Innovation Action

H2020-LC-SC3-SCC-1-2018

D2.2 - Baseline of Oulu PED

WP2, Task 2.2

November 2021 [M36]

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement n°824418.

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Document Information

Grant agreement	824418
Project title	Energy efficient pathway for the city transformation: enabling a positive future
Project acronym	MAKING-CITY
Project coordinator	Cecilia Sanz-Montalvillo (cecsan@cartif.es)- Fundación CARTIF
Project duration	1st December 2018 – 30th November 2023 (60 Months)
Related work package	WP 2 - Demonstration of positive energy district concept in Oulu
Related task(s)	Task 2.2 - Baseline of interventions definition
Lead organisation	20-VTT
Contributing partner (s)	13-OUK, 15-OEN, 16-SIV, 17-YIT, 19-ARI
Due date	30th November 2021
Submission date	20th December 2021
Dissemination level	Public

History

Date	Version	Submitted by	Reviewed by	Comments
09-11-21	0.1	CAR	Cecilia Sanz	ToC
15-11-21	0.2	VTT	JR	Demo area description
19-11-21	0.3	VTT	RMA, JR	Values for Energy & Environment KPIs
29-11-21	0.4	VTT	JR	Economy, Mobility, Social & Residents KPIs
02-12-21	0.5	VTT	JR, RMA, AT	Final version for review
14-12-21	0.6	CAR	Cecilia Sanz	Review version
17-12-21	1.0	VTT		Final version for submission

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Abbreviations and acronyms

Acronym	Description
KPI	Key Performance Indicator
PED	Positive Energy District
DHG	District Heating Grid
GHG	Green House Gases
GGE	Greenhouse Gas Emissions
PEF	Primary Energy Factor
PEC	Primary Energy Consumption
PED	Primary Energy Demand
RES	Renewable Energy Sources
E-PASS	VTT's simulation tool for estimating energy demands
EV	Electrical Vehicles
EEC	Electrical Energy Consumption
EED	Electrical Energy Demand
PV	Photovoltaic
TEC	Thermal Energy Consumption
TED	Thermal Energy Demand

Executive Summary

This deliverable will document the final version of D2.2 - Baseline of Oulu PED. It is the outcome of task 2.2 Baseline of interventions definition, and subtask 2.2.2 Baseline of interventions. Once the needed data sets perceived, simulation models developed and the evaluation framework established in WP5, the reference baseline values to evaluate the performance is now outlined and implemented.

The main objective of this deliverable is to report the measured or simulated baseline data, that has been formulated into key performance indicators, at the starting point of the project: the baseline situation. The measured historic values, references, simulations and other approaches to determine baseline values will be a valuable input to evaluate the final performance of the PED concept and must be developed with enough detail to perform appropriate evaluation and impact assessment activities during the monitoring phase of the project.

All KPI categories including both quantitative and qualitative indicators (Energy & Environment, Mobility, Economy, System Flexibility and Social & Residents) have been considered and presented in this report. However, there are some indicators without baseline values determined, such as two economic indicators (C2: payback time, and C3: economic value of savings), or other technical indicators evaluating only the savings, reduction or other kind of impact (reduction of emissions as an example). This is because we can only calculate these indicators at the end of the monitoring period, when there is enough performance data gathered to make reliable calculations.

Keywords

Baseline, KPIs, Evaluation

1 Introduction

1.1 Purpose and target group

The main objective of this deliverable is to provide baseline values for the key performance indicators measuring the performance of the actions and interventions implemented in Oulu PED. This is done to give a basis to assess the progress and results of the project as objectively as possible.

The selection of project level indicators is in key role in the definition of the baseline, but it has been needed to establish not only the best way to measure these indicators, but also determine how the results can be compared to correctly identify the impact of the implemented actions.

The defined evaluation procedure starting with setting the baseline will also support Lighthouse cities in the establishment of strategic and technical goals for PEDs, since the methodology proposed will allow them to simulate different scenarios modifying the value of the indicators that have been included in the framework.

1.2 Contribution partners

The following Table 1 depicts the main contributions from participant partners in the development of this deliverable.

Table 1: Contribution partners

Partner nº and short name	Contribution
20-VTT	Lead author of the deliverable.
13-OUK	General information and consumption data from B6: School building.
15-OEN	Hour-based consumption data from several demo and reference buildings.
16-SIV	General information and data from Sivakka owned buildings.
17-YIT	General information and data from YIT building.
19-ARI	General information and data from Arina Store.

1.3 Relation to other activities in the project

Table 2 depicts the main relationship of this deliverable to other deliverables developed within the MAKING-CITY Project and that should be considered along with this document for further understanding of its contents.

Table 2: Other related activities

Deliverable / Task nº	Relation
D1.3	D1.3 describes tools for modelling energy demand, supply side, simulation of scenarios and estimation of impacts
D2.1	D2.1 presents Oulu PED (Kaukovainio) interventions detailed design
D2.3	D2.3 presents the simulation models of buildings, energy systems, storage and management of flows algorithms in Oulu
D2.4	D2.4 describes the high performance (demo) buildings in Oulu
D2.5	D2.5 presents the details on Building-level energy management approach in Oulu PED pilot
D2.6	D2.6 presents the positive district energy flows in Oulu
D2.7	D2.7 describes the electric vehicles and charging stations roll-out strategy and analysis in Oulu
D2.8	D2.8 Present the open interfaces and server architecture for the Oulu ICT Platform
D2.9	D2.9 presents the overall architecture of the Oulu ICT Platform in high abstraction level focusing on the context and functional views of the platform
D5.2	D5.2 defines project level KPIs that are calculable from outputs of monitoring programmes
D5.3	D5.3 describes the evaluation procedure for PED actions based on KPIs
D5.4	D5.4 describes the city impact evaluation procedure based on prioritized and weighted city level indicators
D5.5	D5.5 describes the collection of data sets
D5.6	D5.6 defines the guidelines for the Monitoring Programmes
D5.7	D5.7 presents the implementation of the monitoring programme in Oulu
D5.9	D5.9 describes the principles of common open specifications for city ICT platforms
D5.10	Data collection and KPI calculation.
D5.11	D5.11 reports the final version of Evaluation (city level, project level).

2 Brief description of the demo PED

The PED demonstration area in Oulu is Kaukovainio, that is a suburb of about 3000 inhabitants located around 3 kilometres southeast from the Oulu city centre. The residential area consists of high-rise apartment buildings on the eastern and southern sides and low terraced and detached houses on the western side. Services include a school, a library, a grocery store, and kindergartens.

Oulu Kaukovainio PED includes six demo-buildings as shown in Figure 1: on the left bottom corner, marked yellow, building 1, retrofitted Sivakka building in Vaskitie. Below that is building 2.1, new Sivakka building in Jalohaukantie, marked brown. Upwards from that, building 2.2, new Sivakka building in Hiirihaukantie, also in brown. To the right from previous, new YIT building 3. Up from these in orange, new Arina grocery store, building 5, which is one of the most energy efficient grocery stores in the world. Finally, in blue, the existing school and multi-purpose building, demo number 6.

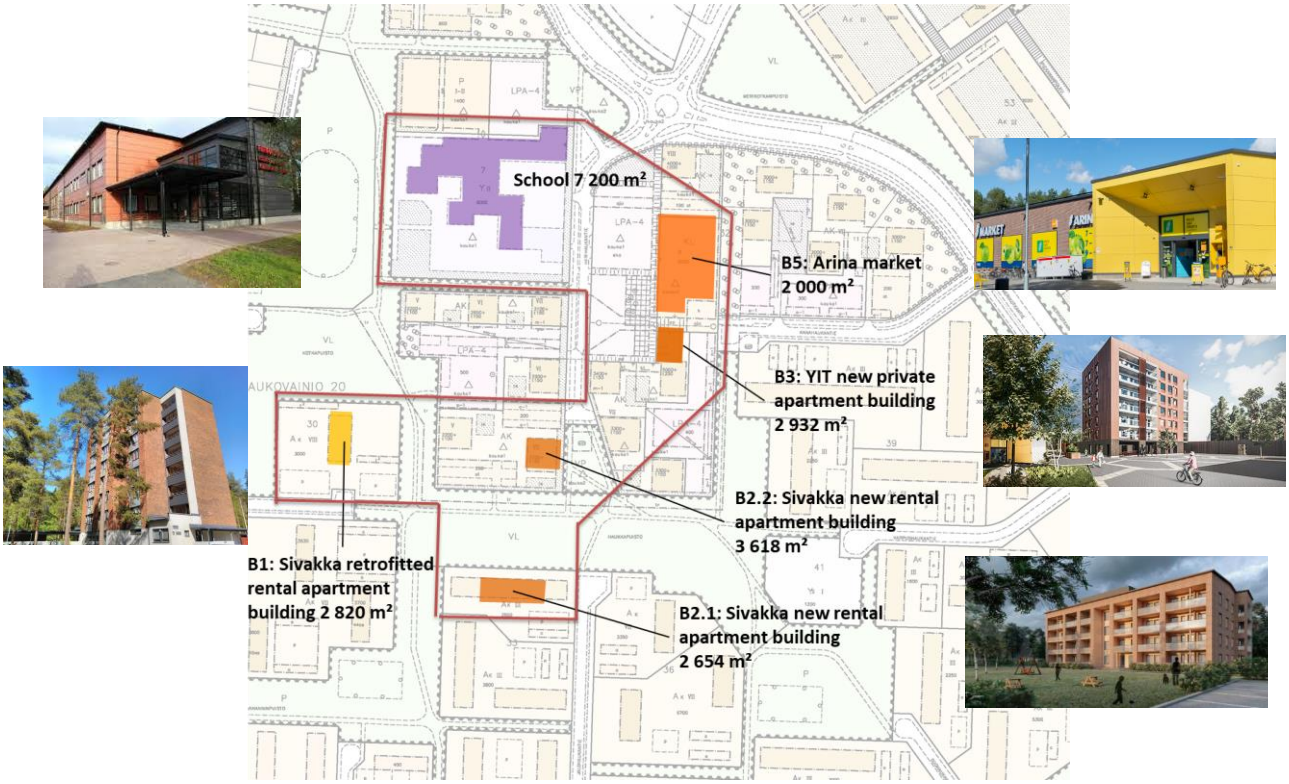

Figure 1: Overview of the project area in Oulu

3 Baseline in the evaluation framework

MAKING-CITY project has selected and defined a set of project level indicators focused on monitoring the evolution of PED demonstration areas towards the final targets. The project level indicators were defined in the 5.2 Project level indicators. The evaluation procedure including a description of baseline was defined in D5.3 Evaluation procedure for PED actions.

The project level evaluation framework consists of key performance indicators selected for evaluating the actions made in the demo areas on short- and medium-term. The project level can be considered as more technical than the city level concentrating not only assessing the level of sustainable energy planning but also the execution of the interventions in the PED areas. The evaluation procedure describes the methodology to assess project actions with the defined indicators. It consists of four steps:

- Step I: Selecting and defining the project level indicators in accordance with the PED actions, setting the objective for monitoring and impact assessment.
- Step II: Defining the baseline situation of the PED and calculating the indicator values at the beginning of the project (before the planned project level interventions).
- Step III: Monitoring the actions/action groups with key performance indicators during the monitoring phase of the project (following the indicators for the evaluation of progress).
- Step VI: Final calculation of the indicators at the end of the project for the final evaluation and impact assessment, where final values are obtained both per category and per application field.

This report concentrates on Step II: Defining the baseline situation of the PED and calculating the indicator values at the beginning of the project.

The final evaluation of the achieved impacts - the impact assessment - and other benefits for both project and city level actions and interventions will be performed during the monitoring phase and reported finally in D5.11 Evaluation (city level, project level). Monitoring and evaluation protocols have been developed and implemented in the framework of WP5 with collaboration of the RTO partners of the project, considering existing KPIs and requirements for DAQ and GDPR.

The KPIs have been divided into five main categories: Energy & Environment, Mobility, Economy, System Flexibility and Social & Residents. On the other hand, project actions have been divided into four categories: High performance buildings, Renewable energy systems online, Other technical actions and Non-technical actions. The alignment of the indicators with the project actions to be monitored is presented in Figure 2.

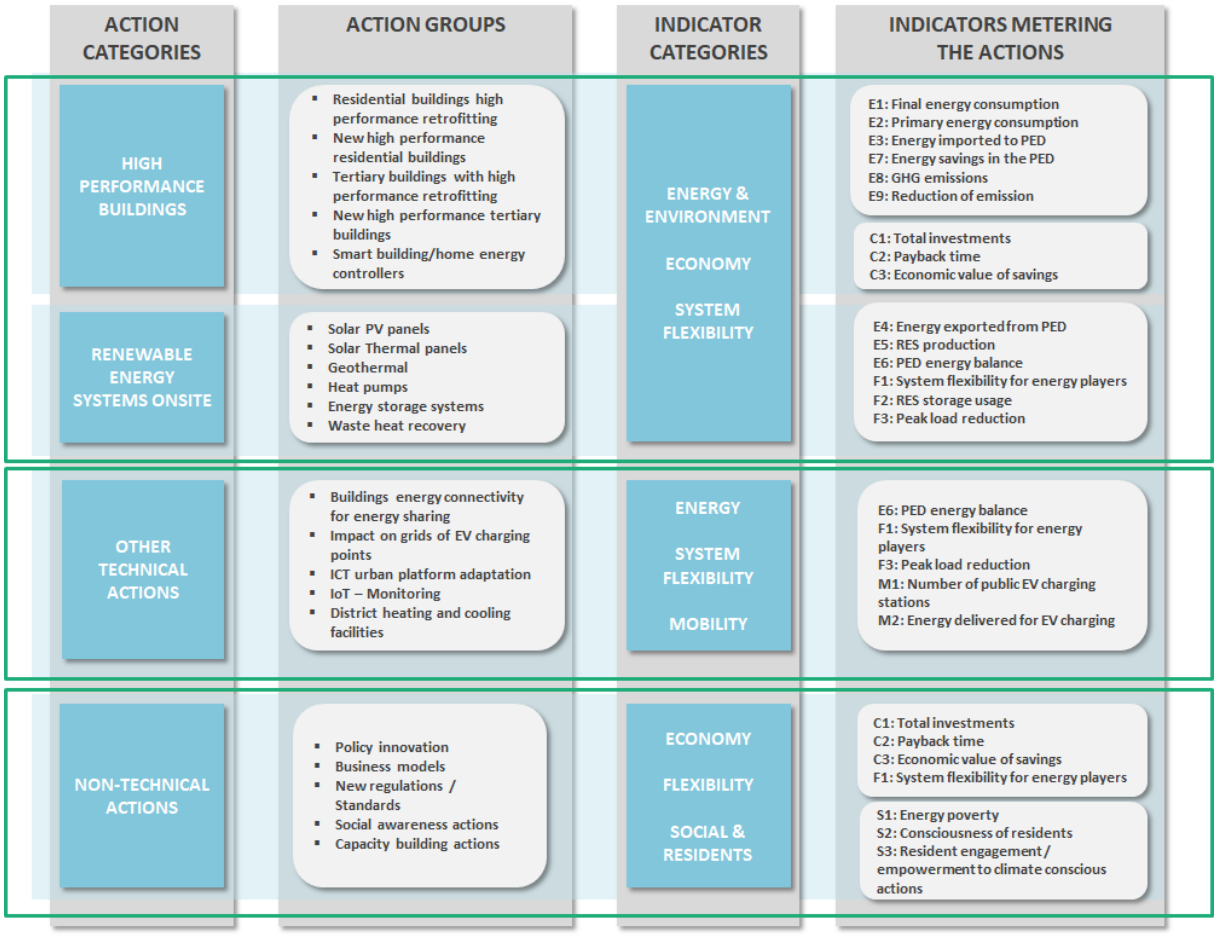

Figure 2: Indicators aligned with the PED actions (source: D5.3)

Baseline assessment refers to the procedure to assess the actual situation before the intervention takes place and which will be used to compare the effect of the intervention. This section focuses on guidelines for specific interventions within the energy scope, which are intended to achieve energy savings or to increase the share of renewable energy once the boundary for the analysis is clearly defined.

Baseline calculations differ whether we are dealing with new developments or renovated buildings. For example, when the boundary of the analysis is at an existing building, a baseline refers to the actual situation before the refurbishment, when the intervention relates to improving the energy efficiency or service level of the building. For new building developments, the baseline refers to the business-as-usual practice, which can be derived e.g. from building regulations or by utilizing measured data from same type of buildings.

In these cases, methodologies such as IPMVP (EVO, 2012) can be directly applicable. IPMVP is a best practice methodology commonly used for measuring, computing and reporting savings achieved by energy efficiency projects at end user facilities. This protocol establishes how to perform the evaluation of energy savings by comparing measured consumption before and after implementation of energy actions making suitable adjustment for changes in conditions. The comparison of baseline period and reporting period is carried out by following the general M&V equation:

Savings = Baseline period energy – Reporting period energy +/- Adjustments

The adjustment term shown in the equation should be computed from identifiable physical facts and in this case, proceed to perform an adjusted of the baseline energy.

The baseline is different for new and existing systems. It is important to meter energy consumption before refurbishment in projects that deal with existing buildings and systems. This data is then used for defining the baseline. For new buildings and systems, the baseline is determined based on the energy performance of similar systems representing state of the art or minimal requirements by law, i.e. buildings with similar purposes and sizes or mobility systems in similar districts or cities. The baseline for a project should be defined as follows:

- Refurbishment cases: at least one year of monitoring of the existing system. The building's energy consumption must be metered before the construction work starts, which will include final energy demand for heating, domestic hot water, cooling, and electrical appliances (kWh/month). In case metering is not possible, data from energy bills can be used to define the status before refurbishment.
- New-built cases: at least one year of synthetic data reflecting the typical scenario. This data must be calculated according to regulations, technical guides or similar projects. The calculation can be also simulated as will be done in many cases.

In addition to the baseline, expected energy performance of the system or systems is predefined in planning phase based on simulation, modelling and calculations. This way, later deviations from design values can be detected.

4 Reference baseline to evaluate the performance

This chapter presents the baseline values for each key performance indicator that will be used for the final evaluation of the performance on the project level. The baseline for the city level indicators were defined in D5.1, and they were also reported in the city diagnosis report of D1.2.

For this report, the KPIs have been divided to exact same groups that was defined in D5.2 and D5.3 (Figure 2) and deployed by interventions for grouping interrelated actions. In the first category, Energy & Environment, each intervention (demo-buildings) has been considered separately, and then combined to represent the whole PED area. The structure follows the same guideline as will be reported in D5.11 Evaluation.

For each intervention, information about the method to obtain baseline, origin of data, and other relevant comments have been provided to support the comparability and future evaluation of the performance development. For each baseline indicator value, the specification of the used KPI variant with the calculation formula has been provided, accordance with the official project level KPIs, that have been described in D5.2 and D5.3, and with more details in Excel-workbook developed by the Making-City KPI task group.

4.1 Baselines for energy and environment indicators

The following Table 3 presents the Energy KPIs for the Kaukovainio PED. The calculation procedure follows in the sections below, with the results for each of the buildings in the PED area.

Table 3: Baseline for Energy and Environment KPIs in Kaukovainio PED

Energy and Environment KPIs			
Indicator	**Calculation parameters**	**Estimated value**	
E1: Final energy consumption	Thermal energy demand (H&C) + Thermal energy demand (DHW)	Thermal:	2121533 kWh/a
	Electrical energy demand (heat pumps) + Electrical energy demand (lighting + ventilation)	Electrical:	1512302.7 kWh/a
E2: Primary energy consumption	PECd=∑PECb	6387519 kWh/a	
E3: Energy imported to PED	Thermal energy imported = Thermal consumption - Th RES production (after storage)	Thermal:	2121533 kWh/a
	Electrical energy imported = Electrical consumption - Elec RES production (after storage)	Electrical:	1512302.7 kWh/a
E4: Energy exported from PED	Thermal energy exported = Thermal consumption - Th RES production (after storage) /m2	Thermal:	0 kWh/a

	Electrical energy exported = Electrical consumption - Elec RES production (after storage)	Electrical:	0 kWh/a
E5: RES production	LPEt=∑Locally produced thermal energy produced	Thermal RES:	0 kWh/a
	LPEe=∑Electrical energy produced	Electrical RES:	0 kWh/a
E6: PED energy balance	PEB= PEI - PEE	6387519 kWh/a	
E7: Energy savings in the PED	(PEC thermal district reporting - PEC thermal district baseline) *100 / PEC thermal district baseline	Thermal:	0 %
	(PEC electric district reporting - PEC electric district baseline) *100 / PEC electric district baseline	Electrical:	0 %
E8: GHG Emissions	GGE_b= (TEC_b · GEFT + EEC_b · GEFE) / Ab	PED level:	20.116 kg CO2 eq/year m2
E9: Reduction of emissions	∑mCO2	0	

4.1.1 Intervention 1: Retrofitting of a rental house (Sivakka 1)

Table 4 contains basic information about building 1. Building 1 is referred as Sivakka 1. Baseline data of the building is monitored which refers to the hourly data that is collected during the years 2014-2020 from Sivakka 1. The data is collected before the second retrofit. Baseline data is calculated as an average of the monthly consumptions during these years.

Table 4: Basic information of residential building Sivakka 1.

