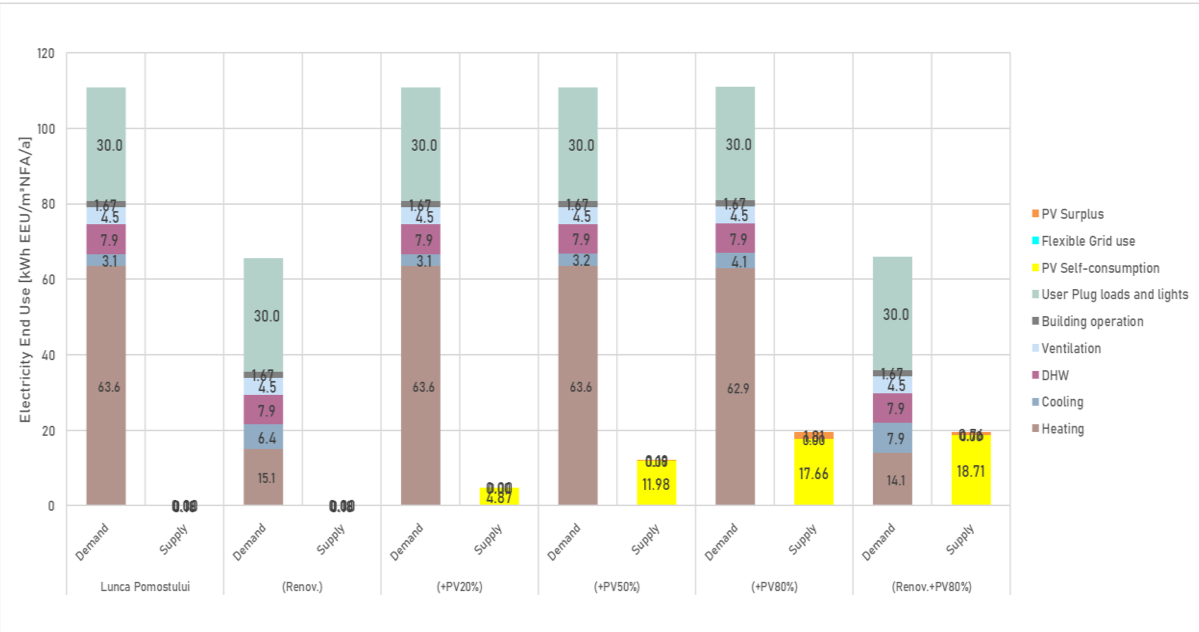


Figure 38. Electricity end use for the FD Lunca Pomostului: current state vs. possible goals

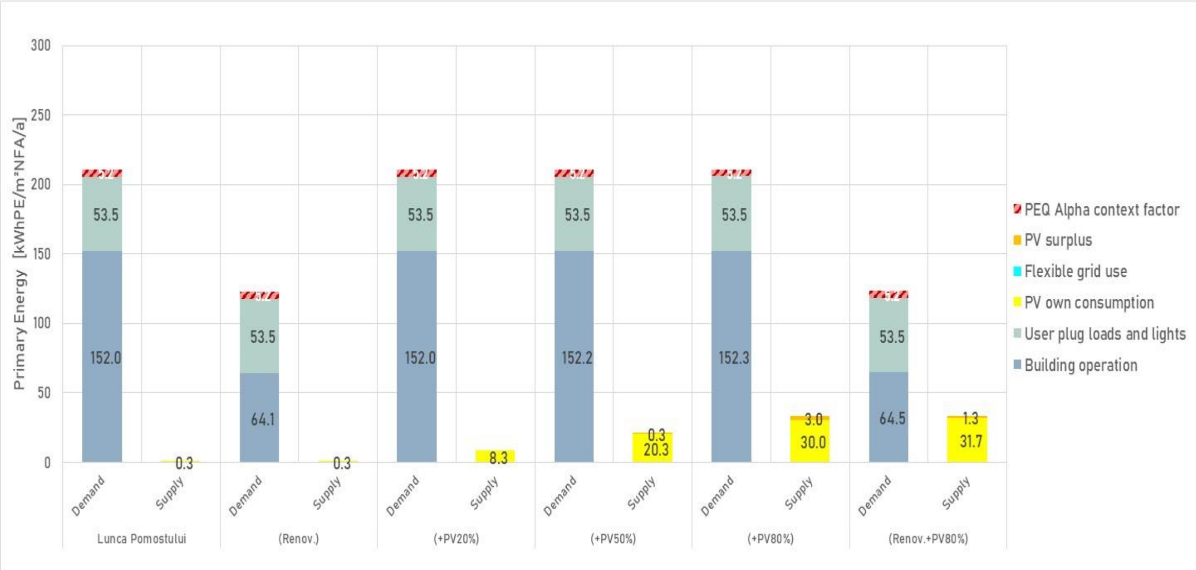


Figure 39. Primary energy for the FD Lunca Pomostului: current state vs. possible goals