Building name	Heated area, m^2	Heated volume, m^3	Method: monitored or simulated building data?	Year of construction / retrofit
Sivakka 1	2820	8930	Monitored	1972/2000/2020

4.1.1.1 E1: Final energy consumption

KPI specification and formula define the following attributes:

E1.3: Building level Thermal energy consumption (TECb), as shown in

Month	Thermal energy consumption [kWh]
January	53501.43
February	43187.14
March	39785.71
April	26954.29
May	16171.67
June	8558.333
July	5856.667
August	7075
September	13549.83
October	30163.5
November	37575
December	44131.67
Yearly	326510.2

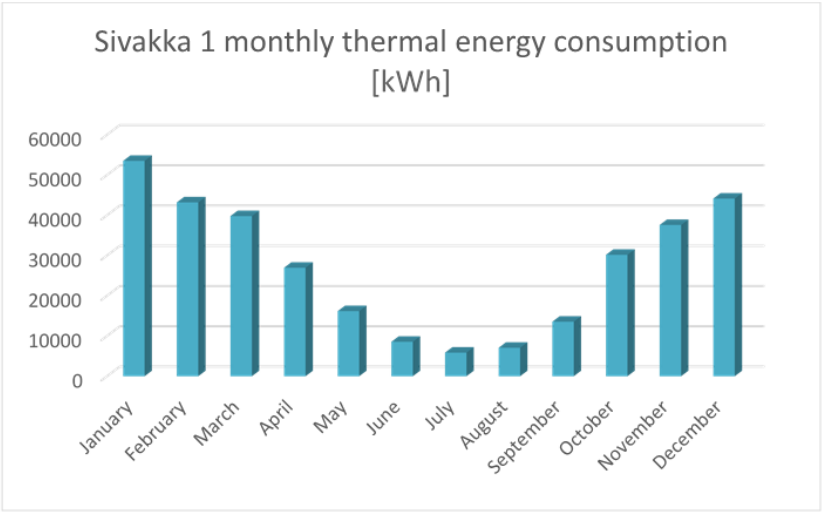

Figure 3, is composed of:

Thermal energy consumption (H&C) + Thermal energy consumption (DHW)

Month	Thermal energy consumption [kWh]
January	53501.43
February	43187.14
March	39785.71
April	26954.29
May	16171.67
June	8558.333
July	5856.667
August	7075
September	13549.83
October	30163.5
November	37575
December	44131.67
Yearly	326510.2

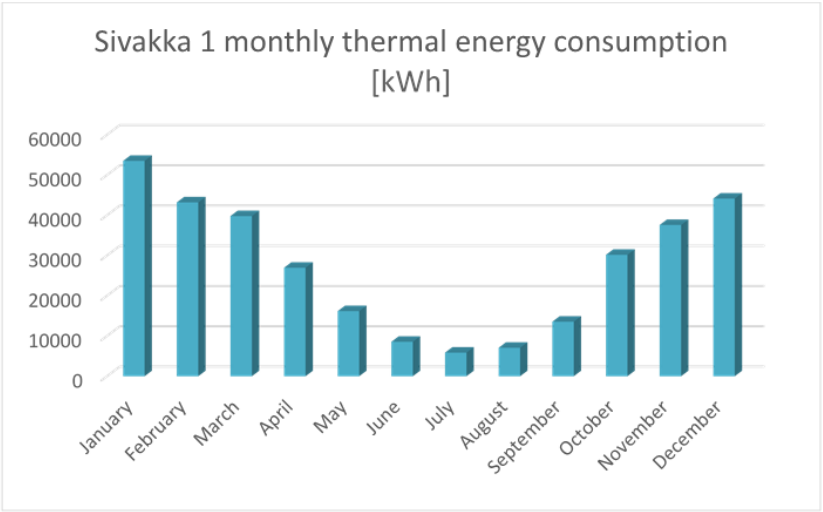

Figure 3: Sivakka 1 thermal energy consumption

E1.3: Building level Thermal Energy consumption per m² (TECb), as shown in

Month	Thermal energy consumption per m² [kWh]
January	18.97214
February	15.31459
March	14.10841
April	9.558257
May	5.734634
June	3.03487
July	2.076832
August	2.508865
September	4.804905
October	10.69628
November	13.32447
December	15.64953
Yearly	115.7838

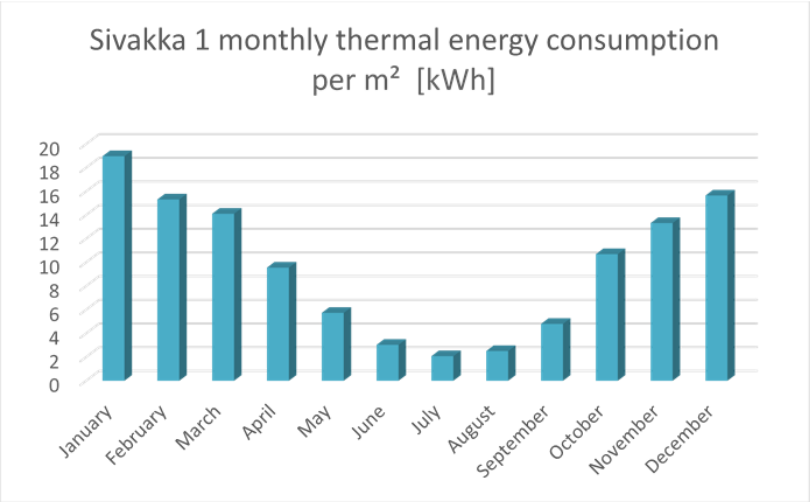

Figure 4, is composed of:

(Thermal energy consumption (H&C) + Thermal energy consumption (DHW))/ building area

Month	Thermal energy consumption per m² [kWh]
January	18.97214
February	15.31459
March	14.10841
April	9.558257
May	5.734634
June	3.03487
July	2.076832
August	2.508865
September	4.804905
October	10.69628
November	13.32447
December	15.64953
Yearly	115.7838

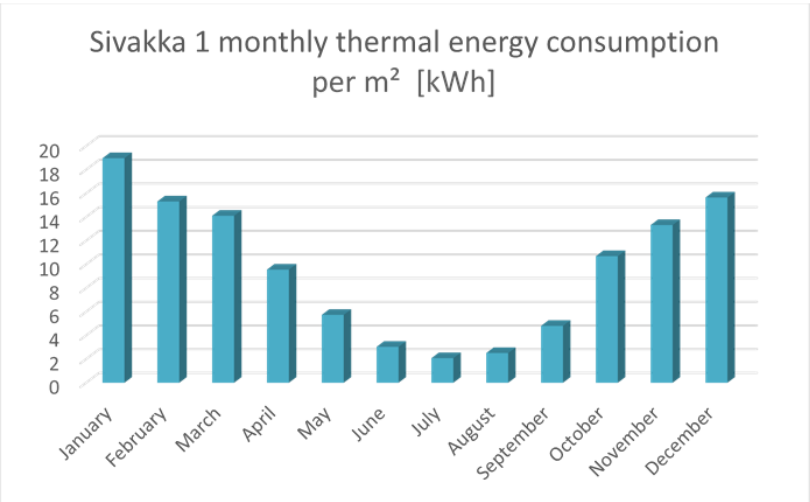

Figure 4: Sivakka 1 thermal energy consumption per m²

E1.4: Building level Electrical energy consumption (EECb), as shown in

Month	Electrical energy consumption [kWh]
January	5477.489
February	4711.299
March	4799.744
April	4161.257
May	3966.652
June	3494.597
July	3412.84
August	3798.177
September	4081.797
October	4707.868
November	4927.115
December	5263.227
Yearly	52802.06

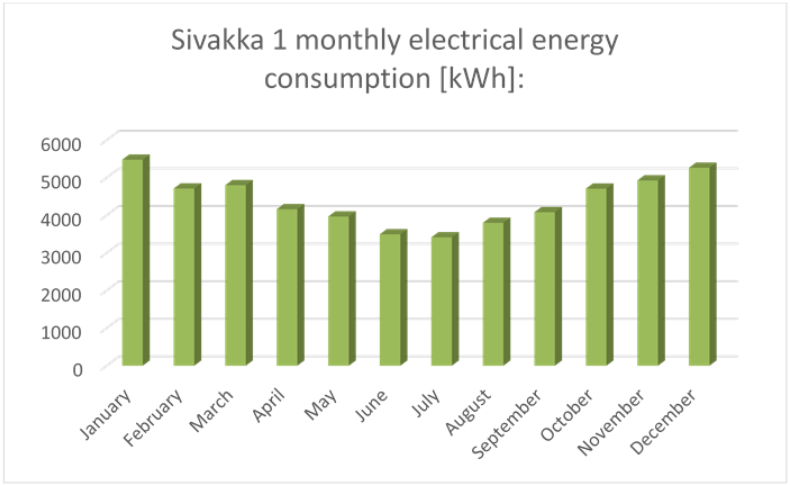

Figure 5, is composed of:

Electrical energy consumption (heat pumps) + Electrical energy consumption (lighting + ventilation)

Month	Electrical energy consumption [kWh]
January	5477.489
February	4711.299
March	4799.744
April	4161.257
May	3966.652
June	3494.597
July	3412.84
August	3798.177
September	4081.797
October	4707.868
November	4927.115
December	5263.227
Yearly	52802.06

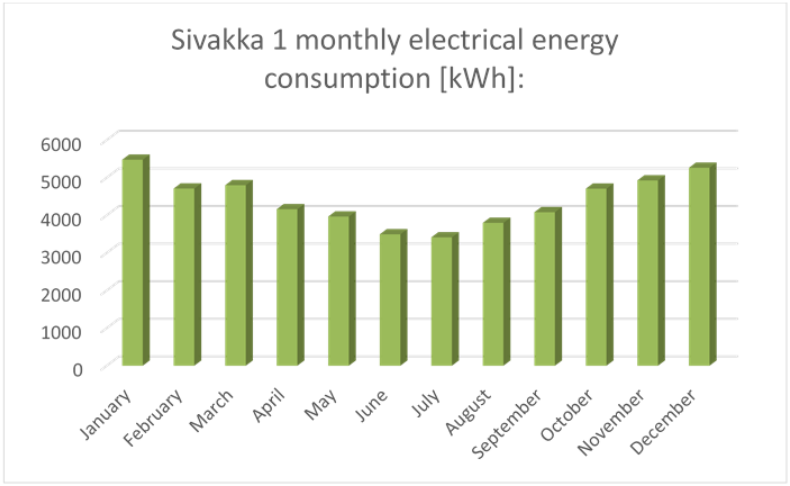

Figure 5: Sivakka 1 electrical energy consumption

E1.4 Building level Electrical energy consumption per m2 (EECb), as shown in

Month	Electrical energy consumption per m2 [kWh]
January	1.942372
February	1.670673
March	1.702037
April	1.475623
May	1.406614
June	1.239219
July	1.210227
August	1.346871
September	1.447446
October	1.669457
November	1.747204
December	1.866392
Yearly	18.72413

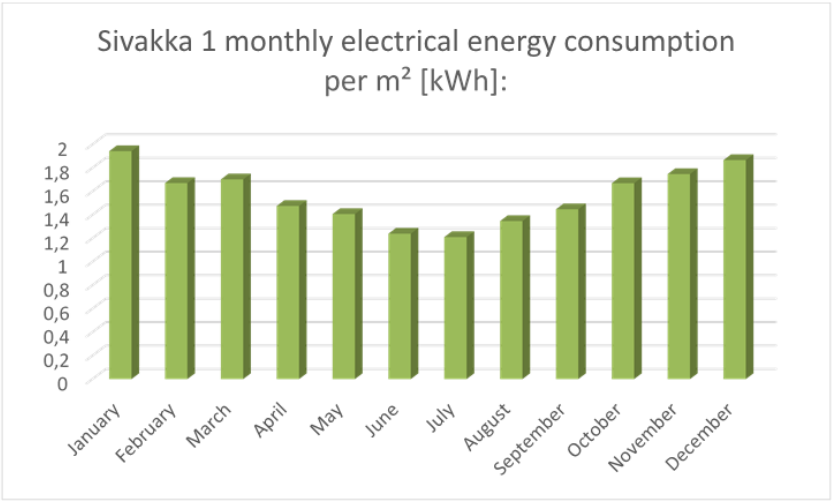

Figure 6, is composed of:

Electrical energy consumption (heat pumps) + Electrical energy consumption (lighting+ventilation) // building area

Month	Electrical energy consumption per m2 [kWh]
January	1.942372
February	1.670673
March	1.702037
April	1.475623
May	1.406614
June	1.239219
July	1.210227
August	1.346871
September	1.447446
October	1.669457
November	1.747204
December	1.866392
Yearly	18.72413

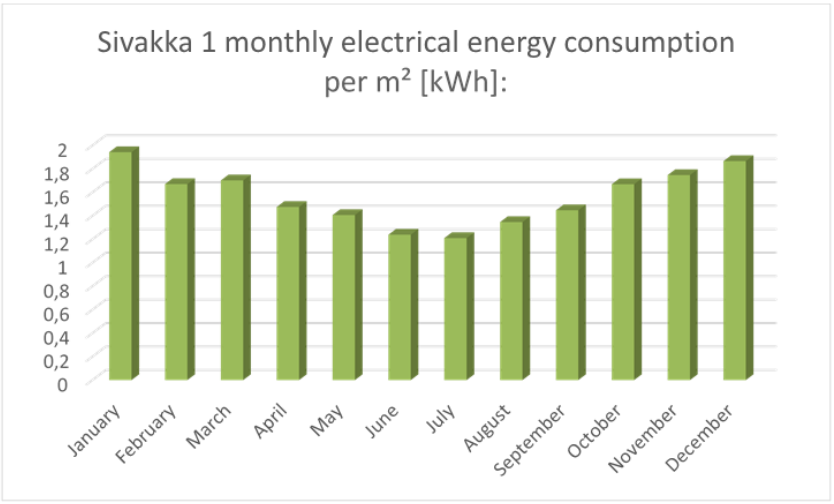

Figure 6: Sivakka 1 electrical energy consumption per m²

4.1.1.2 E2: Primary energy consumption

KPI specification and formula define the following attributes:

E2.2. Primary Energy Consumption, as shown in

Month	Primary energy consumption [kWh]
January	82697.83
February	67450.4
March	63240.81
April	45027.59
May	30543.13
June	19512.87
July	15804.48
August	18313.12
September	27411.1
October	50511.43
November	60672.58
December	70002.91
Yearly	**551188.3**

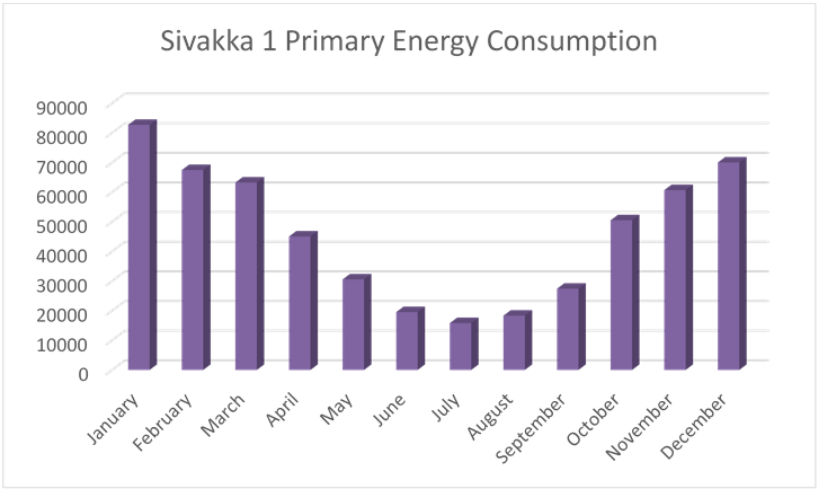

Figure 7, is calculated with the following formula:

PECb = (ERTC_b * PEFt + ERECb * PEFe). The factor of primary thermal is PEFt = 1.3 and the factor of primary electricity is PEFe = 2.4.

Month	Primary energy consumption [kWh]
January	82697.83
February	67450.4
March	63240.81
April	45027.59
May	30543.13
June	19512.87
July	15804.48
August	18313.12
September	27411.1
October	50511.43
November	60672.58
December	70002.91
Yearly	**551188.3**

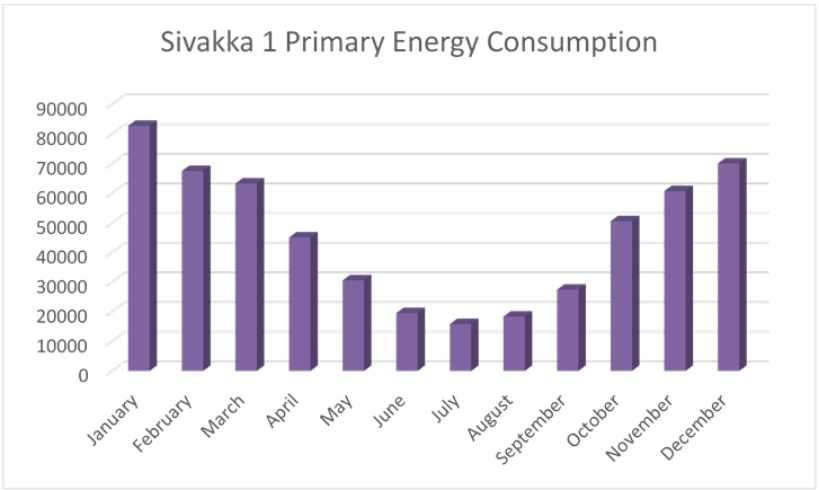

Figure 7: Sivakka 1 primary energy consumption

E2.2. Primary Energy Consumption per m², as shown in

Month	Primary energy consumption per m² [kWh]
January	29.32547153
February	23.91858237
March	22.42582087
April	15.96722975
May	10.8308974
June	6.919455792
July	5.604426478
August	6.494015603
September	9.720246572
October	17.91185603
November	21.51509787
December	24.82372719
Yearly	**195.4568275**

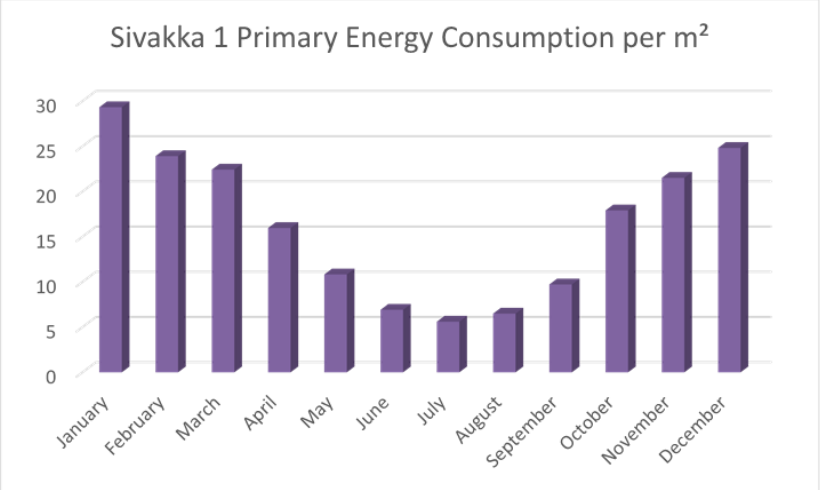

Figure 8, is calculated with the following formula:

PECb = (ERTC_b * PEFt + ERECb * PEFe)/Ab. The factor of primary thermal is PEFt = 1.3 and the factor of primary electricity is PEFe = 2.4.

Month	Primary energy consumption per m² [kWh]
January	29.32547153
February	23.91858237
March	22.42582087
April	15.96722975
May	10.8308974
June	6.919455792
July	5.604426478
August	6.494015603
September	9.720246572
October	17.91185603
November	21.51509787
December	24.82372719
Yearly	**195.4568275**

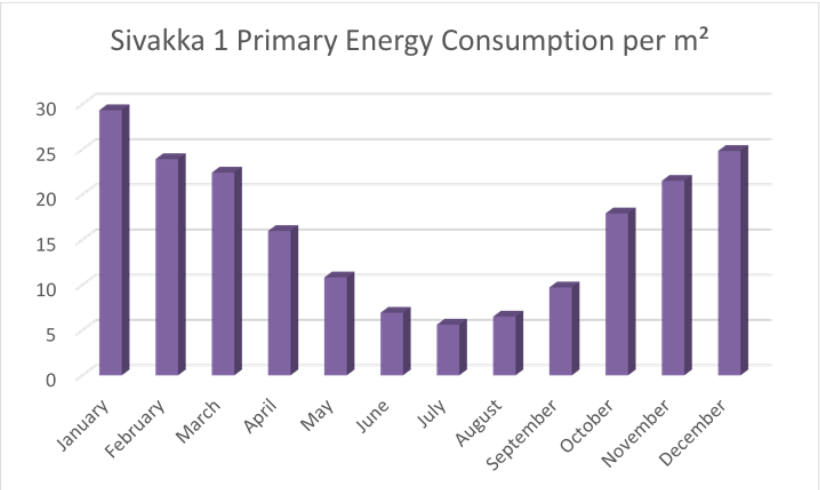

Figure 8: Sivakka 1 primary energy consumption per m²

4.1.1.3 E3: Energy imported to PED

There is no energy production in PED area and hence energy imported to PED is equal to E1: Final energy consumption.

4.1.1.4 E4: Energy exported from PED

The baseline value of E4: Energy exported from PED is 0. There is no energy production in PED area.

4.1.1.5 E5: RES production

The baseline value of E5: RES production is 0. There is no energy production in PED area.

4.1.1.6 E6: PED energy balance

The annual energy balance of the PED area is presented in chapter 4.1.7.

4.1.1.7 E7: Energy savings in the PED

The baseline value of E7: Energy savings in the PED is 0. There is no energy production in PED area.

4.1.1.8 E8: GHG emissions

KPI specification and formula define the following attributes:

E8.2 Greenhouse gas emissions for building per m², as shown in

Month	Greenhouse gas emissions per m² [kWh]
January	2.985671
February	2.417477
March	2.238808
April	1.539983
May	0.961471
June	0.544454
July	0.398661
August	0.473305
September	0.824952
October	1.724642
November	2.124469
December	2.481809
Yearly	**18.7157**

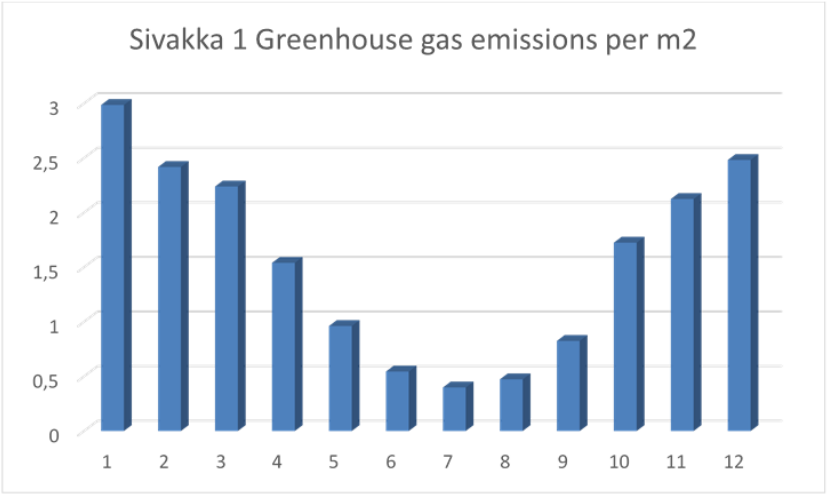

Figure 9, are calculated with the following formula:

GGE_b = (TEC_b · GEFT + EEC_b · GEFE) / Ab. GHG emission value for CO2 district heat is GEFT = 0.15 kgCO2/kWhth and for CO2 electricity is GEFE = 0.072 kgCO2/kWhe.

Month	Greenhouse gas emissions per m² [kWh]
January	2.985671
February	2.417477
March	2.238808
April	1.539983
May	0.961471
June	0.544454
July	0.398661
August	0.473305
September	0.824952
October	1.724642
November	2.124469
December	2.481809
Yearly	**18.7157**

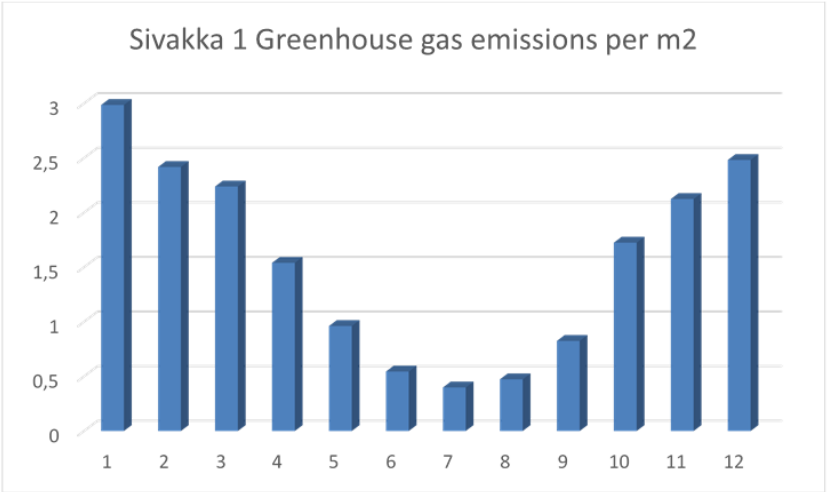

Figure 9: Sivakka 1 greenhouse gas emissions per m²

4.1.1.9 E9: Reduction of emissions

The baseline value of E9: Reduction of emissions is **0**. There is no energy production in PED area.

4.1.2 Intervention 2.1: New rental house (Sivakka 2.1)

Table 5 contains basic information about building 2.1. Building 2.1 is referred as Sivakka 2.1. Baseline data of the building is simulated which refers to the hourly data that is collected from the residential building with comparable energy consumption qualities. Baseline data is calculated as an average of the monthly consumptions and scaled to match Sivakka 2.1 requirements.

Table 5: Basic information of residential building Sivakka 2.1.

Building name	Heated area, m²	Heated volume, m³	Monitored or simulated building data?	Year of construction / retrofit
Sivakka 2.1	2654	N/A	Simulated with reference	2021

4.1.2.1 E1: Final energy consumption

KPI specification and formula define the following attributes:

E1.1 Thermal Energy demand simulated (TEDb), as shown in

Month	Thermal energy demand [kWh]
January	31496.3
February	29187.9
March	26358.8
April	17349.1
May	10803.7
June	5241.6
July	4475
August	4662.46
September	8777.2
October	15449.4
November	21216.4
December	25924.9
Yearly	200943

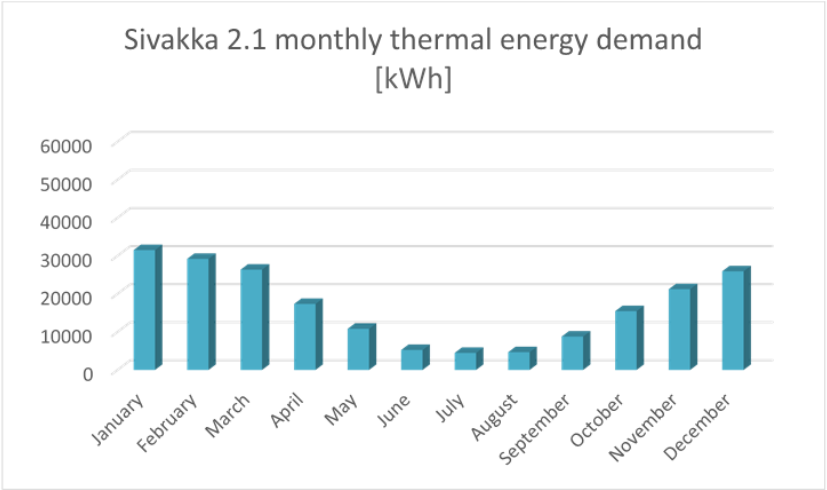

Figure 10, is composed of:

Thermal energy demand (H&C) + Thermal energy demand (DHW)

Month	Thermal energy demand [kWh]
January	31496.3
February	29187.9
March	26358.8
April	17349.1
May	10803.7
June	5241.6
July	4475
August	4662.46
September	8777.2
October	15449.4
November	21216.4
December	25924.9
Yearly	200943

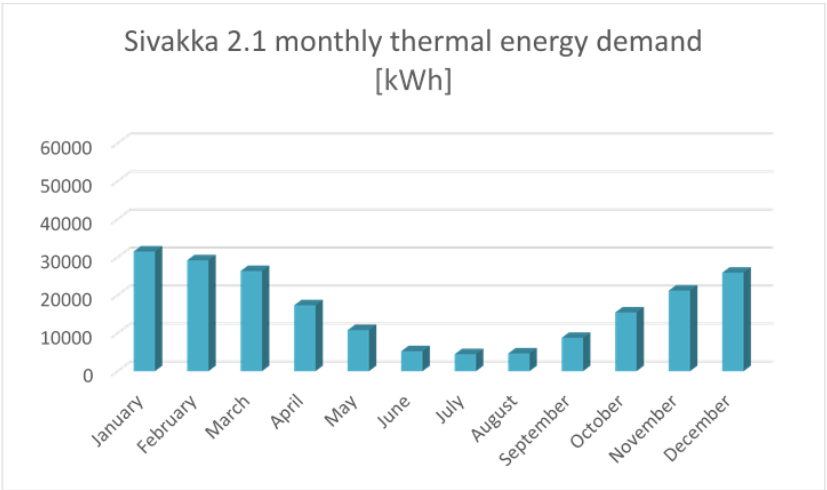

Figure 10: Sivakka 2.1 thermal energy demand

E1.1 Thermal Energy demand simulated per m² (TEDb), as shown in

Month	Thermal energy demand per m² [kWh]
January	11.8675
February	10.9977
March	9.93173
April	6.53697
May	4.07071
June	1.97498
July	1.68613
August	1.75677
September	3.30716
October	5.82117
November	7.99411
December	9.76824
Yearly	75.7132

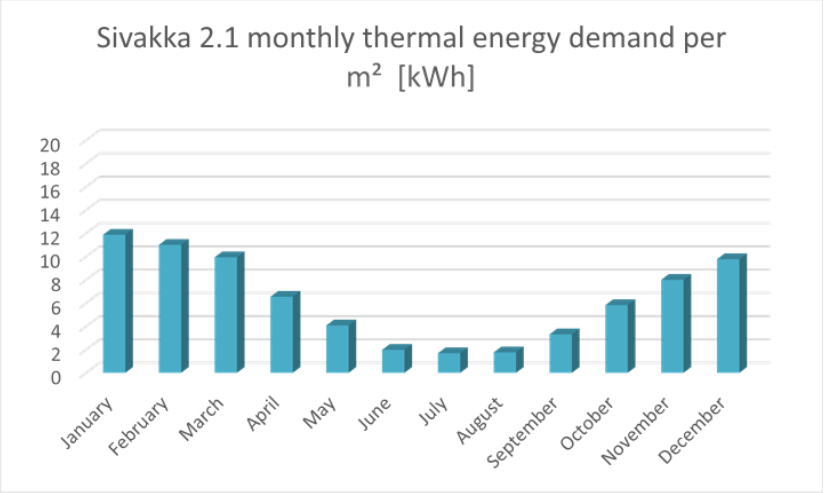

Figure 11, is composed of:

(Thermal energy demand (H&C) + Thermal energy demand (DHW))/ building area

Month	Thermal energy demand per m² [kWh]
January	11.8675
February	10.9977
March	9.93173
April	6.53697
May	4.07071
June	1.97498
July	1.68613
August	1.75677
September	3.30716
October	5.82117
November	7.99411
December	9.76824
Yearly	75.7132

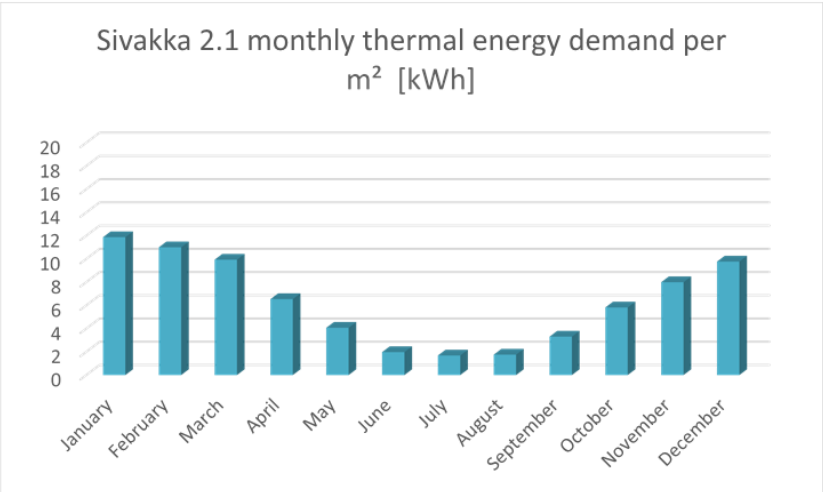

Figure 11: Sivakka 2.1 thermal energy demand per m²

E1.2 Electrical Energy demand simulated (EEDb), as shown in

Month	Electrical energy demand [kWh]
January	3834
February	3400.74
March	3771.17
April	3606.87
May	3478.23
June	3157.49
July	3393.5
August	3515.95
September	3405.84
October	3604.39
November	3733.83
December	3938.99
Yearly	42841

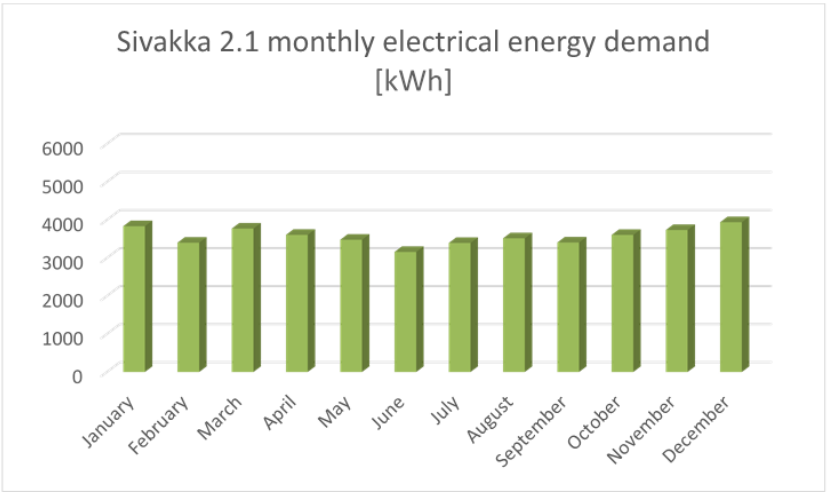

Figure 12, is composed of:

Electrical energy demand (heat pumps) + Electrical energy demand (lighting + ventilation)

Month	Electrical energy demand [kWh]
January	3834
February	3400.74
March	3771.17
April	3606.87
May	3478.23
June	3157.49
July	3393.5
August	3515.95
September	3405.84
October	3604.39
November	3733.83
December	3938.99
Yearly	42841

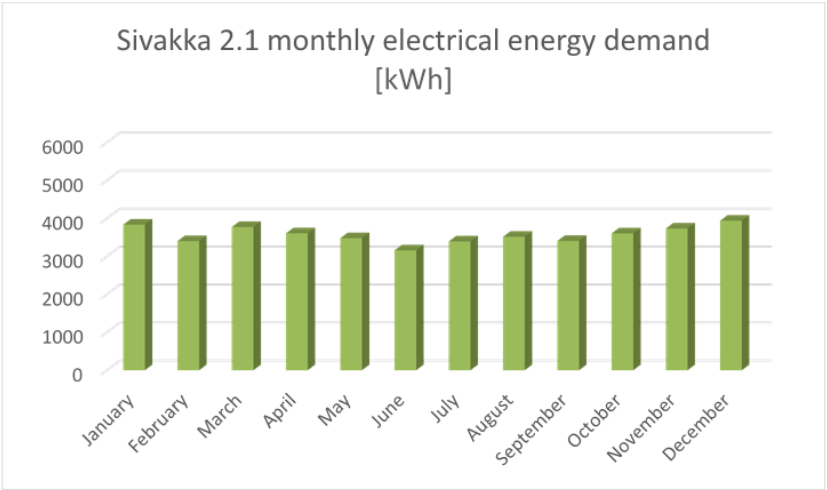

Figure 12: Sivakka 2.1 electrical energy demand

E1.2 Electrical Energy demand simulated per m2 (EEDb), as shown in Figure 13, is composed of:

Electrical energy demand (heat pumps) + Electrical energy demand (lighting+ventilation)/ / building area

Month	Electrical energy demand per m2 [kWh]
January	1.44461
February	1.28136
March	1.42094
April	1.35903
May	1.31056
June	1.18971
July	1.27863
August	1.32478
September	1.28329
October	1.3581
November	1.40687
December	1.48417
Yearly	16.1421

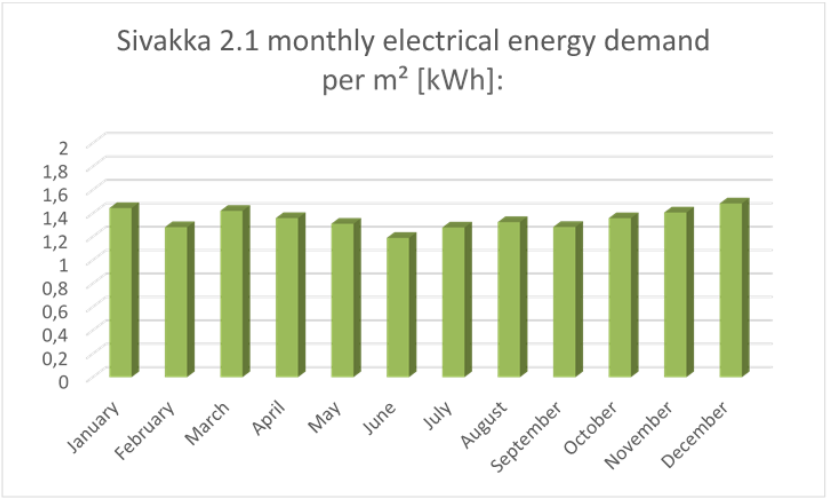

Figure 13: Sivakka 2.1 electrical energy demand per m²

4.1.2.2 E2: Primary energy consumption

KPI specification and formula define the following attributes:

E2.1. Primary Energy Demand (simulated), as shown in

Month	Primary energy demand [kWh]
January	50146.8296
February	46106.0831
March	43317.2722
April	31210.3614
May	22392.5129
June	14392.0679
July	13961.8899
August	14499.4888
September	19584.3819
October	28734.7296
November	36542.4498
December	43155.9421
Yearly	**364044.009**

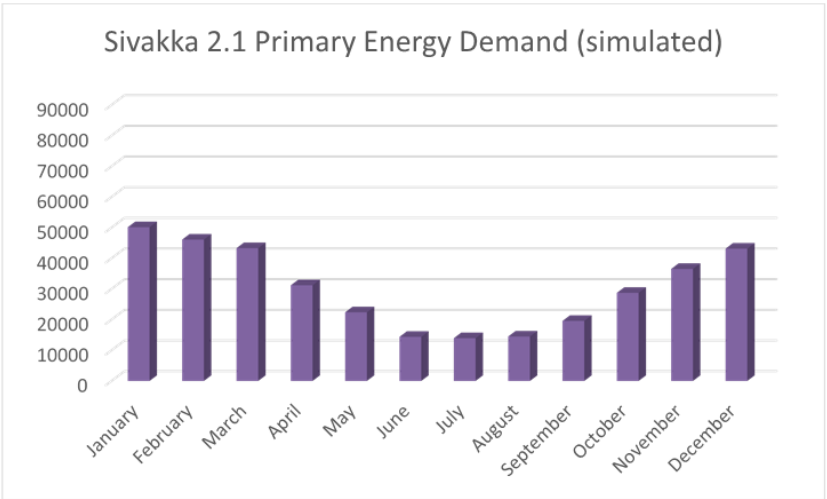

Figure 14, is calculated with the following formula:

PEDb = (ERTD_b * PEFt + EREDb * PEFe). The factor of primary thermal is PEFt = 1.3 and the factor of primary electricity is PEFe = 2.4.

Month	Primary energy demand [kWh]
January	50146.8296
February	46106.0831
March	43317.2722
April	31210.3614
May	22392.5129
June	14392.0679
July	13961.8899
August	14499.4888
September	19584.3819
October	28734.7296
November	36542.4498
December	43155.9421
Yearly	**364044.009**

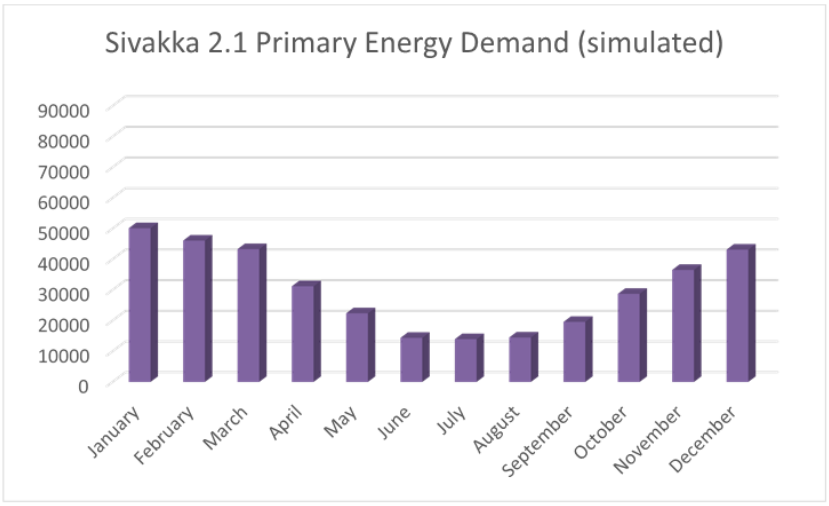

Figure 14: Sivakka 2.1 primary energy demand

E2.2. Primary Energy Consumption per m², as shown in

Month	Primary energy demand per m² [kWh]
January	18.8948115
February	17.3722996
March	16.3215042
April	11.7597443
May	8.43726936
June	5.42278368
July	5.26069702
August	5.46325878
September	7.37919438
October	10.8269516
November	13.7688206
December	16.2607167
Yearly	**137.168052**

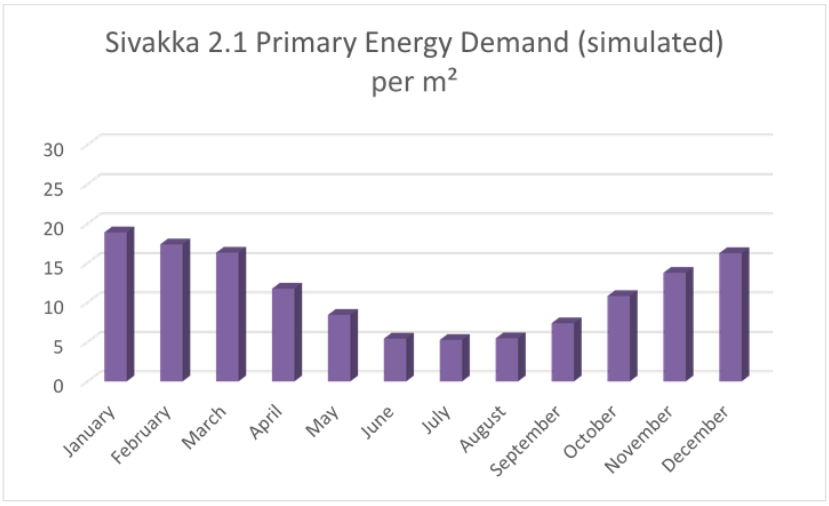

Figure 15, is calculated with the following formula:

PEDb = (ERTD_b * PEFt + EREDb * PEFe)/Ab. The factor of primary thermal is PEFt = 1.3 and the factor of primary electricity is PEFe = 2.4.

Month	Primary energy demand per m² [kWh]
January	18.8948115
February	17.3722996
March	16.3215042
April	11.7597443
May	8.43726936
June	5.42278368
July	5.26069702
August	5.46325878
September	7.37919438
October	10.8269516
November	13.7688206
December	16.2607167
Yearly	**137.168052**

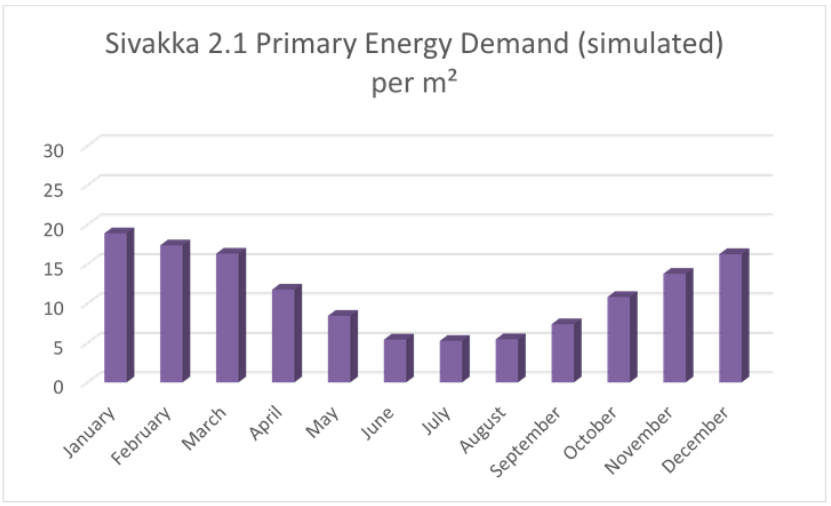

Figure 15: Sivakka 2.1 primary energy demand per m²

4.1.2.3 E3: Energy imported to PED

There is no energy production in PED area and hence energy imported to PED is equal to E1: Final energy consumption.

4.1.2.4 E4: Energy exported from PED

The baseline value of E4: Energy exported from PED is 0. There is no energy production in PED area.

4.1.2.5 E5: RES production

The baseline value of E5: RES production is 0. There is no energy production in PED area.

4.1.2.6 E6: PED energy balance

The annual energy balance of the PED area is presented in chapter 4.1.7.

4.1.2.7 E7: Energy savings in the PED

The baseline value of E7: Energy savings in the PED is 0. There is no energy production in PED area.

4.1.2.8 E8: GHG emissions

KPI specification and formula define the following attributes:

E8.2 Greenhouse gas emissions for building per m², as shown in

Month	Greenhouse gas emissions per m² [kWh]
January	1.884136033
February	1.741914943
March	1.592067587
April	1.078396464
May	0.704967185
June	0.381906539
July	0.34498175
August	0.358898947
September	0.588470378
October	0.970958024
November	1.300410525
December	1.572095828
Yearly	**12.5192042**

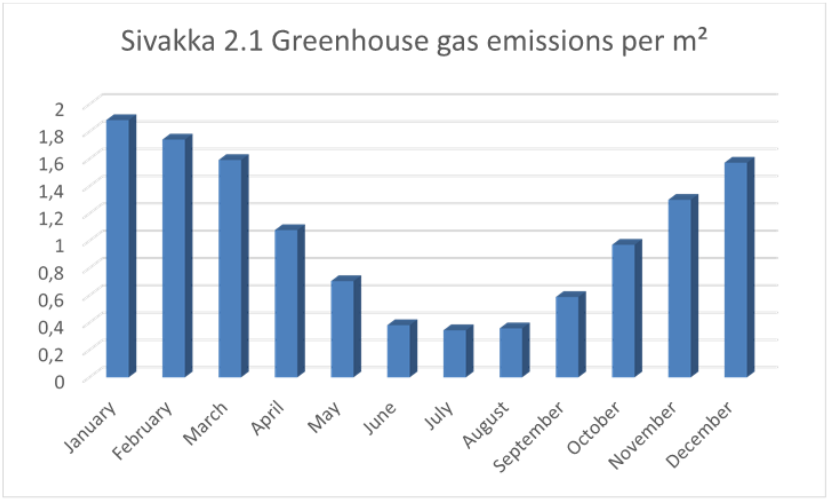

Figure 16, are calculated with the following formula:

GGE_b = (TEC_b · GEFT + EEC_b · GEFE) / Ab. GHG emission value for CO2 district heat is GEFT = 0.15 kgCO2/kWhth and for CO2 electricity is GEFE = 0.072 kgCO2/kWhe.

Month	Greenhouse gas emissions per m² [kWh]
January	1.884136033
February	1.741914943
March	1.592067587
April	1.078396464
May	0.704967185
June	0.381906539
July	0.34498175
August	0.358898947
September	0.588470378
October	0.970958024
November	1.300410525
December	1.572095828
Yearly	**12.5192042**

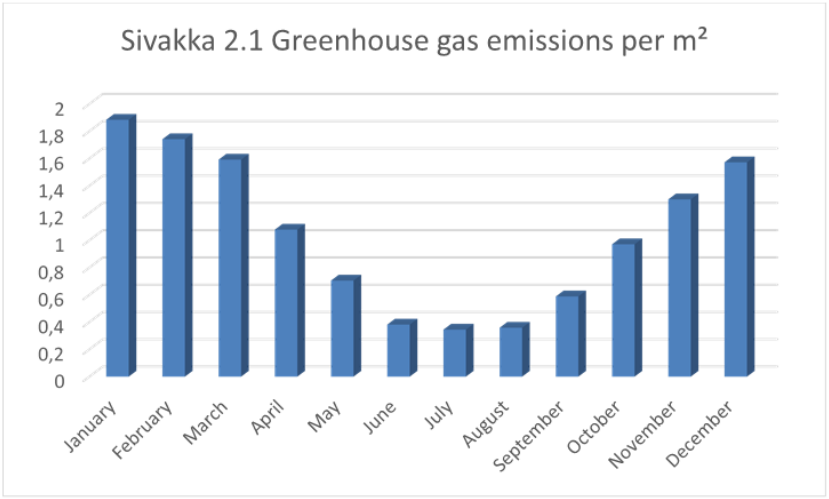

Figure 16: Sivakka 2.1 greenhouse gas emissions per m²

4.1.2.9 E9: Reduction of emissions

The baseline value of E9: Reduction of emissions is 0. There is no energy production in PED area.

4.1.3 Intervention 2.2: New rental house (Sivakka 2.2)

Table 6 contains basic information about building 2.2. Building 2.2 is referred as Sivakka 2.2. Baseline data of the building is simulated which refers to the hourly and monthly data that is collected from the residential building with comparable energy consumption qualities. Baseline data is calculated as an average of the monthly consumptions and scaled to match Sivakka 2.2 requirements.

Table 6: Basic information of residential building Sivakka 2.2.