Implementing flexible grid usage and using more efficient energy equipment is another pathway toward PED (Figure 40, Figure 41). The difference between demand and supply could reach 29.39 kWh EE/m²NGF for electricity end use and 48 kWh EE/m²NGF.

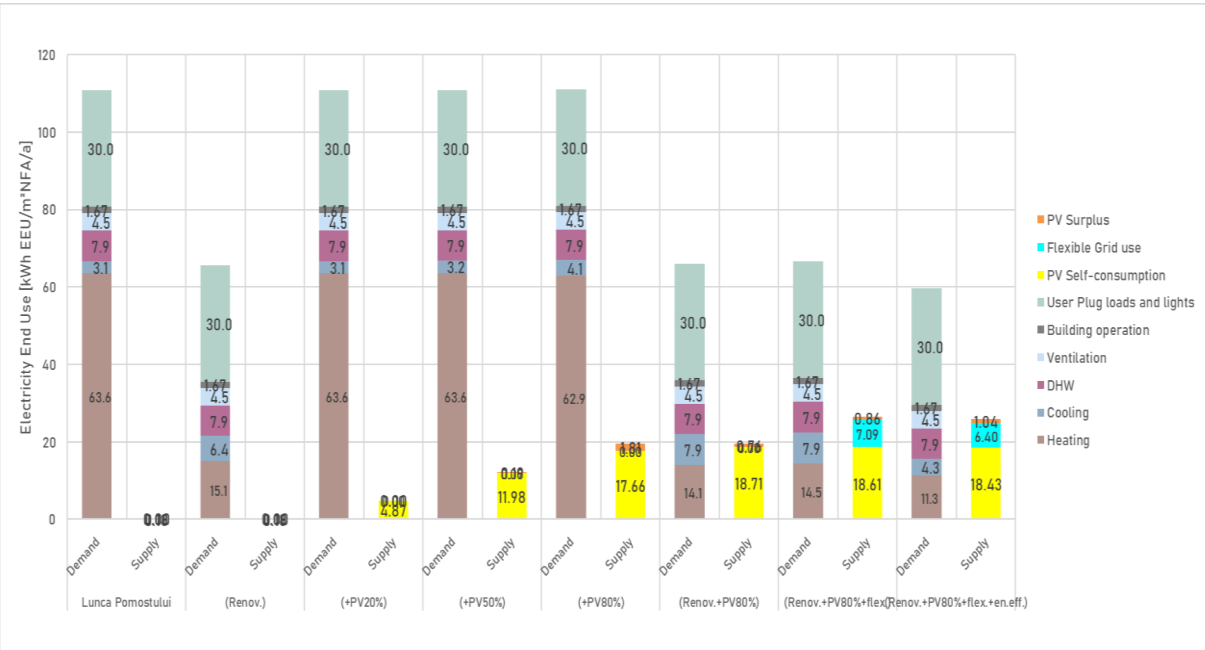


Figure 40. Electricity end use for the FD Lunca Pomostului

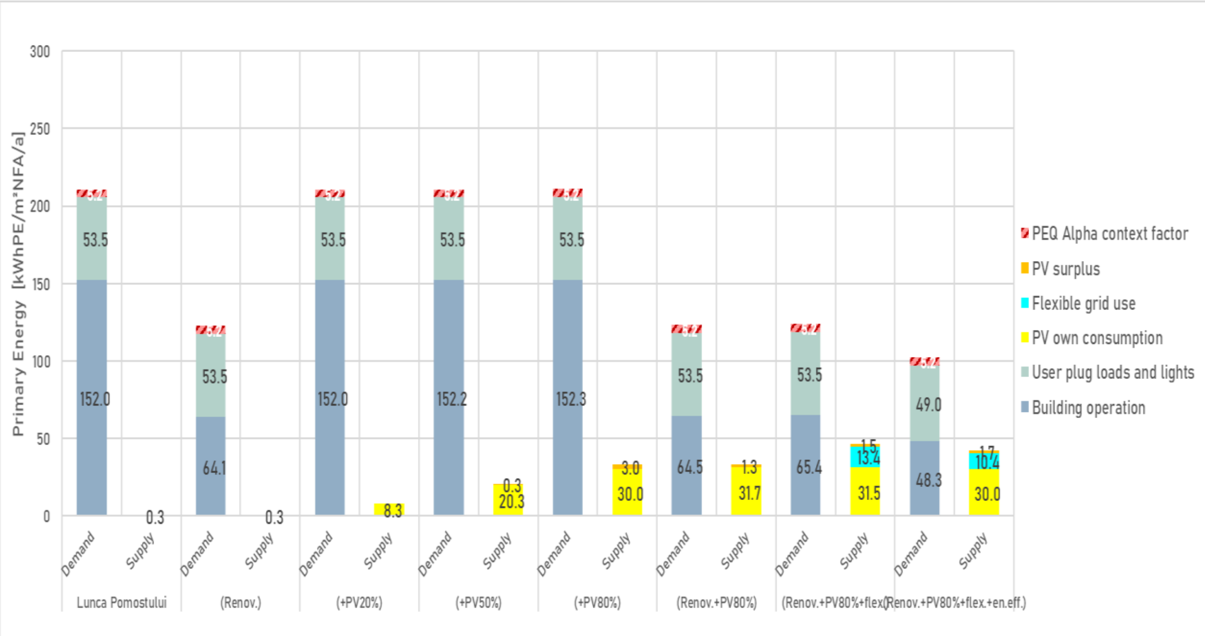


Figure 41. Primary energy for the FD Lunca Pomostului

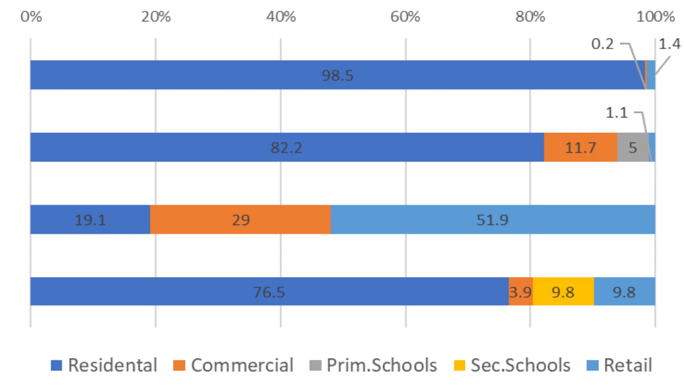
As seen from the simulation the most effective measures are implementing building renovation, flexible grid usage, and installing PV panels. However, the district still has high user plug loads, which is typical for a relatively high population-density district. The next pathways toward PED could be in decreasing user plug loads and improving energy conversion factors through implementing renewable energy technologies.

9 Discussions and Conclusions

In this report, the summary of the energy balance simulation for the four FDs was presented. The simulation was done using methodology developed by UASTW and based on a normative approach.

Districts' characteristics are presented in Table 13, where FAR – floor area ratio, NFA – net floor area. The residential area dominates in 3 districts, except Amsterdam.

Table 13 – FDs area characteristics

District	NFA, m^2	FAR	Usage
Settimo Torinese	171149.7	7.93	
Großschönau	40161.0	0.15	
Amsterdam	79153.0	3.29	
Resita	303214.4	0.9	

For all considered FDs the development scenarios towards the PED are lying in the renovation of buildings (insulation walls, roofs, basements; windows replacement) and installing PV panels. For regions with relatively cold climates, these measures play an important role and allow to decrease heat losses during the winter period. Installing PV is more efficient for southern regions with high solar irradiation. At the same time, the energy loads for cooling for those regions are increasing.

For the development scenarios, the most effective measures are in combination with all possible actions (e.g. including flexible grid usage) and implementing renewable energy technologies.

As Primary energy is the main factor in positive energy district assessment the development scenarios could be presented as a comparison of the demand and supply of primary energy (Figure 42). The dashed gray line represents the balance (equality) between demand and supply, which is the minimum requirement in the classical understanding of the PED. However, with a more deep and clear consideration of the PED, the context factor should be taken into account [2]. In Figure 42 PEDs' pathways without taking into account the context factors are presented as a blue line and with context factors – as an orange line. Scenarios are considered starting from the current state (right points) through the renovation, renovation with PV installation (or increasing their percentage in the districts), implementing flexible grid usage, and all mentioned measures with the implementation of more effective energy equipment in the FD (left points).