Building name	Heated area, m^2	Heated volume, m^3	Monitored or simulated building data?	Year of construction / retrofit
Sivakka 2.2	3618	N/A	Simulated	2021

4.1.3.1 E1: Final energy consumption

KPI specification and formula define the following attributes:

E1.1 Thermal Energy demand simulated (TEDb), as shown in

Month	Thermal energy demand [kWh]
January	42329.8
February	38664.6
March	33761.0
April	22164.6
May	14931.3
June	8412.2
July	7195.2
August	8009.7
September	12919.9
October	21735.5
November	29498.3
December	33903.7
Yearly	273525.8

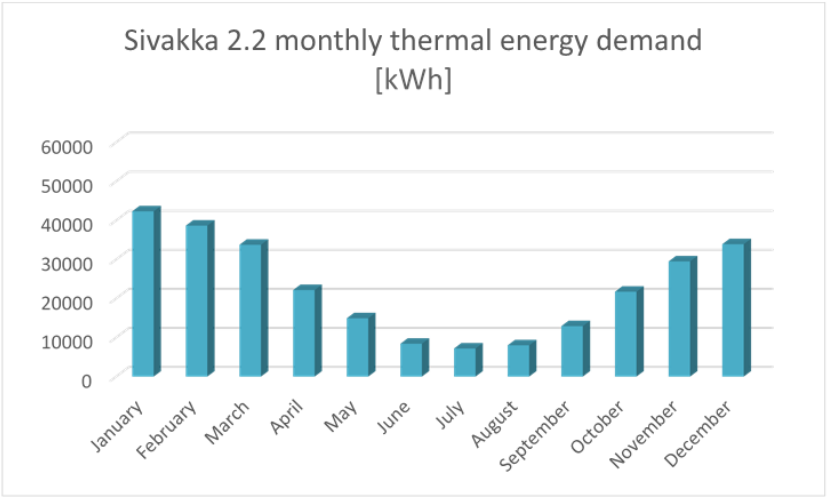

Figure 17, is composed of:

Thermal energy demand (H&C) + Thermal energy demand (DHW)

Month	Thermal energy demand [kWh]
January	42329.8
February	38664.6
March	33761.0
April	22164.6
May	14931.3
June	8412.2
July	7195.2
August	8009.7
September	12919.9
October	21735.5
November	29498.3
December	33903.7
Yearly	273525.8

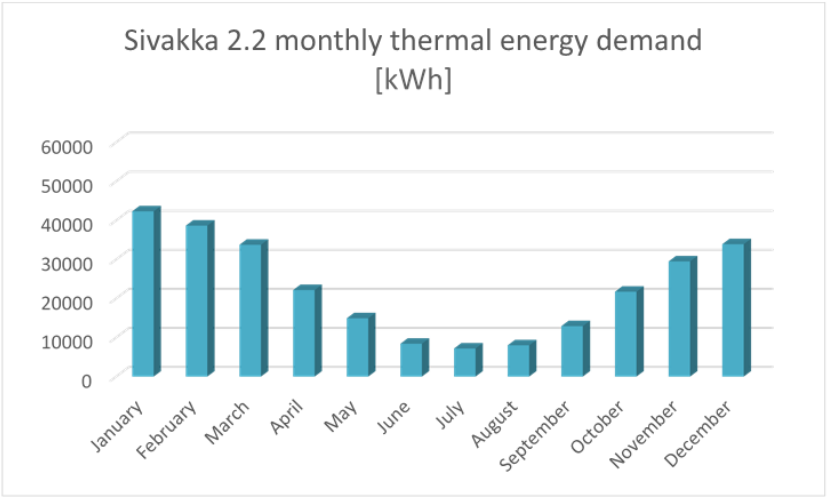

Figure 17: Sivakka 2.2 thermal energy demand

E1.1 Thermal Energy demand simulated per m² (TEDb), as shown in

Month	Thermal energy demand per m² [kWh]
January	11.69978089
February	10.68673648
March	9.331405917
April	6.126208661
May	4.126943544
June	2.325085069
July	1.988719601
August	2.213851824
September	3.571017252
October	6.007599636
November	8.153202168
December	9.37083613
Yearly	75.60

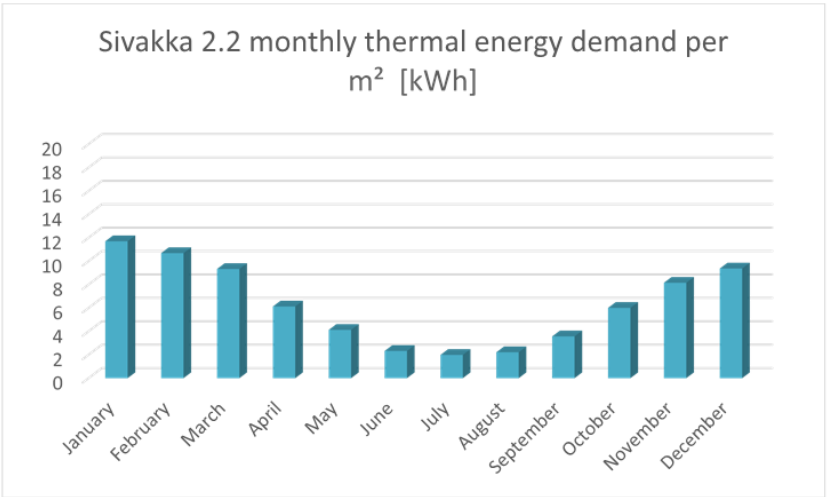

Figure 18, is composed of:

(Thermal energy demand (H&C) + Thermal energy demand (DHW))/ building area

Month	Thermal energy demand per m² [kWh]
January	11.69978089
February	10.68673648
March	9.331405917
April	6.126208661
May	4.126943544
June	2.325085069
July	1.988719601
August	2.213851824
September	3.571017252
October	6.007599636
November	8.153202168
December	9.37083613
Yearly	75.60

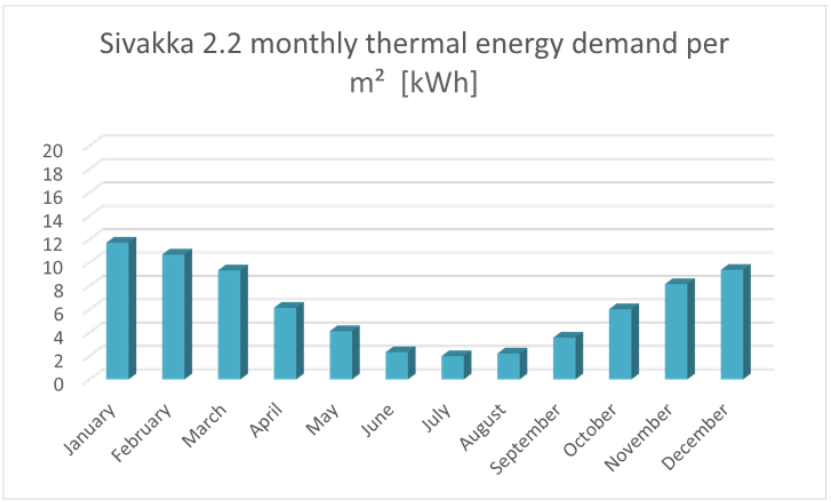

Figure 18: Sivakka 2.2 thermal energy demand per m²

E1.2 Electrical Energy demand simulated (EEDb), as shown in

Month	Electrical energy demand [kWh]
January	3280.106
February	4567.482
March	4194.954
April	3971.944
May	3721.058
June	3751.468
July	3768.363
August	3892.539
September	3913.657
October	4439.082
November	4461.046
December	4450.064
Yearly	48411.76

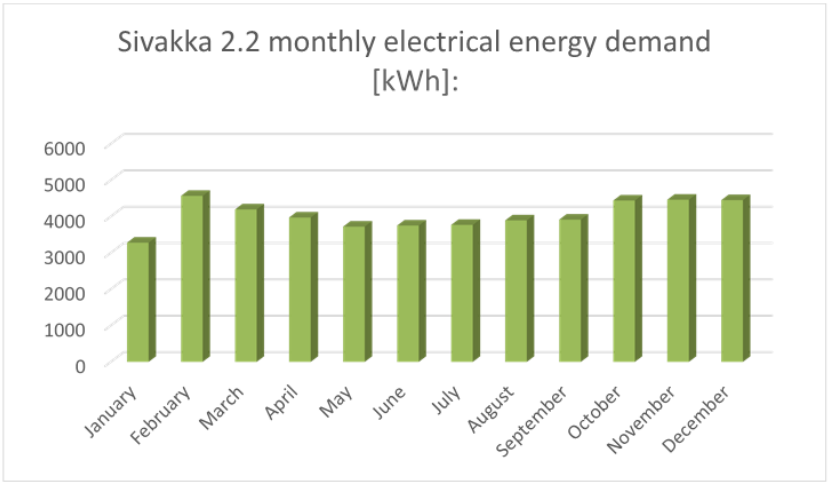

Figure 19, is composed of:

Electrical energy demand (heat pumps) + Electrical energy demand (lighting + ventilation)

Month	Electrical energy demand [kWh]
January	3280.106
February	4567.482
March	4194.954
April	3971.944
May	3721.058
June	3751.468
July	3768.363
August	3892.539
September	3913.657
October	4439.082
November	4461.046
December	4450.064
Yearly	48411.76

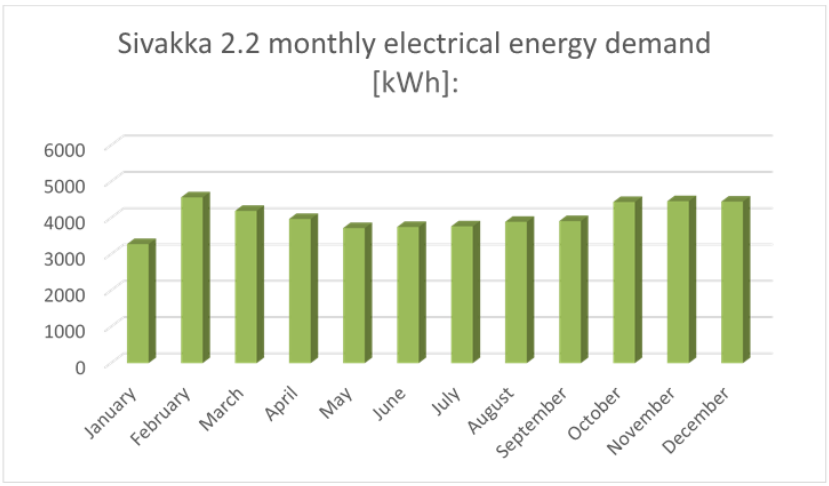

Figure 19: Sivakka 2.2 electrical energy demand

E1.2 Electrical Energy demand simulated per m² (EEDb), as shown in

Month	Electrical energy demand per m² [kWh]
January	0.906608
February	1.262433
March	1.159468
April	1.097829
May	1.028485
June	1.03689
July	1.04156
August	1.075881
September	1.081718
October	1.226944
November	1.233014
December	1.229979
Yearly	13.38081

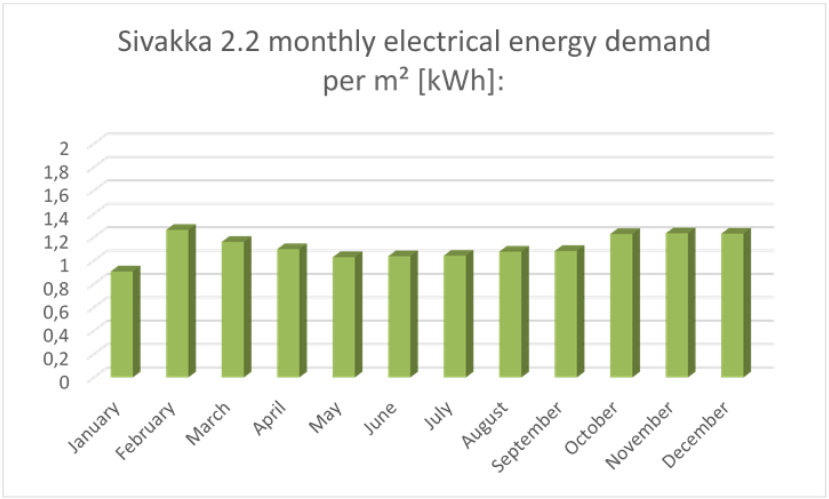

Figure 20, is composed of:

Electrical energy demand (heat pumps) + Electrical energy demand (lighting+ventilation)/ / building area

Month	Electrical energy demand per m² [kWh]
January	0.906608
February	1.262433
March	1.159468
April	1.097829
May	1.028485
June	1.03689
July	1.04156
August	1.075881
September	1.081718
October	1.226944
November	1.233014
December	1.229979
Yearly	13.38081

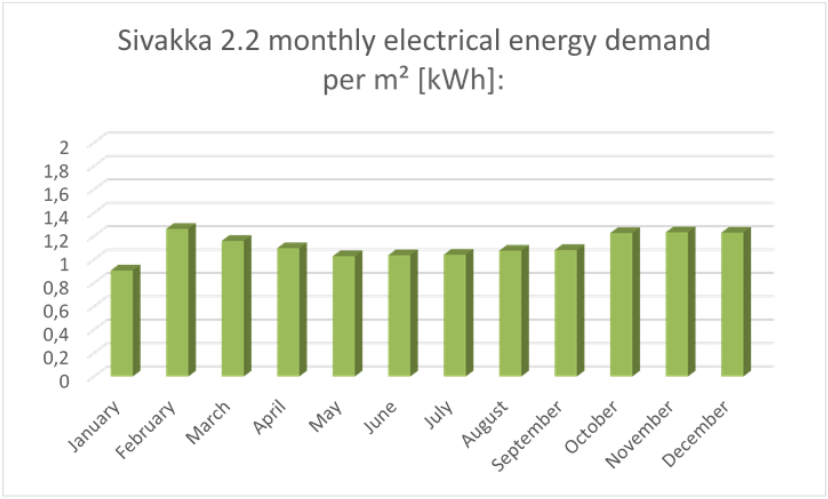

Figure 20: Sivakka 2.2 electrical energy demand per m²

4.1.3.2 E2: Primary energy consumption

KPI specification and formula define the following attributes:

E2.1. Primary Energy Demand (simulated), as shown in Figure 21, is calculated with the following formula:

PEDb = (ERTD_b * PEFt + EREDb * PEFe). The factor of primary thermal is PEFt = 1.3 and the factor of primary electricity is PEFe = 2.4.

Month	Primary energy demand [kWh]
January	62901.0038
February	61225.9535
March	53957.2242
April	38346.6753
May	28341.2047
June	19939.3286
July	18397.8146
August	19754.724
September	26188.6999
October	38909.9419
November	49054.2803
December	54754.9442
Yearly	**471771.795**

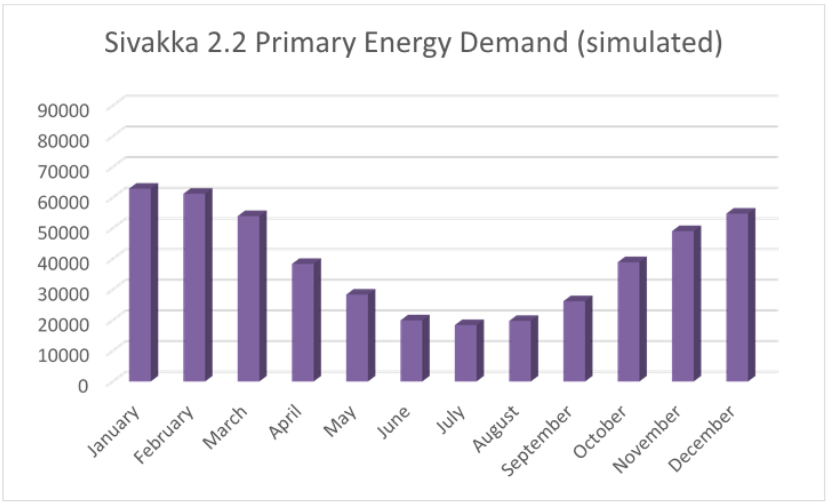

Figure 21: Sivakka 2.2 primary energy demand

E2.2. Primary Energy Demand per m², as shown in

Month	Primary energy demand per m² [kWh]
January	17.3855732
February	16.92259632
March	14.91355008
April	10.59885996
May	7.833389904
June	5.511146662
July	5.085078652
August	5.460122711
September	7.238446639
October	10.75454448
November	13.558397
December	15.13403654
Yearly	**130.3957421**

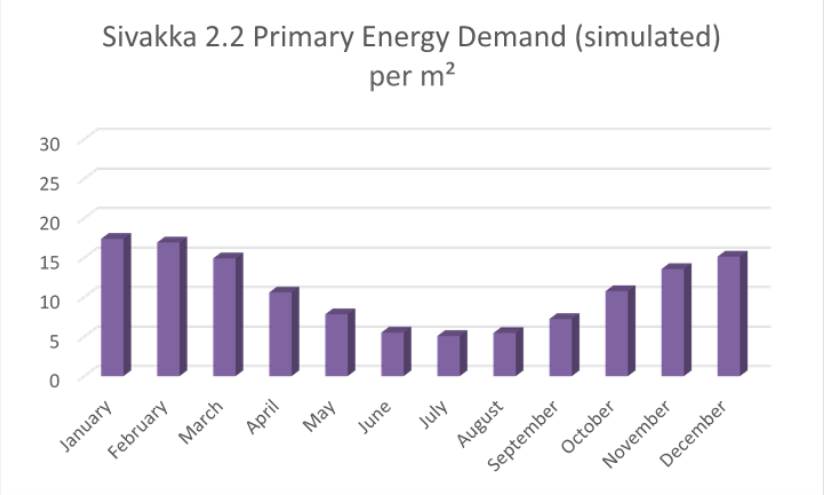

Figure 22, is calculated with the following formula:

PEDb = (ERTD_b * PEFt + EREDb * PEFe)/Ab. The factor of primary thermal is PEFt = 1.3 and the factor of primary electricity is PEFe = 2.4.

Month	Primary energy demand per m² [kWh]
January	17.3855732
February	16.92259632
March	14.91355008
April	10.59885996
May	7.833389904
June	5.511146662
July	5.085078652
August	5.460122711
September	7.238446639
October	10.75454448
November	13.558397
December	15.13403654
Yearly	**130.3957421**

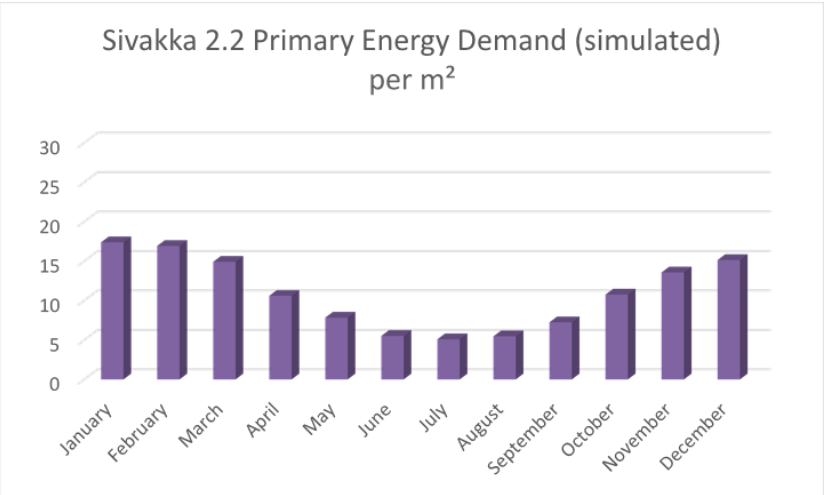

Figure 22: Sivakka 2.2 primary energy demand per m²

4.1.3.3 E3: Energy imported to PED

There is no energy production in PED area and hence energy imported to PED is equal to E1: Final energy consumption.

4.1.3.4 E4: Energy exported from PED

The baseline value of E4: Energy exported from PED is 0. There is no energy production in PED area.

4.1.3.5 E5: RES production

The baseline value of E5: RES production is 0. There is no energy production in PED area.

4.1.3.6 E6: PED energy balance

The annual energy balance of the PED area is presented in chapter 4.1.7.

4.1.3.7 E7: Energy savings in the PED

The baseline value of E7: Energy savings in the PED is 0. There is no energy production in PED area.

4.1.3.8 E8: GHG emissions

KPI specification and formula define the following attributes:

E8.2 Greenhouse gas emissions for building per m², as shown in

Month	Greenhouse gas emissions per m² [kWh]
January	1.820242874
February	1.693905639
March	1.483192559
April	0.99797496
May	0.69309243
June	0.423418842
July	0.373300235
August	0.409541234
September	0.613536314
October	0.989479894
November	1.311757351
December	1.494183907
Yearly	**12.30362624**

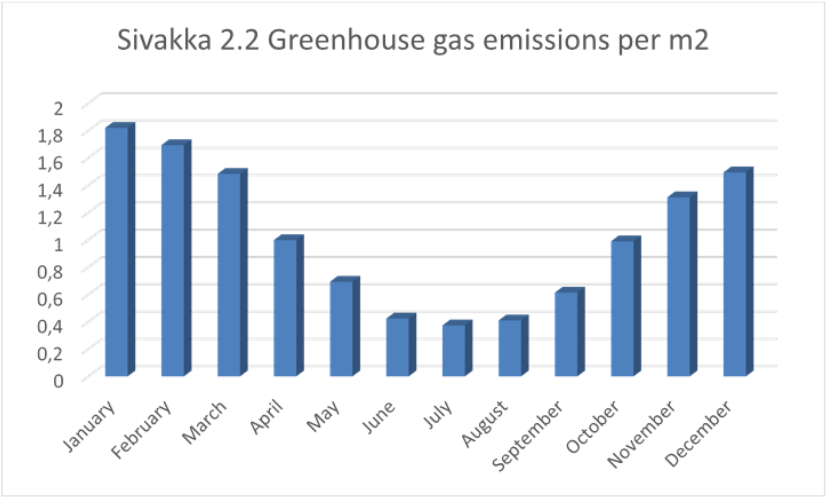

Figure 23, are calculated with the following formula:

GGE_b = (TEC_b · GEFT + EEC_b · GEFE) / Ab. GHG emission value for CO2 district heat is GEFT = 0.15 kgCO2/kWhth and for CO2 electricity is GEFE = 0.072 kgCO2/kWhe.

Month	Greenhouse gas emissions per m² [kWh]
January	1.820242874
February	1.693905639
March	1.483192559
April	0.99797496
May	0.69309243
June	0.423418842
July	0.373300235
August	0.409541234
September	0.613536314
October	0.989479894
November	1.311757351
December	1.494183907
Yearly	**12.30362624**

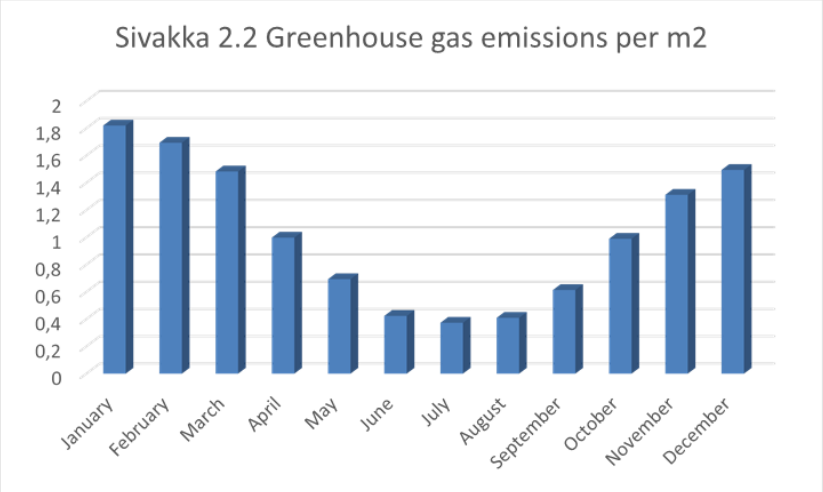

Figure 23: Sivakka 2.2 greenhouse gas emissions per m²

4.1.3.9 E9: Reduction of emissions

The baseline value of E9: Reduction of emissions is 0. There is no energy production in PED area.

4.1.4 Intervention 3: New private house (YIT 3)

Table 7 contains basic information about building 3. Building 3 is referred as YIT 3. Baseline data of the building is simulated which refers to the hourly data that is collected from the residential building with comparable energy consumption qualities. Baseline data is calculated as an average of the monthly consumptions and scaled to match YIT 3 requirements.

Table 7: Basic information of residential building YIT 3.

Building name	Heated area, m²	Heated volume, m³	Monitored or simulated building data?	Year of construction / retrofit
YIT 3	2932	N/A	Simulated	2020

4.1.4.1 E1: Final energy consumption

KPI specification and formula define the following attributes:

E1.1 Thermal Energy demand simulated (TEDb), as shown in

Month	Thermal energy demand [kWh]
January	34549.62
February	31789.4
March	28239.76
April	18564.23
May	12017.76
June	6303.899
July	5387.335
August	5820.928
September	10083.41
October	17340.97
November	23671.96
December	28057.88
Yearly	221827.2

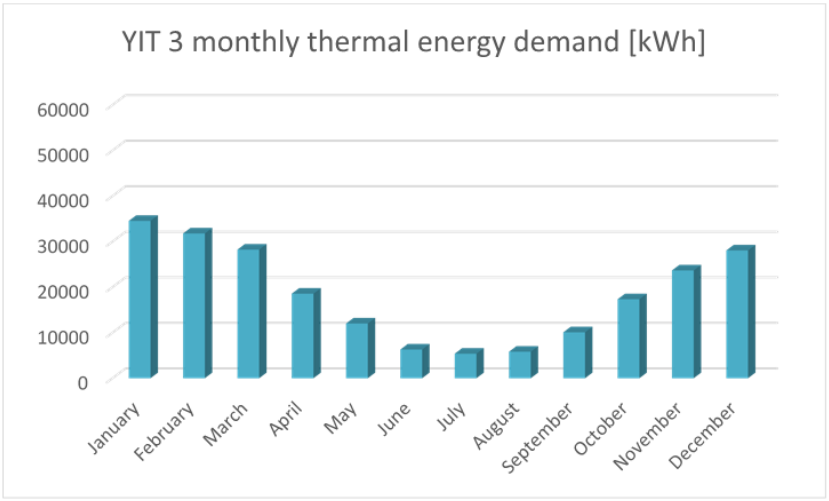

Figure 24, is composed of:

Thermal energy demand (H&C) + Thermal energy demand (DHW)

Month	Thermal energy demand [kWh]
January	34549.62
February	31789.4
March	28239.76
April	18564.23
May	12017.76
June	6303.899
July	5387.335
August	5820.928
September	10083.41
October	17340.97
November	23671.96
December	28057.88
Yearly	221827.2

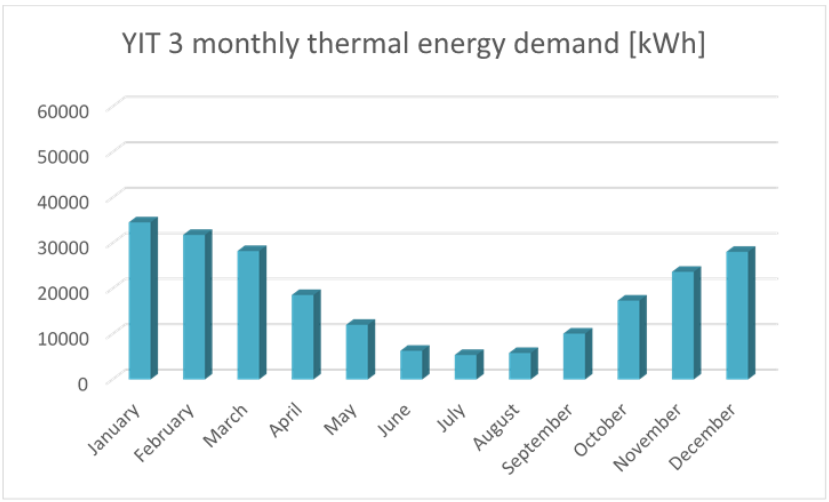

Figure 24: YIT 3 thermal energy demand

E1.1 Thermal Energy demand simulated per m² (TEDb), as shown in

Month	Thermal energy demand per m² [kWh]
January	11.78364
February	10.84222
March	9.63157
April	6.331591
May	4.098828
June	2.150034
July	1.837427
August	1.98531
September	3.439088
October	5.914383
November	8.073655
December	9.569537
Yearly	75.65728

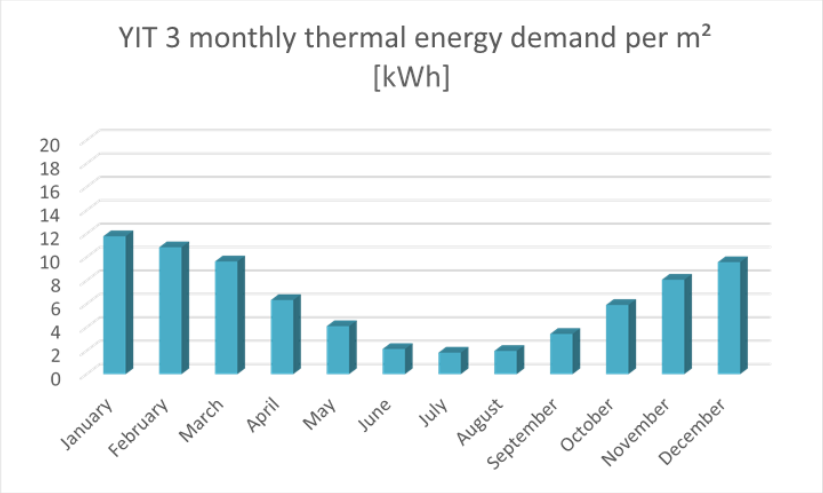

Figure 25, is composed of:

(Thermal energy demand (H&C) + Thermal energy demand (DHW))/ building area

Month	Thermal energy demand per m² [kWh]
January	11.78364
February	10.84222
March	9.63157
April	6.331591
May	4.098828
June	2.150034
July	1.837427
August	1.98531
September	3.439088
October	5.914383
November	8.073655
December	9.569537
Yearly	75.65728

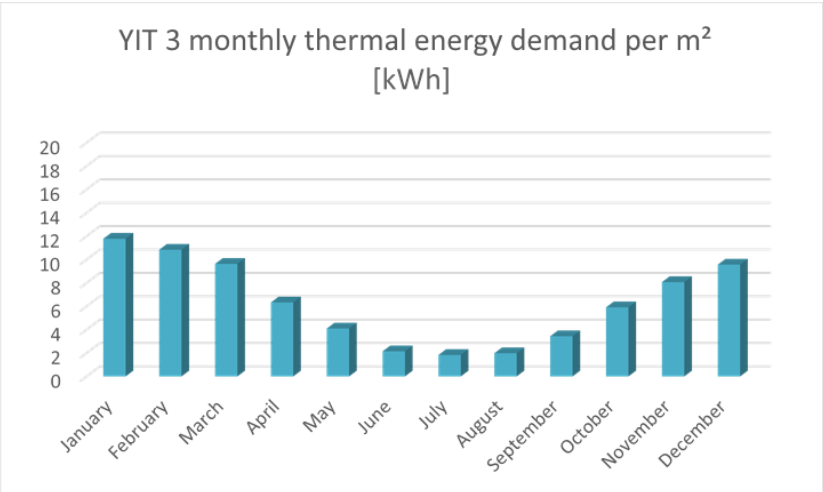

Figure 25: YIT 3 thermal energy demand per m²

E1.2 Electrical Energy demand simulated (EEDb), as shown in Figure 26, is composed of:

Electrical energy demand (heat pumps) + Electrical energy demand (lighting + ventilation)

Month	Electrical energy demand [kWh]
January	3446.889
February	3729.207
March	3782.874
April	3601.758
May	3429.039
June	3264.197
July	3401.405
August	3519.363
September	3467.098
October	3789.671
November	3870.066
December	3978.943
Yearly	43280.51

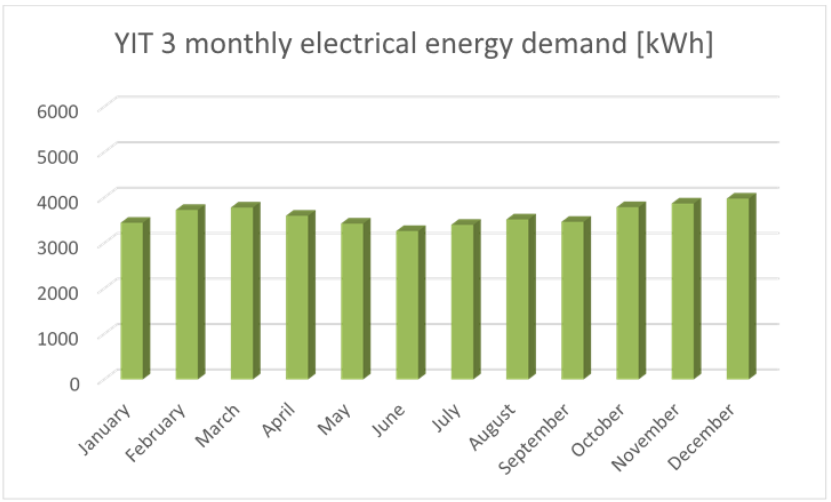

Figure 26: YIT 3 electrical energy demand

E1.2 Electrical Energy demand simulated per m² (EEDb), as shown in Figure 27, is composed of:

Electrical energy demand (heat pumps) + Electrical energy demand (lighting+ventilation)/ / building area

Month	Electrical energy demand per m² [kWh]
January	1.17561
February	1.271899
March	1.290203
April	1.228431
May	1.169522
June	1.113301
July	1.160097
August	1.200328
September	1.182503
October	1.292521
November	1.319941
December	1.357075
Yearly	14.76143

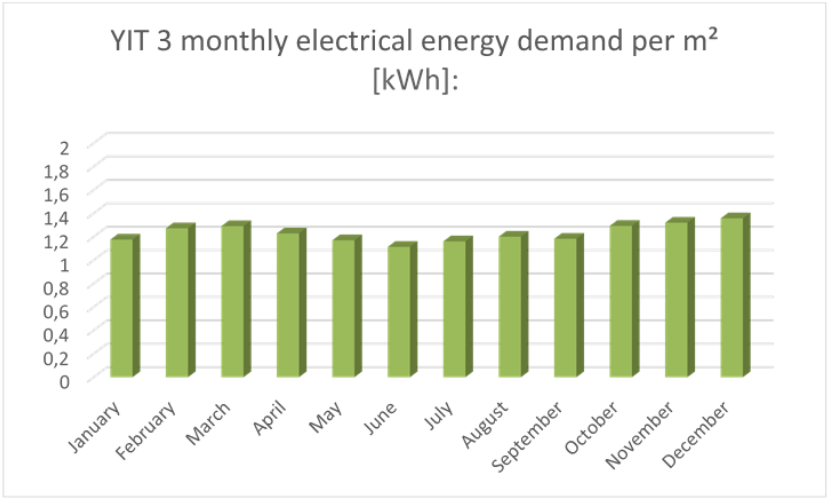

Figure 27: YIT 3 electrical energy demand per m²

4.1.4.2 E2: Primary energy consumption

KPI specification and formula define the following attributes:

E2.1. Primary Energy Demand (simulated), as shown in

Month	Primary energy demand [kWh]
January	53187.04
February	50276.32
March	45790.59
April	32777.71
May	23852.79
June	16029.14
July	15166.91
August	16013.68
September	21429.46
October	31638.47
November	40061.7
December	46024.71
Yearly	**392248.5**

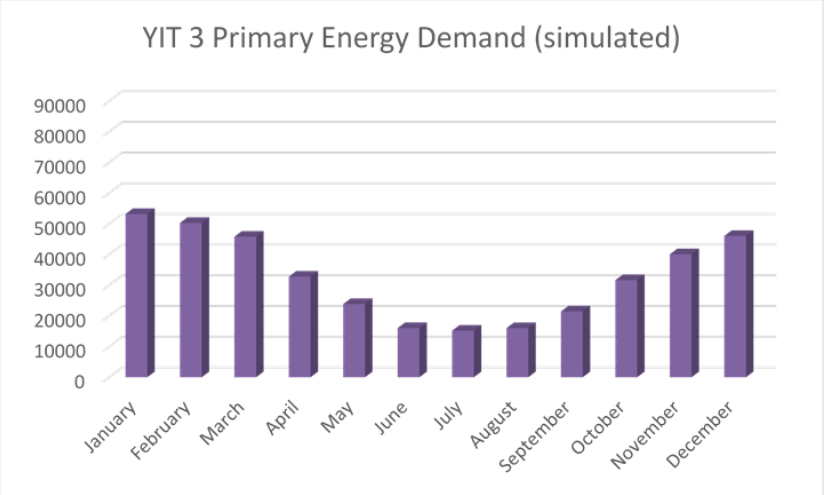

Figure 28, is calculated with the following formula:

PEDb = (ERTD_b * PEFt + EREDb * PEFe). The factor of primary thermal is PEFt = 1.3 and the factor of primary electricity is PEFe = 2.4.

Month	Primary energy demand [kWh]
January	53187.04
February	50276.32
March	45790.59
April	32777.71
May	23852.79
June	16029.14
July	15166.91
August	16013.68
September	21429.46
October	31638.47
November	40061.7
December	46024.71
Yearly	**392248.5**

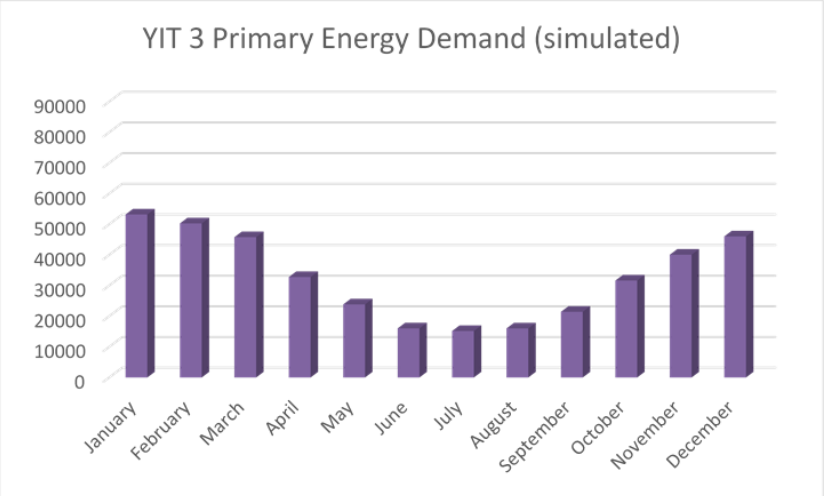

Figure 28: YIT 3 primary energy demand

E2.2. Primary Energy Demand per m², as shown in

Month	Primary energy demand per m² [kWh]
January	18.14019
February	17.14745
March	15.61753
April	11.1793
May	8.13533
June	5.466965
July	5.172888
August	5.461691
September	7.308821
October	10.79075
November	13.66361
December	15.69738
Yearly	**133.7819**

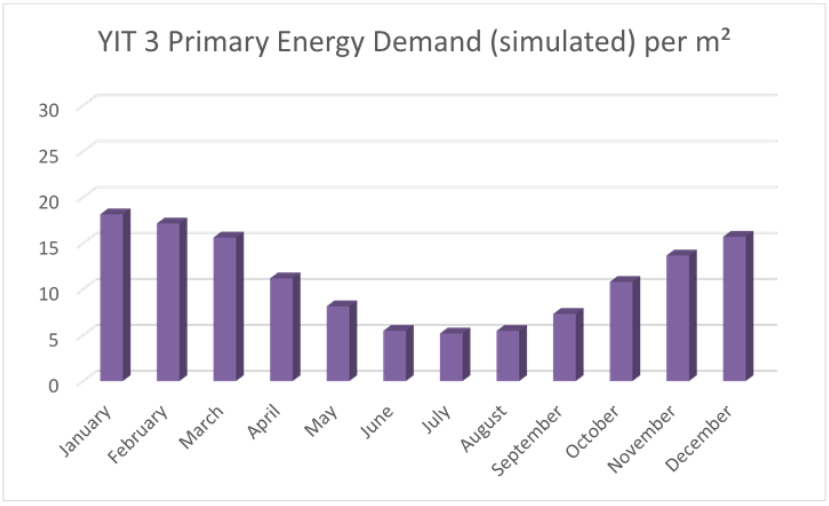

Figure 29, is calculated with the following formula:

PEDb = (ERTD_b * PEFt + EREDb * PEFe)/Ab. The factor of primary thermal is PEFt = 1.3 and the factor of primary electricity is PEFe = 2.4.

Month	Primary energy demand per m² [kWh]
January	18.14019
February	17.14745
March	15.61753
April	11.1793
May	8.13533
June	5.466965
July	5.172888
August	5.461691
September	7.308821
October	10.79075
November	13.66361
December	15.69738
Yearly	**133.7819**

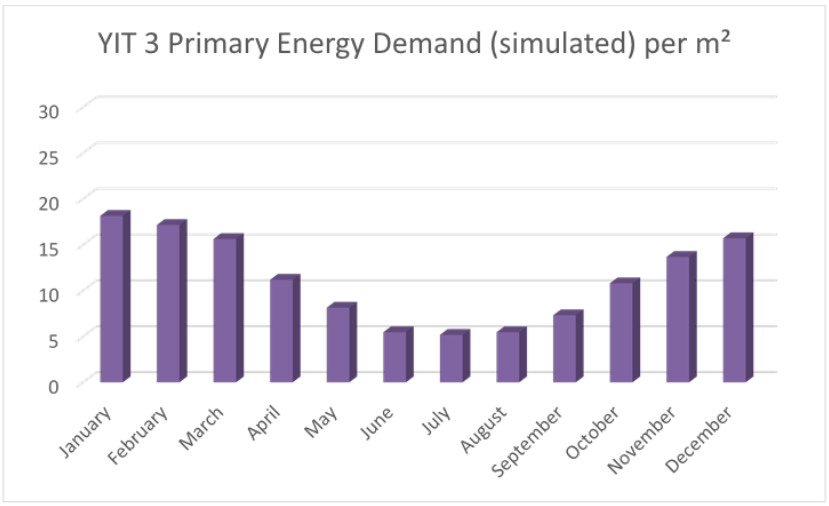

Figure 29: YIT 3 primary energy demand per m²

4.1.4.3 E3: Energy imported to PED

There is no energy production in PED area and hence energy imported to PED is equal to E1: Final energy consumption.

4.1.4.4 E4: Energy exported from PED

The baseline value of E4: Energy exported from PED is 0. There is no energy production in PED area.

4.1.4.5 E5: RES production

The baseline value of E5: RES production is 0. There is no energy production in PED area.

4.1.4.6 E6: PED energy balance

The annual energy balance of the PED area is presented in chapter 4.1.7.

4.1.4.7 E7: Energy savings in the PED

The baseline value of E7: Energy savings in the PED is 0. There is no energy production in PED area.

4.1.4.8 E8: GHG emissions

KPI specification and formula define the following attributes:

E8.2 Greenhouse gas emissions for building per m², as shown in

Month	Greenhouse gas emissions per m² [kWh]
January	1.852189454
February	1.717910291
March	1.537630073
April	1.038185712
May	0.699029808
June	0.402662691
July	0.359140993
August	0.38422009
September	0.601003346
October	0.980218959
November	1.306083938
December	1.533139867
Yearly	**12.41141522**

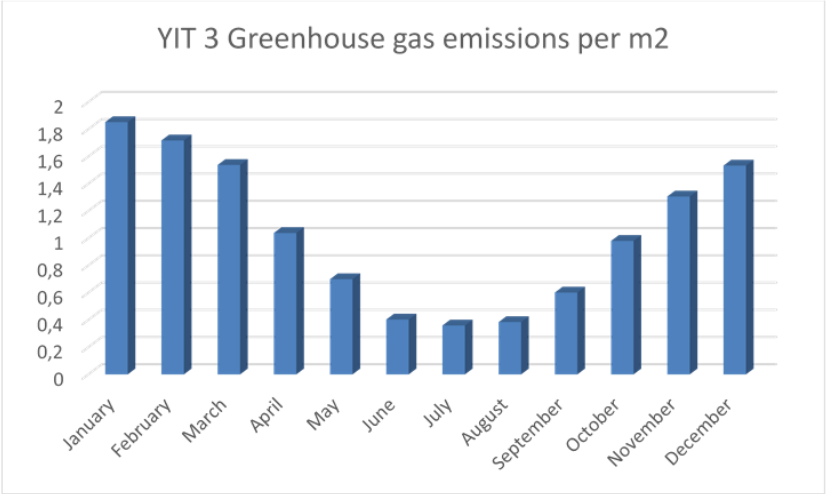

Figure 30, are calculated with the following formula:

GGE_b = (TEC_b · GEFT + EEC_b · GEFE) / Ab. GHG emission value for CO2 district heat is GEFT = 0.15 kgCO2/kWhth and for CO2 electricity is GEFE = 0.072 kgCO2/kWhe.

Month	Greenhouse gas emissions per m² [kWh]
January	1.852189454
February	1.717910291
March	1.537630073
April	1.038185712
May	0.699029808
June	0.402662691
July	0.359140993
August	0.38422009
September	0.601003346
October	0.980218959
November	1.306083938
December	1.533139867
Yearly	**12.41141522**

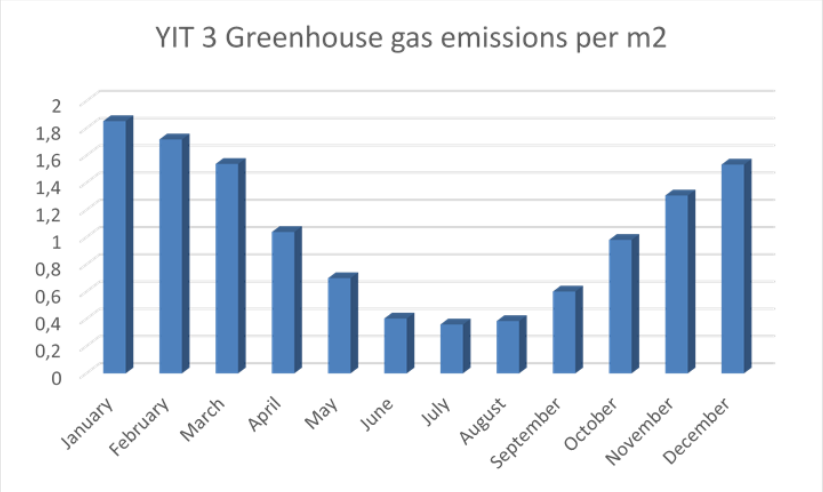

Figure 30: YIT 3 greenhouse gas emissions per m²

4.1.4.9 E9: Reduction of emissions

The baseline value of E9: Reduction of emissions is 0. There is no energy production in PED area.

4.1.5 Intervention 5: New Arina shopping mall (Arina 5)

Table 8 contains basic information about building 5. Building 5 is referred as Arina 5. Baseline data of the building is simulated which refers to the hourly data that is collected from the shopping mall with comparable energy consumption qualities. Baseline data is calculated as an average of the monthly consumptions and scaled to match Arina 5 requirements. There is no thermal energy used in Arina 5.

Table 8: Basic information of shopping mall Arina 5.