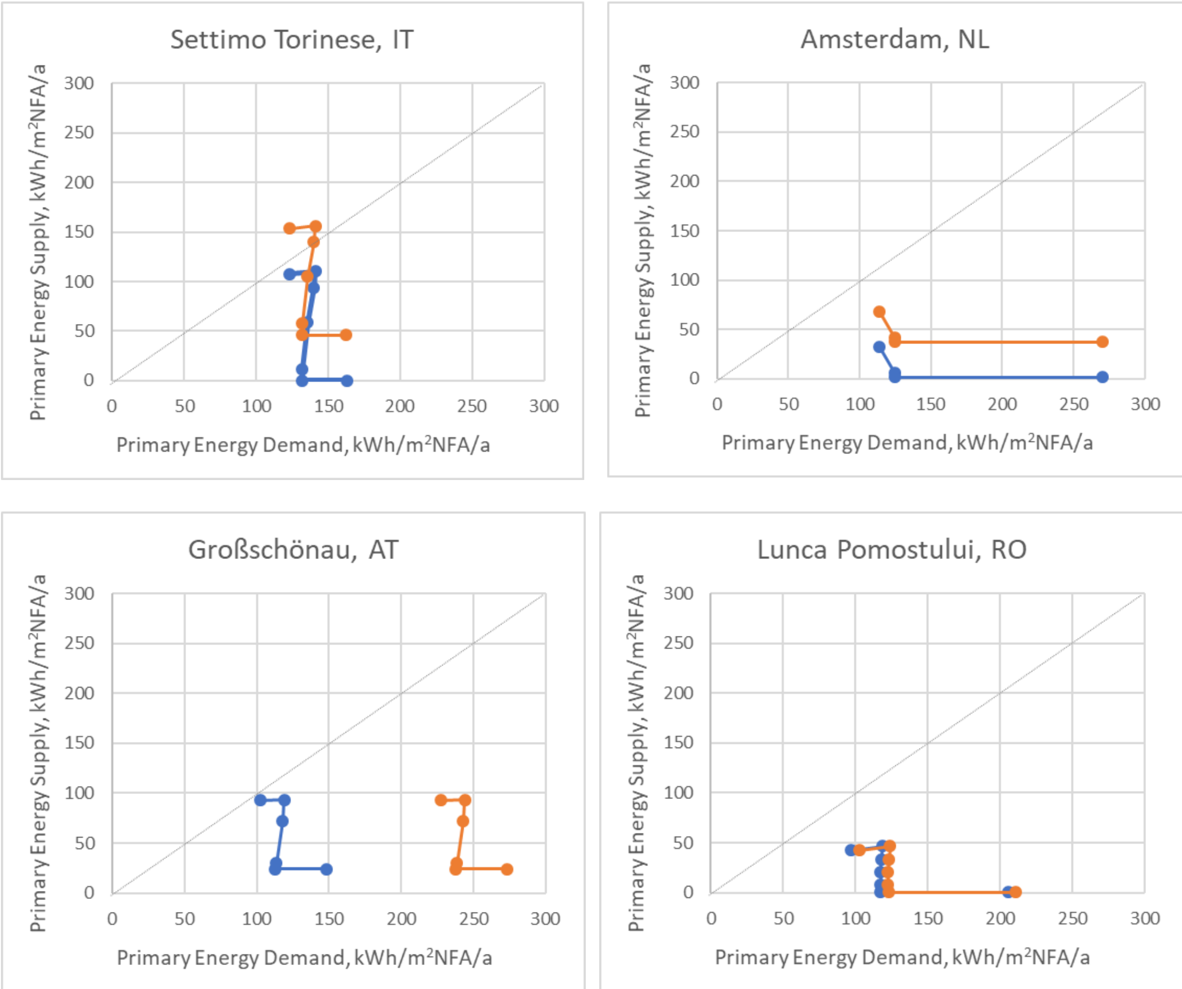


Figure 42. FDs Primary Energy: Demand vs. Supply

Results obtained for considered FDs highlight directions of the district development and could be used as a base for district stakeholders towards the PED implementation. However, it should be noted, that all calculations were done with assumptions, which, of course, reflected in the final results. At the same time, the type of assumption varies from simply eliminated (e.g. assumptions at area calculations) to assumptions with high uncertainties (e.g. energy conversion factors). All potential ways to the methodology improvement, i.e. results quality improvement, will be discussed under Task 5.3 "Feedback Implications to the PED Definition Framework and selected SIMPLY Positive Methodology".

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