Building name	Heated area, m²	Heated volume, m³	Monitored or simulated building data?	Year of construction / retrofit
Arina 5	2000	N/A	Simulated	2018

4.1.5.1 E1: Final energy consumption

KPI specification and formula define the following attributes:

E1.2 Electrical Energy demand simulated (EEDb), as shown in

Month	Electrical energy demand [kWh]
January	73858.2
February	70930.85
March	65542.95
April	56910.85
May	48493.15
June	53909.5
July	59845.6
August	58811.85
September	56331
October	63799.7
November	64454.4
December	72854
Yearly	745742.05

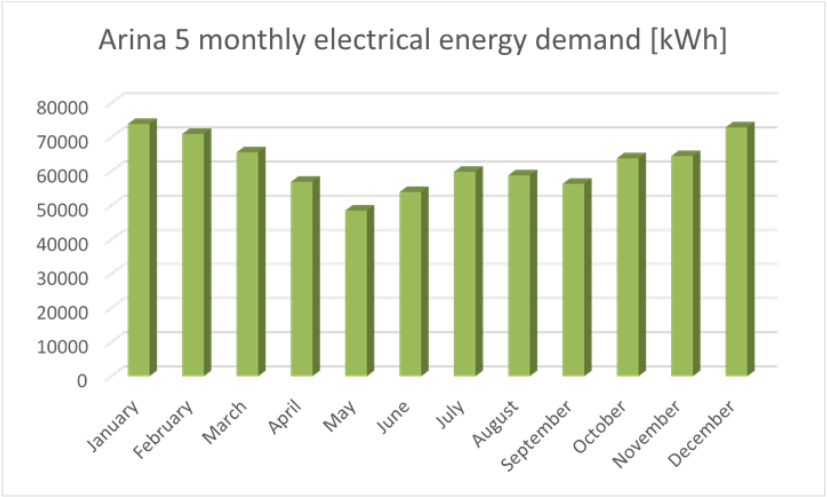

Figure 31, is composed of:

Electrical energy demand (heat pumps) + Electrical energy demand (lighting + ventilation)

Month	Electrical energy demand [kWh]
January	73858.2
February	70930.85
March	65542.95
April	56910.85
May	48493.15
June	53909.5
July	59845.6
August	58811.85
September	56331
October	63799.7
November	64454.4
December	72854
Yearly	745742.05

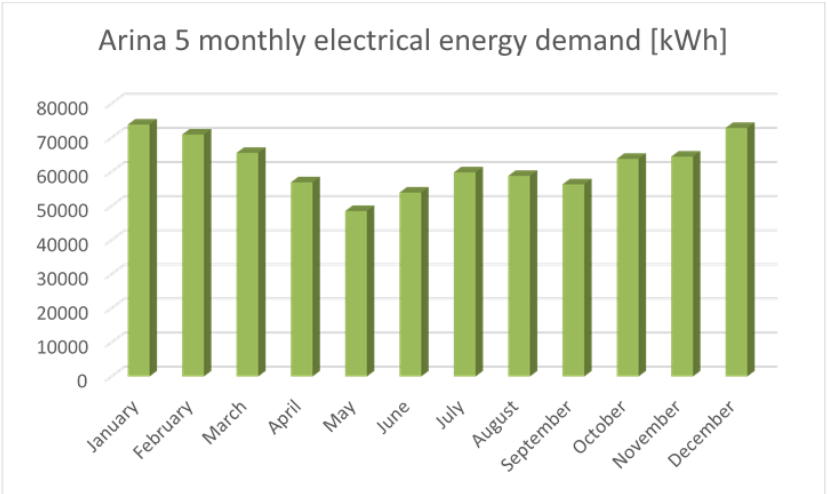

Figure 31: Arina 5 electrical energy demand

E1.2 Electrical Energy demand simulated per m² (EEDb), as shown in Figure 32, is composed of:

Electrical energy demand (heat pumps) + Electrical energy demand (lighting+ventilation)/ / building area

Month	Electrical energy demand per m2 [kWh]
January	36.9291
February	35.46543
March	32.77147
April	28.45543
May	24.24658
June	26.95475
July	29.9228
August	29.40593
September	28.1655
October	31.89985
November	32.2272
December	36.427
Yearly	372.871

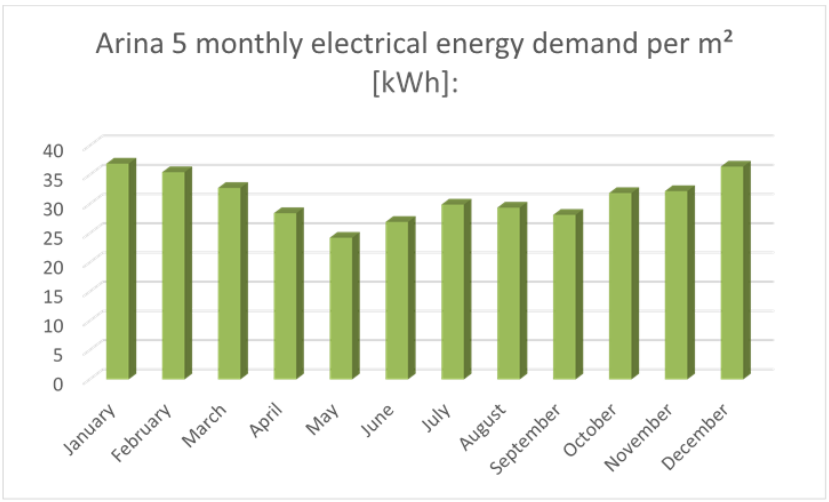

Figure 32: Arina 5 electrical energy demand per m²

4.1.5.2 E2: Primary energy consumption

KPI specification and formula define the following attributes:

E2.1. Primary Energy Demand (simulated), as seen in

Month	Primary energy demand [kWh]
January	177259.7
February	170234
March	157303.1
April	136586
May	116383.6
June	129382.8
July	143629.4
August	141148.4
September	135194.4
October	153119.3
November	154690.6
December	174849.6
Yearly	**1789781**

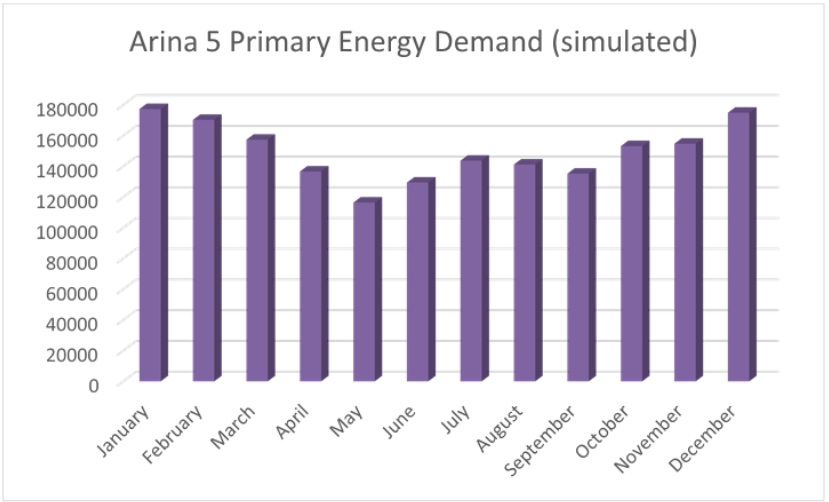

Figure 33, is calculated with the following formula:

PEDb = (EREDb * PEFe). The factor of primary electricity is PEFe = 2.4.

Month	Primary energy demand [kWh]
January	177259.7
February	170234
March	157303.1
April	136586
May	116383.6
June	129382.8
July	143629.4
August	141148.4
September	135194.4
October	153119.3
November	154690.6
December	174849.6
Yearly	**1789781**

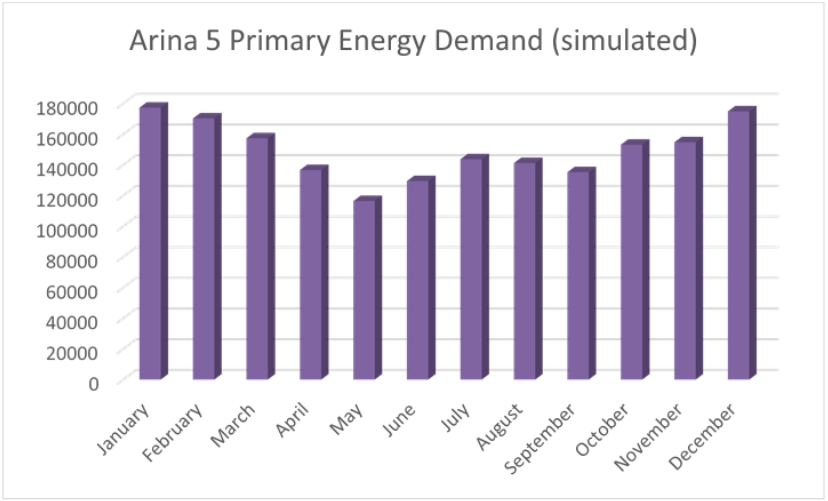

Figure 33: Arina 5 primary energy demand

E2.2. Primary Energy Consumption per m², as shown in

Month	Primary energy demand per m² [kWh]
January	88.62984
February	85.11702
March	78.65154
April	68.29302
May	58.19178
June	64.6914
July	71.81472
August	70.57422
September	67.5972
October	76.55964
November	77.34528
December	87.4248
Yearly	**894.89046**

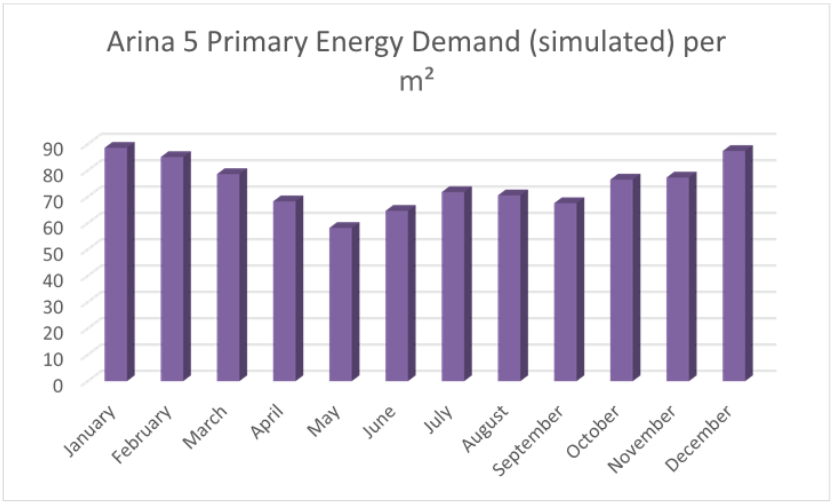

Figure 34, is calculated with the following formula:

PEDb = (EREDb * PEFe)/Ab. The factor of primary electricity is PEFe = 2.4.

Month	Primary energy demand per m² [kWh]
January	88.62984
February	85.11702
March	78.65154
April	68.29302
May	58.19178
June	64.6914
July	71.81472
August	70.57422
September	67.5972
October	76.55964
November	77.34528
December	87.4248
Yearly	**894.89046**

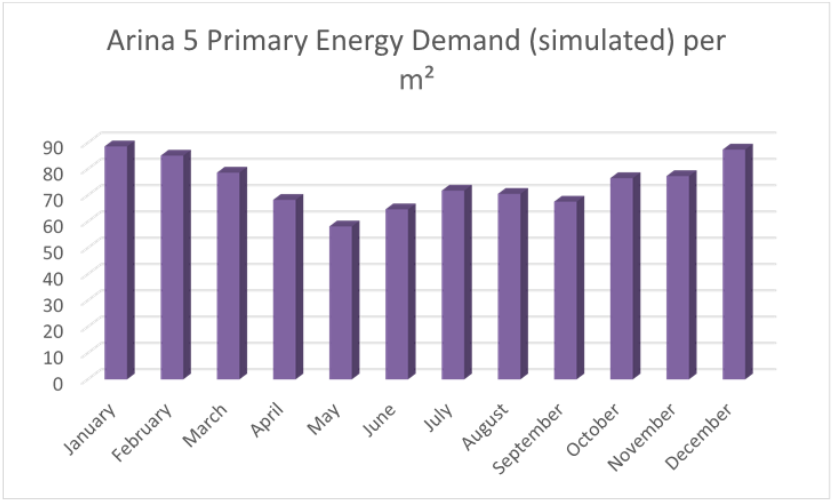

Figure 34: Arina 5 primary energy demand per m²

4.1.5.3 E3: Energy imported to PED

There is no energy production in PED area and hence energy imported to PED is equal to E1: Final energy consumption.

4.1.5.4 E4: Energy exported from PED

The baseline value of E4: Energy exported from PED is 0. There is no energy production in PED area.

4.1.5.5 E5: RES production

The baseline value of E5: RES production is 0. There is no energy production in PED area.

4.1.5.6 E6: PED energy balance

The annual energy balance of the PED area is presented in chapter 4.1.7.

4.1.5.7 E7: Energy savings in the PED

The baseline value of E7: Energy savings in the PED is 0. There is no energy production in PED area.

4.1.5.8 E8: GHG emissions

KPI specification and formula define the following attributes:

E8.2 Greenhouse gas emissions for building per m², as shown in

Month	Greenhouse gas emissions per m² [kWh]
January	2.6588952
February	2.5535106
March	2.3595462
April	2.0487906
May	1.7457534
June	1.940742
July	2.1544416
August	2.1172266
September	2.027916
October	2.2967892
November	2.3203584
December	2.622744
Yearly	**26.8467138**

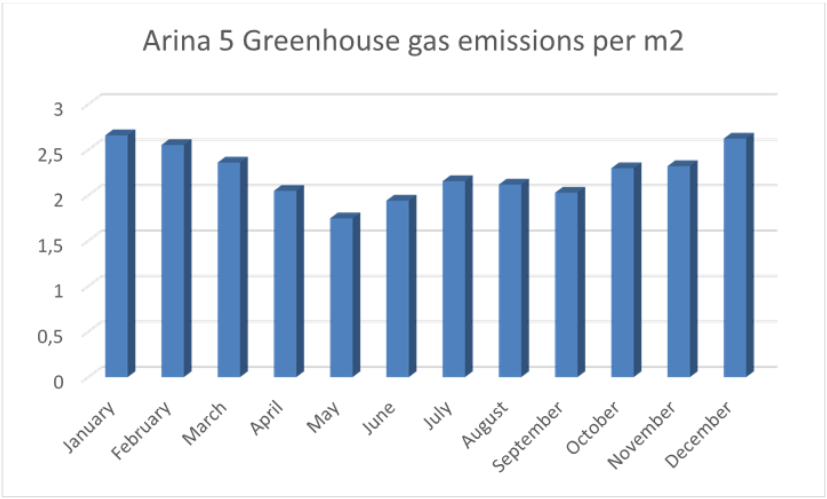

Figure 35, are calculated with the following formula:

GGE_b = (TEC_b · GEFT + EEC_b · GEFE) / Ab. GHG emission value for CO2 district heat is GEFT = 0.15 kgCO2/kWhth and for CO2 electricity is GEFE = 0.072 kgCO2/kWhe.

Month	Greenhouse gas emissions per m² [kWh]
January	2.6588952
February	2.5535106
March	2.3595462
April	2.0487906
May	1.7457534
June	1.940742
July	2.1544416
August	2.1172266
September	2.027916
October	2.2967892
November	2.3203584
December	2.622744
Yearly	**26.8467138**

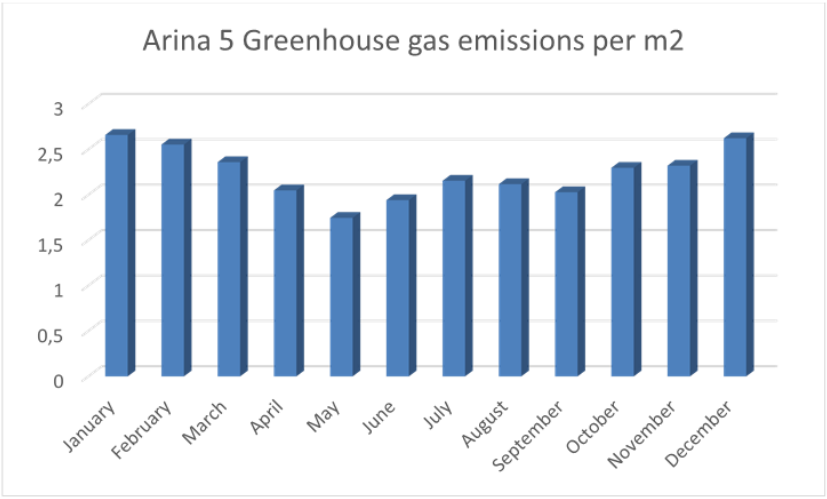

Figure 35: Arina 5 greenhouse gas emissions per m²

4.1.5.9 E9: Reduction of emissions

The baseline value of E9: Reduction of emissions is 0. There is no energy production in PED area.

4.1.6 Intervention 6: multifunctional building with a public school (School 6)

Table 9 contains basic information about building 6. Building 6 is referred as School 6. Baseline data of the building is monitored which refers to the monthly data that is collected from the School 6 during the years 2017-2019. Baseline data is calculated as an average of the monthly consumptions.

Table 9: Basic information of school building School 6.

Building name	Heated area, m^2	Heated volume, m^3	Monitored or simulated building data?	Year of construction / retrofit
School 6	7209	31059	Monitored	1971/2000/2021

4.1.6.1 E1: Final energy consumption

KPI specification and formula define the following attributes:

E1.3 Thermal energy consumption (TECb), as shown in

Month	Thermal energy consumption [kWh]
January	183890
February	170153.3
March	151726.7
April	92493.33
May	53943.33
June	21393.33
July	10846.67
August	18290
September	42693.33
October	94466.67
November	117696.7
December	141133.3
Yearly	1098727

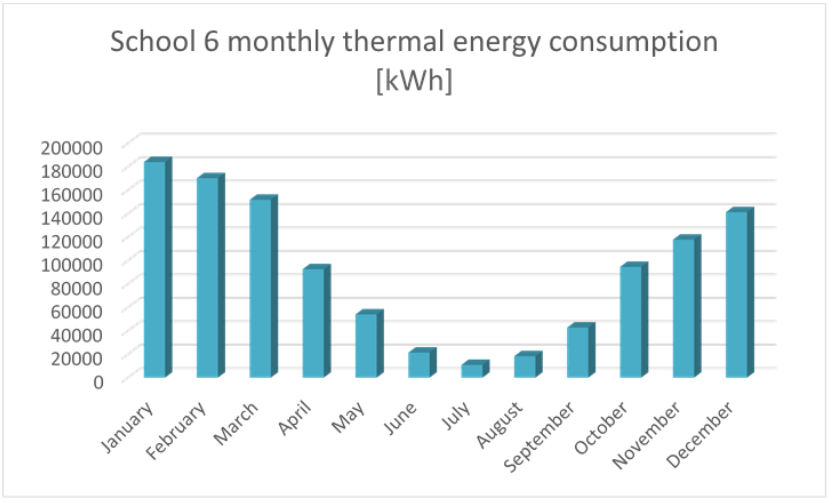

Figure 36, is composed of:

Thermal energy consumption (H&C) + Thermal energy consumption (DHW)

Month	Thermal energy consumption [kWh]
January	183890
February	170153.3
March	151726.7
April	92493.33
May	53943.33
June	21393.33
July	10846.67
August	18290
September	42693.33
October	94466.67
November	117696.7
December	141133.3
Yearly	1098727

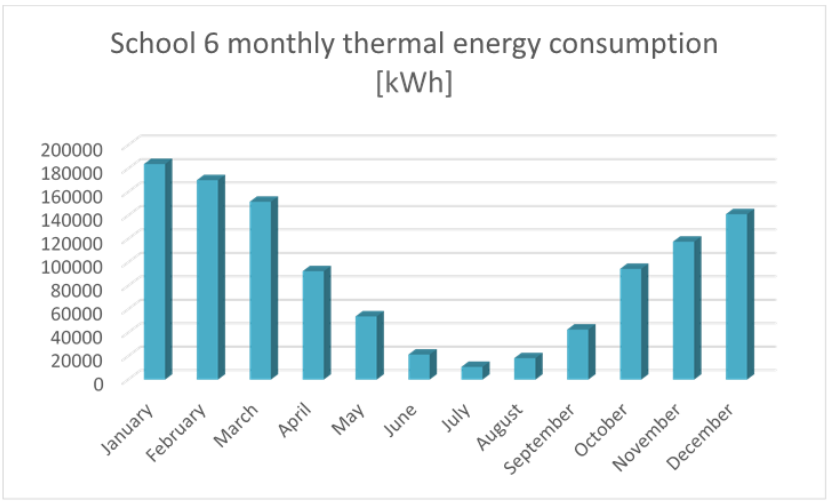

Figure 36: School 6 thermal energy consumption

E1.3 Thermal Energy consumption per m² (TECb), as shown in

Month	Thermal energy consumption per m² [kWh]
January	25.508392
February	23.602904
March	21.04684
April	12.830258
May	7.4827762
June	2.9675868
July	1.5046007
August	2.5371064
September	5.9222268
October	13.10399
November	16.326351
December	19.57738
Yearly	152.41041

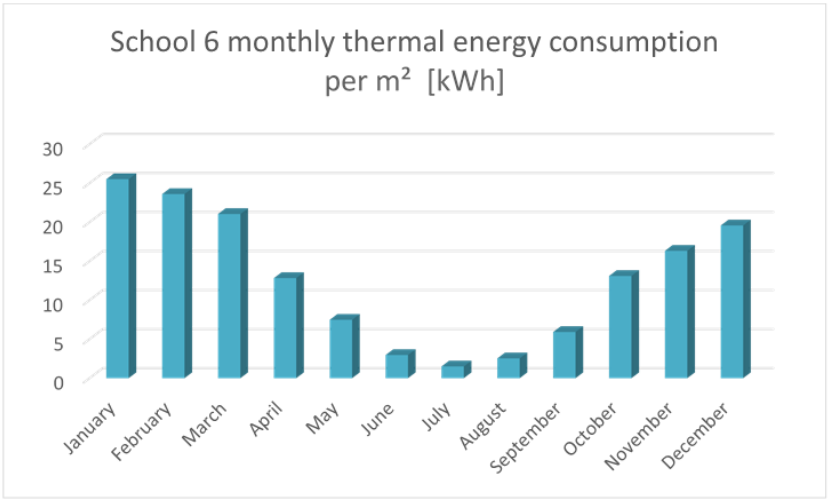

Figure 37, is composed of:

(Thermal energy consumption (H&C) + Thermal energy consumption (DHW))/ building area

Month	Thermal energy consumption per m² [kWh]
January	25.508392
February	23.602904
March	21.04684
April	12.830258
May	7.4827762
June	2.9675868
July	1.5046007
August	2.5371064
September	5.9222268
October	13.10399
November	16.326351
December	19.57738
Yearly	152.41041

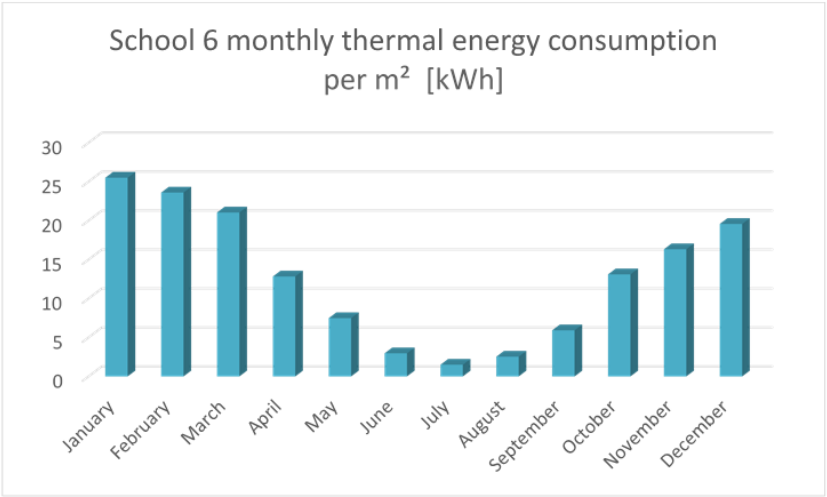

Figure 37: School 6 thermal energy consumption per m²

E1.4 Electrical energy consumption (EECb), as shown in

Month	Electrical energy consumption [kWh]
January	55 575
February	51 534
March	52 992
April	51 178
May	47 031
June	34 573
July	33 214
August	45 526
September	47 210
October	51 110
November	55 618
December	53 664
Yearly	579 225

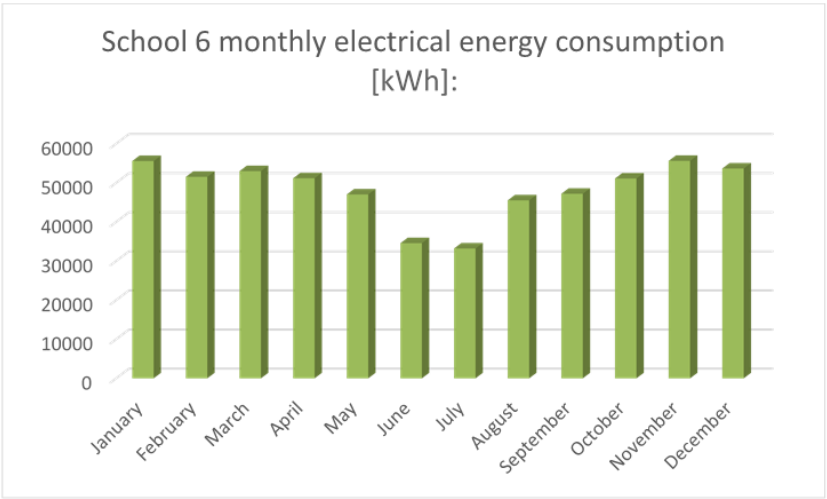

Figure 38, is composed of:

Electrical energy consumption (heat pumps) + Electrical energy consumption (lighting + ventilation)

Month	Electrical energy consumption [kWh]
January	55 575
February	51 534
March	52 992
April	51 178
May	47 031
June	34 573
July	33 214
August	45 526
September	47 210
October	51 110
November	55 618
December	53 664
Yearly	579 225

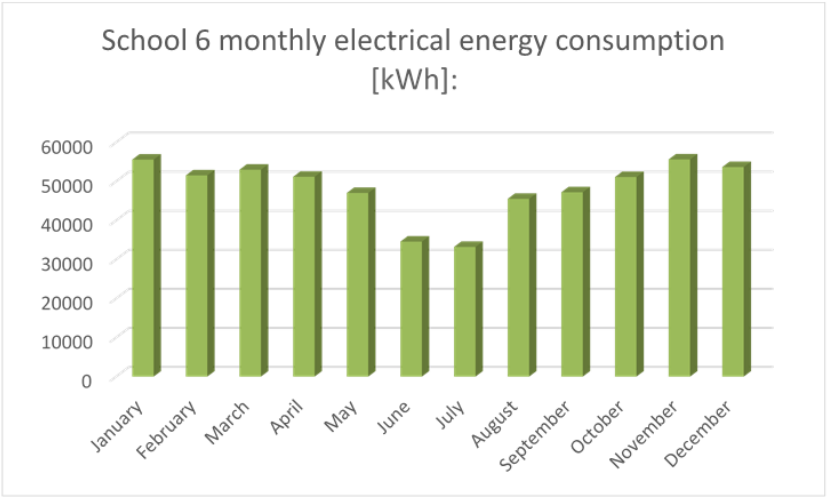

Figure 38: School 6 electrical energy consumption

E1.4 Electrical energy consumption per m² (EECb), as shown in

Month	Electrical energy consumption per m² [kWh]
January	7.709114
February	7.148518
March	7.350858
April	7.099228
May	6.523882
June	4.795857
July	4.607343
August	6.315115
September	6.548712
October	7.089795
November	7.715078
December	7.444028
Yearly	80.34753

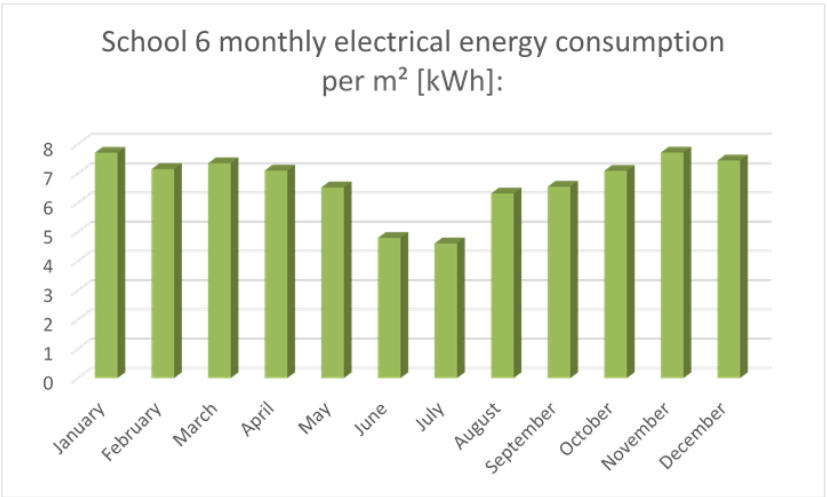

Figure 39, is composed of:

Electrical energy consumption (heat pumps) + Electrical energy consumption (lighting+ventilation) // building area

Month	Electrical energy consumption per m² [kWh]
January	7.709114
February	7.148518
March	7.350858
April	7.099228
May	6.523882
June	4.795857
July	4.607343
August	6.315115
September	6.548712
October	7.089795
November	7.715078
December	7.444028
Yearly	80.34753

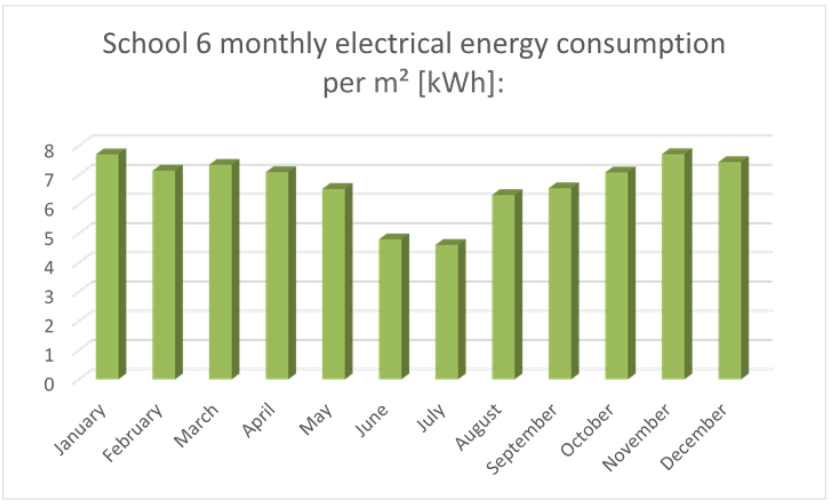

Figure 39: School 6 electrical energy consumption per m²

4.1.6.2 E2: Primary energy consumption

KPI specification and formula define the following attributes:

E2.2. Primary Energy Consumption, as shown in

Month	Primary energy consumption [kWh]
January	372437
February	344880.13
March	324426.27
April	243069.33
May	182999.93
June	110787.33
July	93815.067
August	133038.6
September	168804.53
October	245471.47
November	286488.87
December	312266.93
Yearly	**2818485.5**

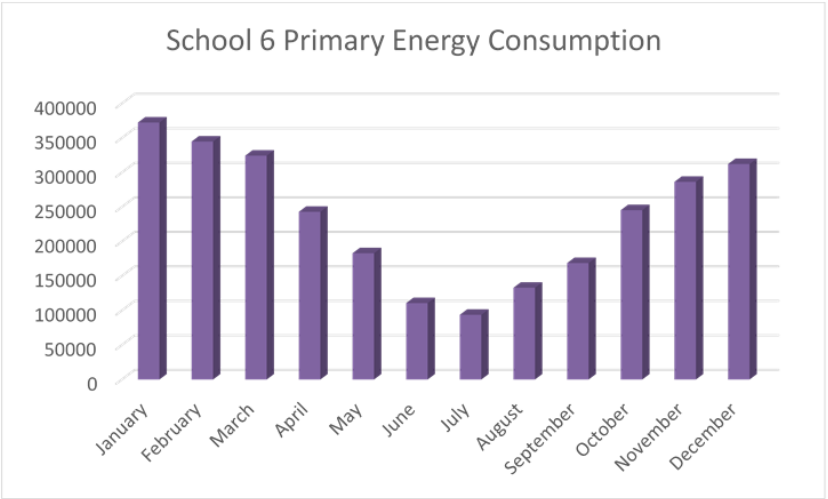

Figure 40, is calculated with the following formula:

PECb = (ERTC_b * PEFt + ERECb * PEFe). The factor of primary thermal is PEFt = 1.3 and the factor of primary electricity is PEFe = 2.4.

Month	Primary energy consumption [kWh]
January	372437
February	344880.13
March	324426.27
April	243069.33
May	182999.93
June	110787.33
July	93815.067
August	133038.6
September	168804.53
October	245471.47
November	286488.87
December	312266.93
Yearly	**2818485.5**

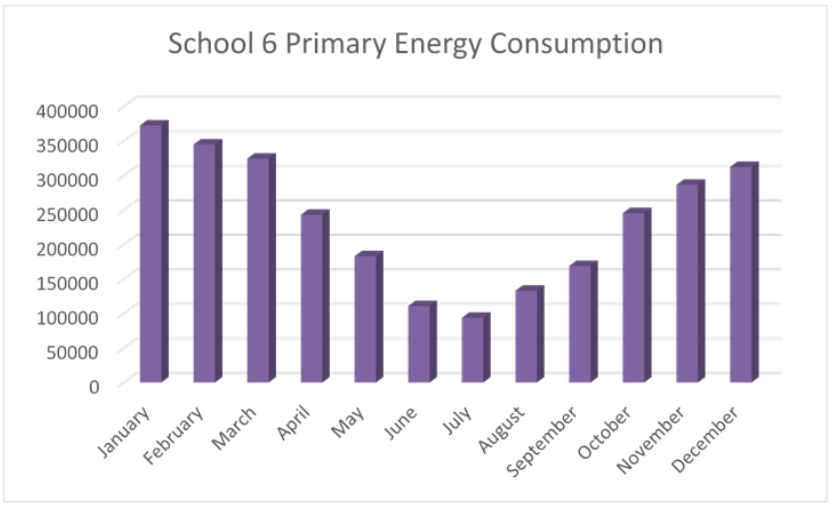

Figure 40: School 6 primary energy consumption

E2.2. Primary Energy Consumption per m², as shown in

Figure 41, is calculated with the following formula:

PECb = (ERTC_b * PEFt + ERECb * PEFe)/Ab. The factor of primary thermal is PEFt = 1.3 and the factor of primary electricity is PEFe = 2.4.

Month	Primary energy consumption per m² [kWh]
January	51.66278
February	47.84022
March	45.00295
April	33.71748
May	25.38493
June	15.36792
July	13.0136
August	18.45452
September	23.4158
October	34.0507
November	39.74044
December	43.31626
Yearly	**390.9676**

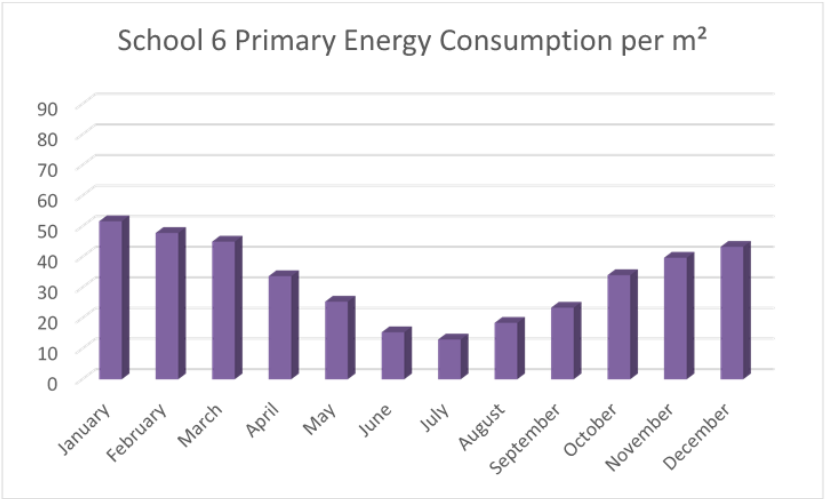

Figure 41: School 6 primary energy consumption per m²

4.1.6.3 E3: Energy imported to PED

There is no energy production in PED area and hence energy imported to PED is equal to E1: Final energy consumption.

4.1.6.4 E4: Energy exported from PED

The baseline value of E4: Energy exported from PED is 0. There is no energy production in PED area.

4.1.6.5 E5: RES production

The baseline value of E5: RES production is 0. There is no energy production in PED area.

4.1.6.6 E6: PED energy balance

The annual energy balance of the PED area is presented in chapter 4.1.7.

4.1.6.7 E7: Energy savings in the PED

The baseline value of E7: Energy savings in the PED is 0. There is no energy production in PED area.

4.1.6.8 E8: GHG emissions

KPI specification and formula defines the following attributes.

E8.2 Greenhouse gas emissions for building per m², as shown in

Month	Greenhouse gas emissions per m² [kWh]
January	4.381315023
February	4.055128867
March	3.686287696
April	2.435683174
May	1.592135941
June	0.790439728
July	0.557418782
August	0.835254266
September	1.359841309
October	2.476063809
November	3.004438341
December	3.472577056
Yearly	**28.64658399**

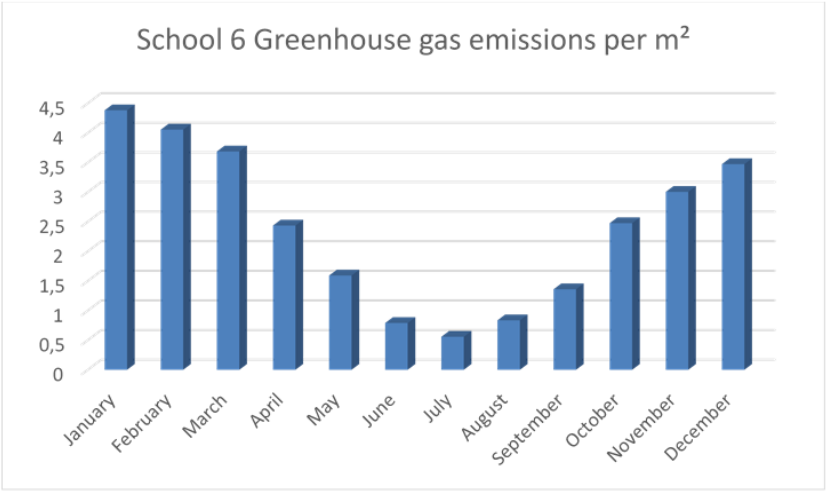

Figure 42, are calculated with the following formula:

GGE_b = (TEC_b · GEFT + EEC_b · GEFE) / Ab. GHG emission value for CO2 district heat is GEFT = 0.15 kgCO2/kWhth and for CO2 electricity is GEFE = 0.072 kgCO2/kWhe.

Month	Greenhouse gas emissions per m² [kWh]
January	4.381315023
February	4.055128867
March	3.686287696
April	2.435683174
May	1.592135941
June	0.790439728
July	0.557418782
August	0.835254266
September	1.359841309
October	2.476063809
November	3.004438341
December	3.472577056
Yearly	**28.64658399**

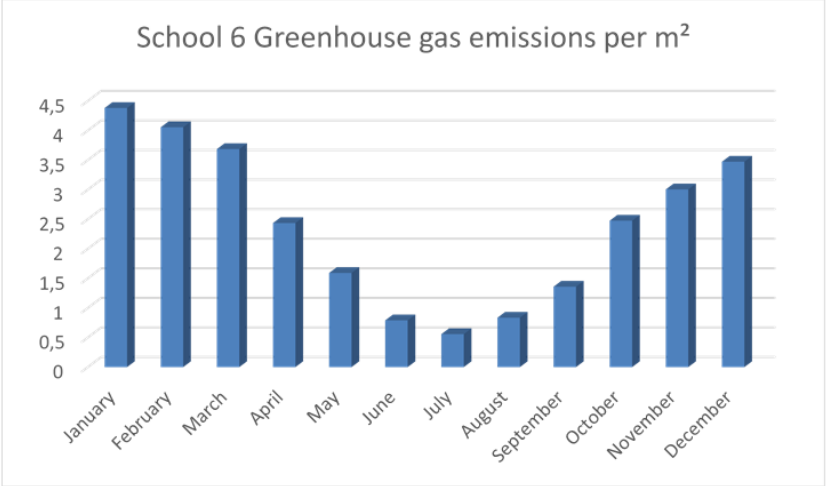

Figure 42: School 6 greenhouse gas emissions per m²

4.1.6.9 E9: Reduction of emissions

The baseline value of E9: Reduction of emissions is 0. There is no energy production in PED area.

4.1.7 PED level

PED level summarizes all described interventions (Table 10). In total, PED area covers 21233 m² of heated net floor area.

Table 10: Information of all PED area buildings.

Building name	Heated area, m²	Heated volume, m³	Monitored or simulated building data?	Year of construction / retrofit
Sivakka 1	2820	8930	Monitored	1972/2000/2020
Sivakka 2.1	2654	N/A	Simulated	2021
Sivakka 2.2	3618	N/A	Simulated	2021
YIT 3	2932	N/A	Simulated	2020
Arina 5	2000	N/A	Simulated	2018
School 6	7209	31059	Monitored	1971/2000/2021
TOTAL:	21233			

4.1.7.1 E1: Final energy consumption

KPI specification and formula define the following attributes:

E1.5 District level Thermal Energy demand simulated (TEDd), as shown in

Month	Thermal energy demand [kWh]
January	345767
February	312982
March	279872
April	177526
May	107868
June	49909.3
July	33760.9
August	43858.1
September	88023.7
October	179156
November	229658
December	273151
Yearly	2121533

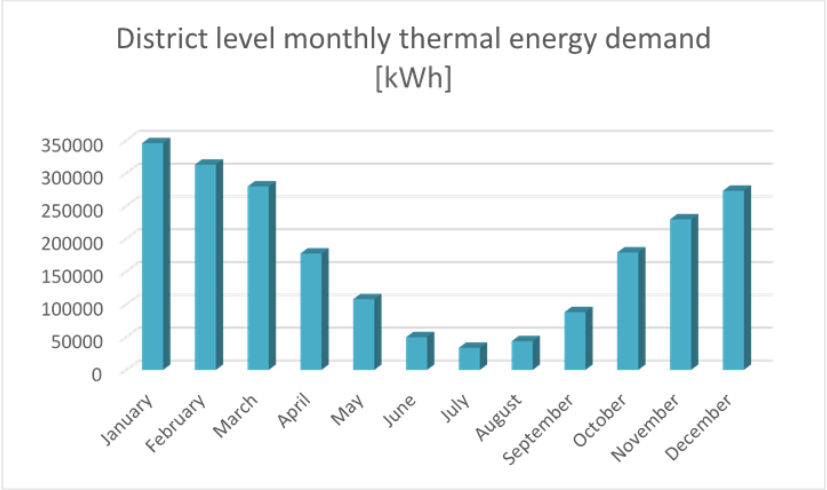

Figure 43, is calculated with the following formula:

∑Thermal energy demand (H&C) + ∑Thermal energy demand (DHW)

Month	Thermal energy demand [kWh]
January	345767
February	312982
March	279872
April	177526
May	107868
June	49909.3
July	33760.9
August	43858.1
September	88023.7
October	179156
November	229658
December	273151
Yearly	2121533

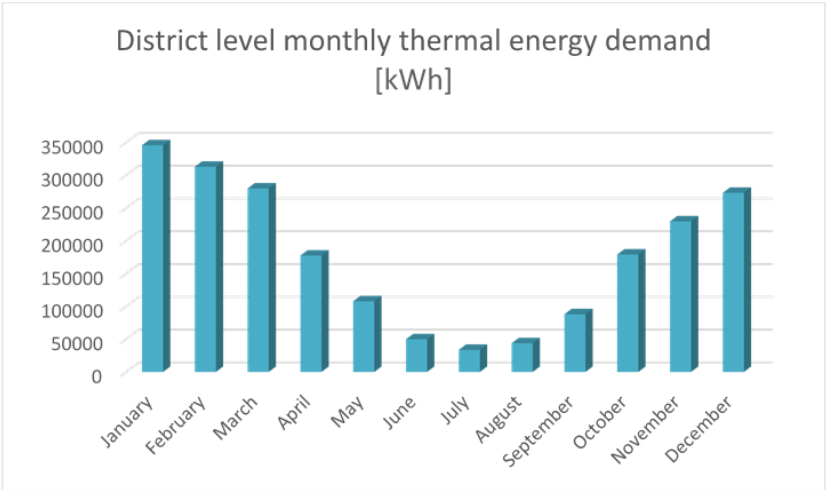

Figure 43: District level thermal energy demand

E1.5 District level Thermal Energy demand simulated per m² (TEDd), as shown in

Month	Thermal energy demand per m² [kWh]
January	16.28442
February	14.74038
March	13.18099
April	8.360834
May	5.080192
June	2.350555
July	1.590018
August	2.065563
September	4.145609
October	8.437621
November	10.8161
December	12.86448
Yearly	99.91676

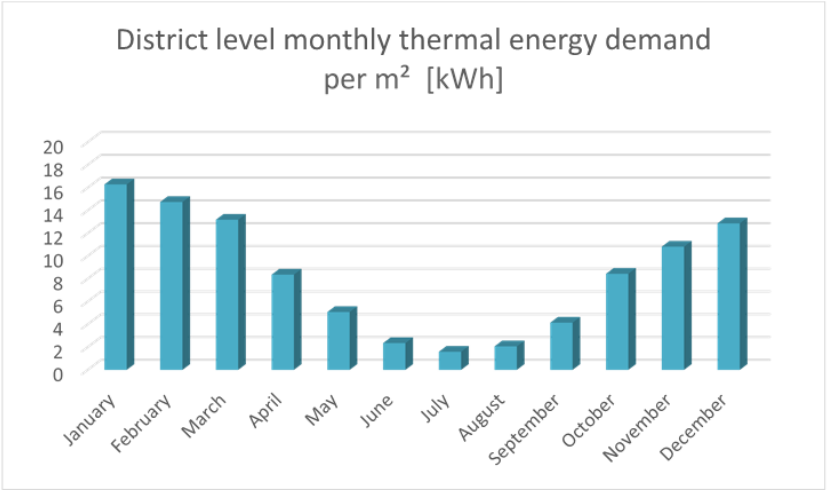

Figure 44, is calculated with the following formula:

∑Thermal energy demand (H&C) + ∑Thermal energy demand (DHW))/ district area

Month	Thermal energy demand per m² [kWh]
January	16.28442
February	14.74038
March	13.18099
April	8.360834
May	5.080192
June	2.350555
July	1.590018
August	2.065563
September	4.145609
October	8.437621
November	10.8161
December	12.86448
Yearly	99.91676

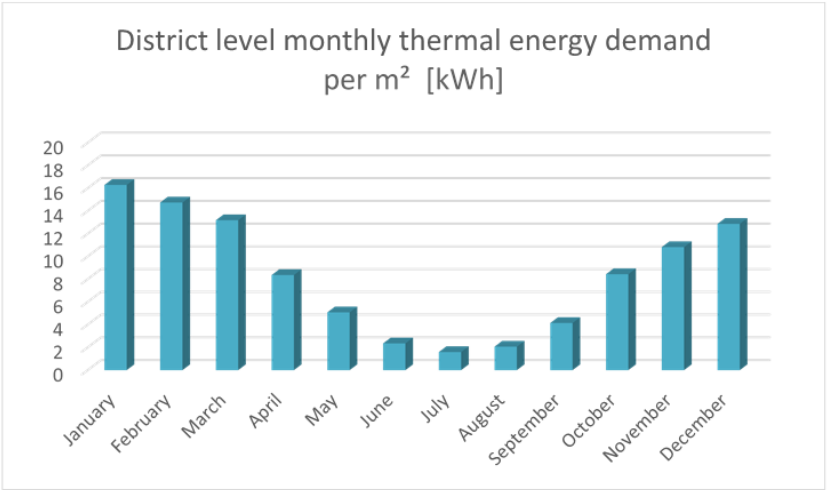

Figure 44: District level thermal energy demand per m²

E1.6 District level Electrical Energy demand simulated (EEDd), as shown in

Month	Electrical energy demand [kWh]
January	145471.69
February	138873.25
March	135084.02
April	123431.01
May	110118.79
June	102150.59
July	107036.04
August	119063.55
September	118409.06
October	131451.05
November	137064.45
December	144149.22
Yearly	1512302.7

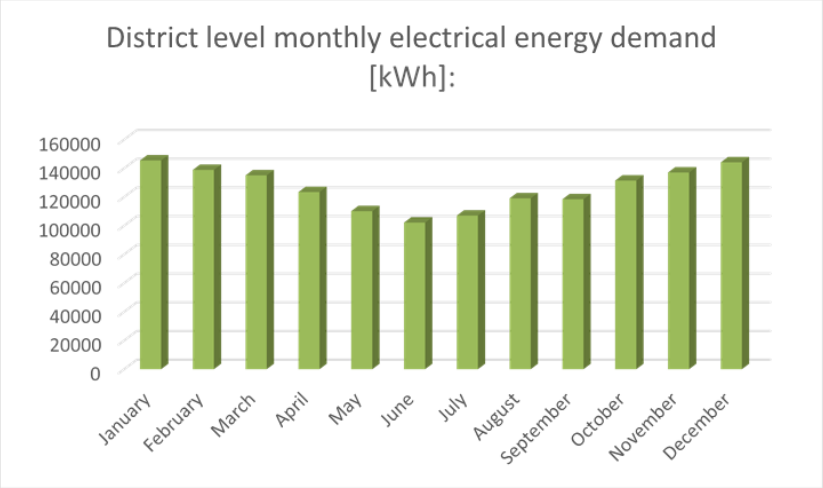

Figure 45, is calculated with the following formula:

∑Electrical energy demand (heat pumps) +∑ Electrical energy demand (lighting + ventilation)

Month	Electrical energy demand [kWh]
January	145471.69
February	138873.25
March	135084.02
April	123431.01
May	110118.79
June	102150.59
July	107036.04
August	119063.55
September	118409.06
October	131451.05
November	137064.45
December	144149.22
Yearly	1512302.7

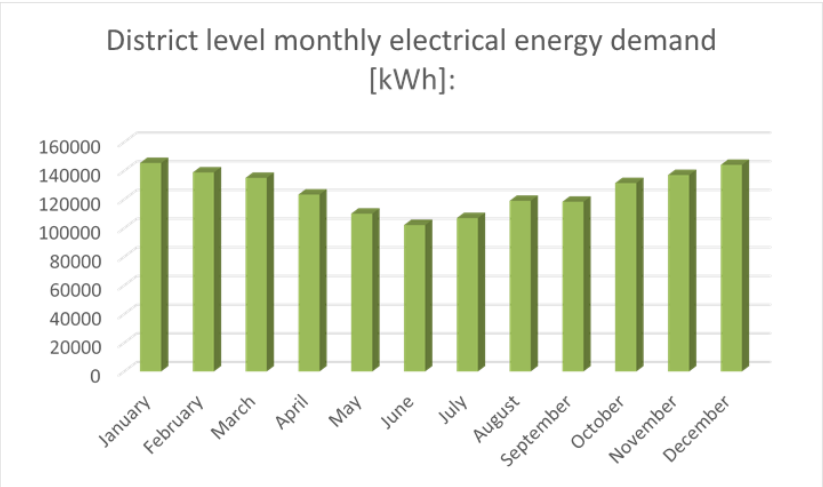

Figure 45: District level electrical energy demand

E1.6 District level Electrical Energy demand simulated per m² (EEDd), as shown in

Month	Electrical energy demand per m² [kWh]
January	6.851207
February	6.540444
March	6.361985
April	5.813169
May	5.18621
June	4.810935
July	5.041023
August	5.607477
September	5.576652
October	6.190884
November	6.455256
December	6.788924
Yearly	71.22417

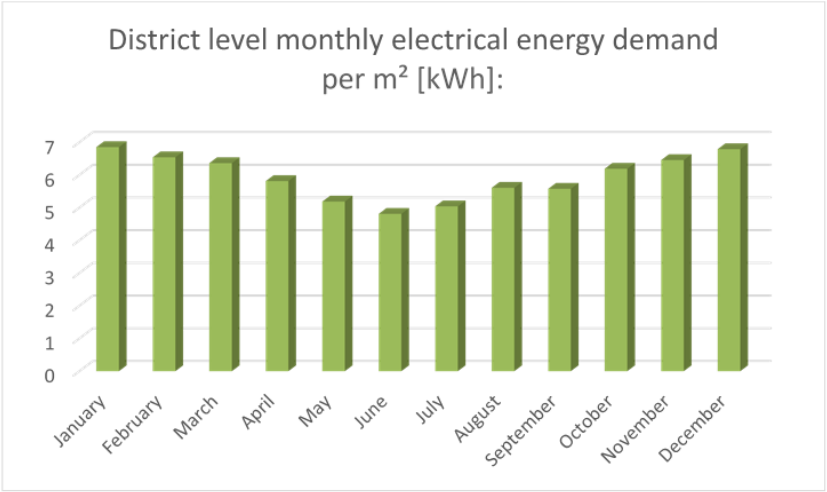

Figure 46, is calculated with the following formula:

∑Electrical energy demand (heat pumps) + ∑Electrical energy demand (lighting+ventilation) / district area

Month	Electrical energy demand per m² [kWh]
January	6.851207
February	6.540444
March	6.361985
April	5.813169
May	5.18621
June	4.810935
July	5.041023
August	5.607477
September	5.576652
October	6.190884
November	6.455256
December	6.788924
Yearly	71.22417

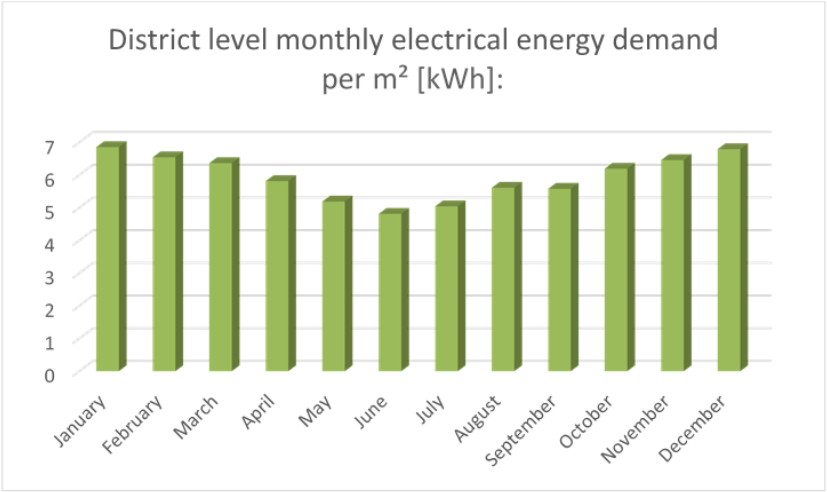

Figure 46: District level electrical energy demand per m²

4.1.7.2 E2: Primary energy consumption

KPI specification and formula define the following attributes:

E2.3. Primary Energy demand (simulated) of the district, as shown in

Month	Primary energy demand of the district [kWh]
January	798629.4
February	740172.9
March	688035.2
April	527017.7
May	404513.1
June	310043.5
July	300775.6
August	342768.1
September	398612.6
October	548385.3
November	627510.4
December	701055
Yearly	**6387519**

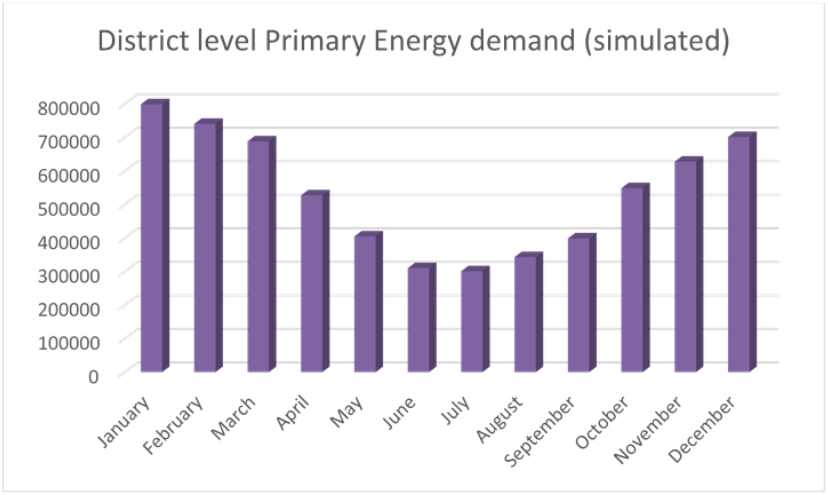

Figure 47, is calculated with the following formula:

PEDd = ∑PEDb

Month	Primary energy demand of the district [kWh]
January	798629.4
February	740172.9
March	688035.2
April	527017.7
May	404513.1
June	310043.5
July	300775.6
August	342768.1
September	398612.6
October	548385.3
November	627510.4
December	701055
Yearly	**6387519**

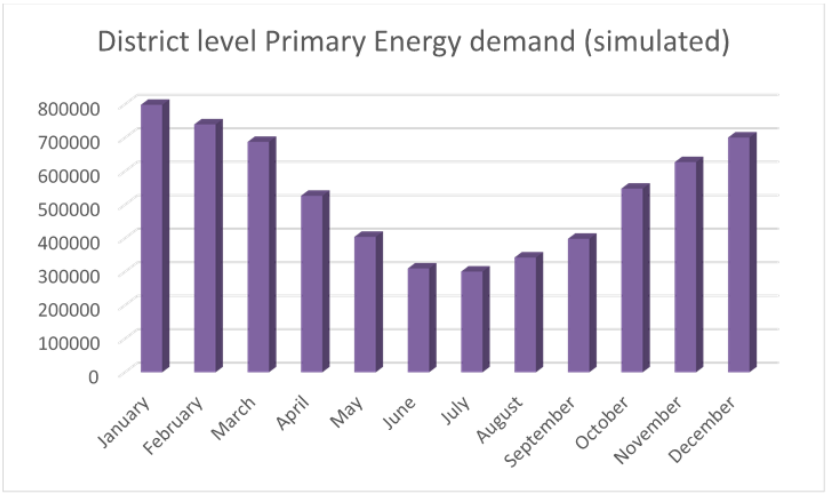

Figure 47: District level primary energy demand

E2.3. Primary Energy demand (simulated) of the district per m², as shown in Figure 48, is calculated with the following formula:

PEDd = ∑PEDb

Month	Primary energy demand of the district per m² [kWh]
January	224.0386711
February	208.3181645
March	192.9328923
April	151.5156389
May	118.8135925
June	103.379671
July	105.9514134
August	111.907823
September	122.6597124
October	160.8944361
November	179.591649
December	202.6569191
Yearly	**1882.660583**

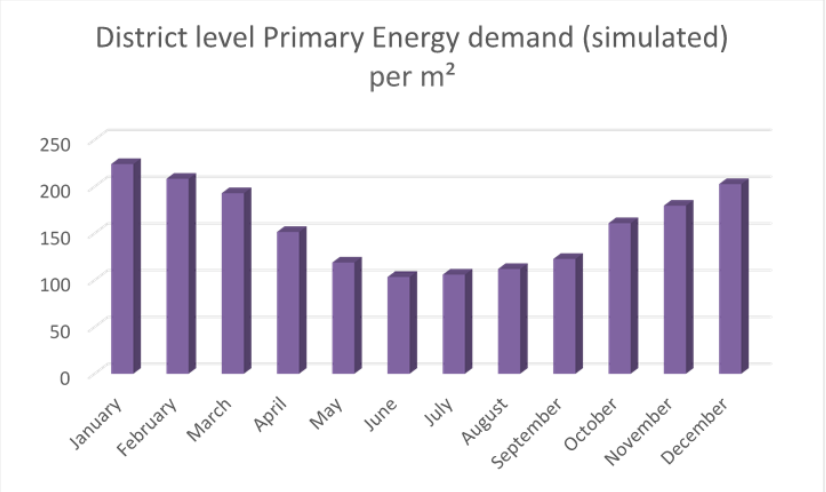

Figure 48: District level primary energy demand per m²

4.1.7.3 E3: Energy imported to PED

There is no energy production in PED area and hence energy imported to PED is equal to E1: Final energy consumption.

4.1.7.4 E4: Energy exported from PED

The baseline value of E4: Energy exported from PED is **0**. There is no renewable energy production in the PED area at baseline situation.

4.1.7.5 E5: RES production

The baseline value of E5: RES production is **0**. There is no renewable energy production in the PED area at baseline situation.

4.1.7.6 E6: PED energy balance

The annual energy balance of the PED area is presented in chapter 4.1.7.

4.1.7.7 E7: Energy savings in the PED

The value for E7: Energy savings in the PED, will be reported in D5.11 Evaluation.

4.1.7.8 E8: GHG emissions

KPI specification and formula define the following attributes:

E8.4. Greenhouse gas emissions for district per m2, as shown in

Month	Greenhouse gas emissions per m² [kWh]
January	2.935951
February	2.681968
March	2.435212
April	1.672673
May	1.135436
June	0.698971
July	0.601456
August	0.713573
September	1.02336
October	1.711387
November	2.087194
December	2.418474
Yearly	**20.11565**

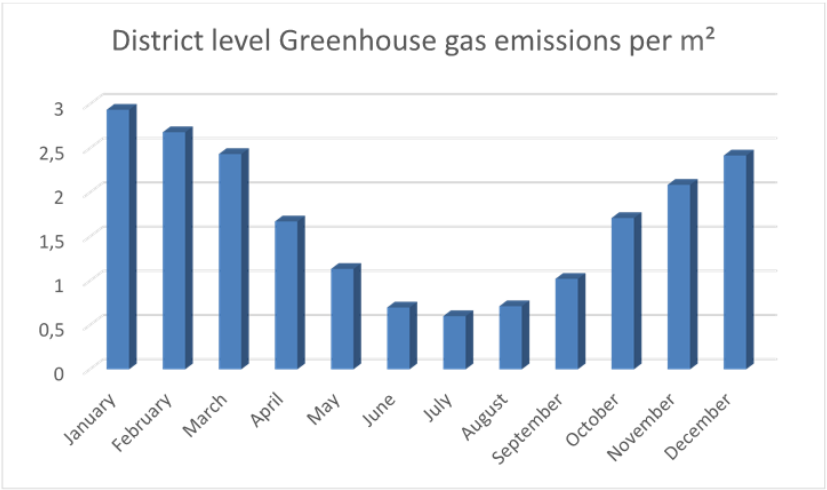

Figure 49, are calculated with the following formula:

GGE_d=(TEC_d · GEFT + EEC_d · GEFE) / Ad. GHG emission value for CO2 district heat is GEFT = 0.15 kgCO2/kWhth and for CO2 electricity is GEFE = 0.072 kgCO2/kWhe.

Month	Greenhouse gas emissions per m² [kWh]
January	2.935951
February	2.681968
March	2.435212
April	1.672673
May	1.135436
June	0.698971
July	0.601456
August	0.713573
September	1.02336
October	1.711387
November	2.087194
December	2.418474
Yearly	**20.11565**

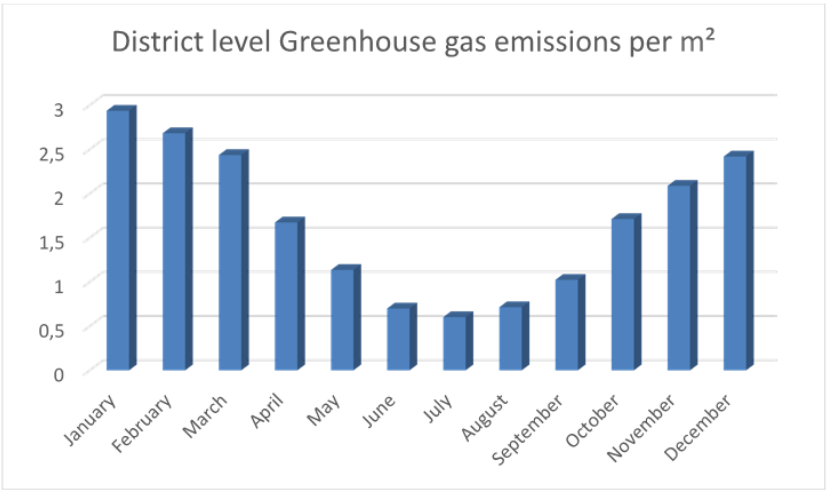

Figure 49: District level greenhouse gas emissions per m²

4.1.7.9 E9: Reduction of emissions

The value for E9: Reduction of emissions, will be reported in D5.11 Evaluation.

4.2 Baselines for mobility indicators

The following Table 11 presents the mobility KPIs for the Kaukovainio PED. The calculation procedure follows in the sections below.

Table 11: Baseline for mobility KPIs in Kaukovainio PED

Mobility related technologies	
Indicator	Estimated value
M1: Number of public EV charging stations	0
M2: Energy delivered for EV charging	0

4.2.1 M1: Number of public EV charging stations

The baseline value of M1: Number of public EV charging stations in the Oulu PED area is **0**. There are no existing public charging stations in the PED area before the project interventions.

4.2.2 M2: Energy delivered for EV charging

The baseline value of M2: **0 kWh**. There are no existing public charging stations in the PED area before the project interventions.

4.3 Baselines for economic indicators

The following Table 12 presents the mobility KPIs for the Kaukovainio PED. The calculation procedure follows in the sections below.

Table 12: Baseline for economic KPIs in Kaukovainio PED

Economic performance	
Indicator	Estimated value
C1: Total investments	0
C2: Payback time	Not applicable
C3: Economic value of savings	Not applicable

The selected economic indicators differ from most other KPI categories, in a sense that it is not possible or feasible to define baseline values to be compared later to monitored values. Only the development of C1 total investments, can be followed. The investments for interventions occur bit by bit during the project timeline, but indicators C2 and C3 can only be calculated once all the investments have been completed, and there is enough data from interventions for reliable assessments. Therefore, the baselines for C2 and C3 will not be provided in this deliverable.

4.3.1C1: Total investments

The baseline value of C1: Total investments is **0 €**. There are no investments related to project interventions carried out prior to, or at the very beginning of the project.

4.3.2C2: Payback time

This indicator has no baseline value. The final value for C2 will be calculated later in the D5.11 Evaluation (city level, project level).

4.3.3C3: Economic value of savings

This indicator has no baseline value. The final value for C3 will be calculated later in the D5.11 Evaluation (city level, project level).

4.4 Baselines for system flexibility indicators

The following Table 13 presents the system flexibility KPIs for the Kaukovainio PED. The calculation procedure follows in the sections below.

Table 13: Baseline for system flexibility KPIs in Kaukovainio PED

System flexibility	
Indicator	Estimated value
F1: System flexibility for energy players	0
F2: RES storage usage	0
F3: Peak load reduction	Not applicable

4.4.1F1: System flexibility for energy players

Description of the indicator:

This KPI is an indication of the ability of the system to respond to – as well as stabilize and balance – supply and demand in real time, as a measure of the demand side participation in energy markets and in energy efficiency intervention. Stability refers to the maintaining of voltage and frequency of a given power system within acceptable levels.

The amount of load capacity in demand side management at baseline is **0**. There is no load capacity in use for demand side management.

4.4.2F2: RES storage usage

Description of the indicator:

The combined usage of energy storage capacity in the PED area. The aim is to increase energy system flexibility with local energy storages for electricity and heat.

Energy Storage usage:

Charging time + Discharging time / Time available * 100%

Time available can be on day / month or year basis

For congestion management (dis)charging power is also relevant.

The baseline value for RES storage use is 0. There are no RES storages in use at the baseline situation.

4.4.3F3: Peak load reduction

Description of the indicator:

The indicator is used to analyze the maximum power demand of a system in comparison with the average power. With the correct application of ICT systems, the peak load can be reduced on a high extent and therefore the dimension of the supply system. E.g., Peak load is the maximum power consumption of a building or a group of buildings to provide certain comfort levels.

Compare the peak demand before the aggregator implementation (baseline) with the peak demand after the aggregator implementation (per final consumer, per feeder, per network). E.g. Peak load is the maximum power consumption of a building or a group of buildings to provide certain comfort levels. With the correct application of ICT systems, the peak load can be reduced on a high extent and therefore the dimension of the supply system. In SCIS, the indicator is used to analyze the maximum power demand of a system in comparison with the average power.

4.4.3.1 E2: Thermal energy peak load reduction building level (simulation)

Thermal energy peak load, as shown in

Month	Sivakka 1 Thermal Energy peak load [kWh]
January	125
February	122
March	110
April	90
May	80
June	60
July	40
August	30
September	80
October	90
November	100
December	109

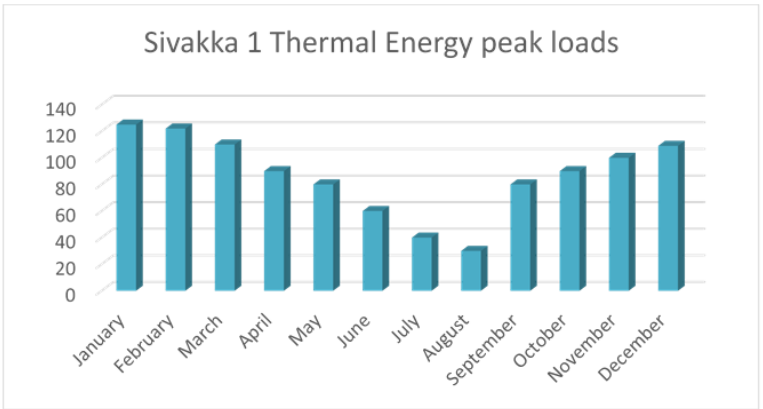

Figure 50 to

Month	School 6 Thermal Energy peak load [kWh]
January	429.638
February	480.6686
March	419.4958
April	308.8339
May	266.8535
June	149.9825
July	74.08084
August	77.55477
September	252.0671
October	281.8639
November	313.2314
December	348.5825

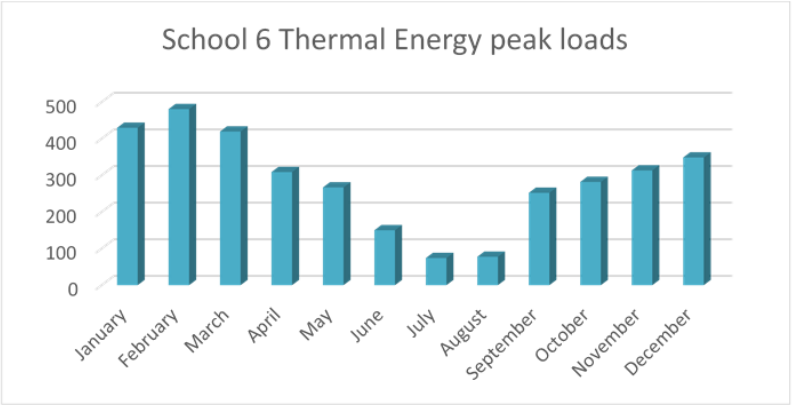

Figure 54, displays simulation of the maximum thermal energy demand in each building per month. Arina store is not using any district heating, and therefore not included in this simulation for thermal energy peak loads.

Month	Sivakka 1 Thermal Energy peak load [kWh]
January	125
February	122
March	110
April	90
May	80
June	60
July	40
August	30
September	80
October	90
November	100
December	109

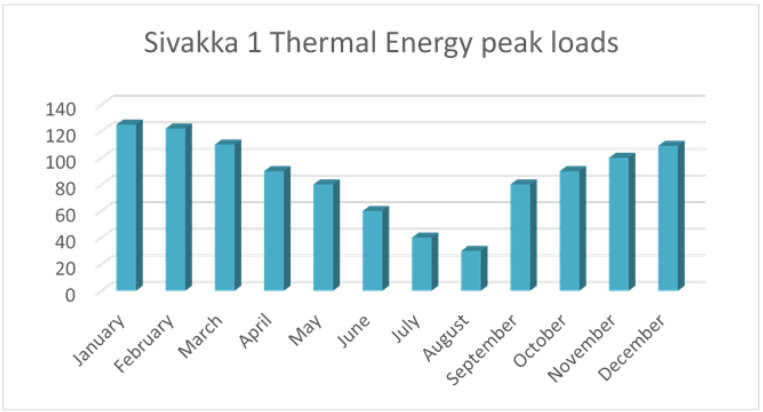

Figure 50: Sivakka 1 thermal energy peak loads

Month	Sivakka 2.1 Thermal Energy peak load [kWh]
January	79.592
February	71.214
March	67.025
April	58.64
May	37.701
June	25.134
July	16.756
August	19.26
September	37.701
October	54.458
November	62.83
December	67.025

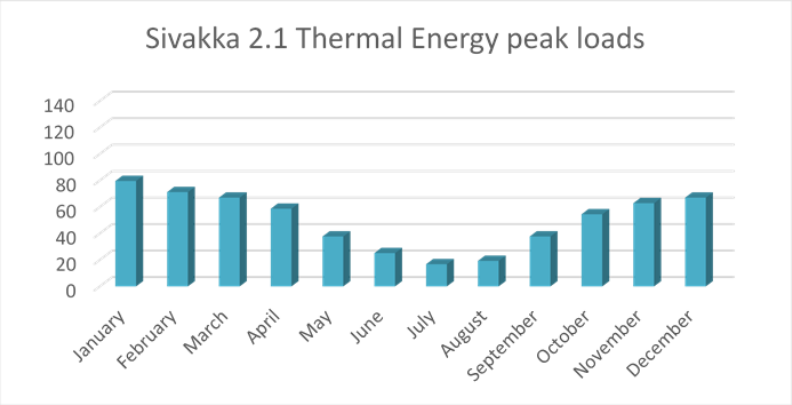

Figure 51: Sivakka 2.1 thermal energy peak loads

Month	Sivakka 2.2 Thermal Energy peak load [kWh]
January	112.860
February	128.983
March	96.737
April	64.491
May	64.491
June	48.368
July	48.368
August	48.368
September	64.491
October	64.491
November	80.614
December	96.737

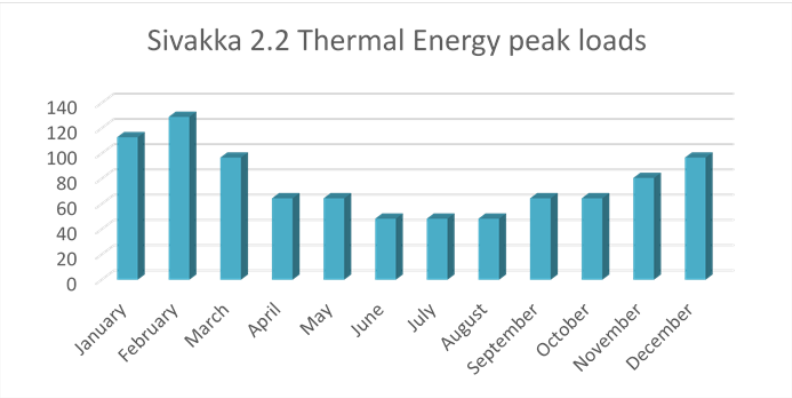

Figure 52: Sivakka 2.2 thermal energy peak loads

Month	YIT 3 Thermal Energy peak load [kWh]
January	89.695
February	91.600
March	76.220
April	58.527
May	46.957
June	33.48
July	28.854
August	30.243
September	46.957
October	56.21
November	67.374
December	76.220

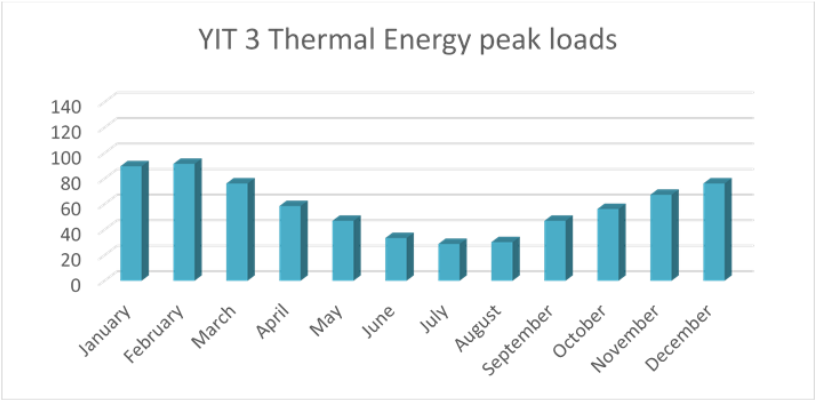

Figure 53: YIT 3 thermal energy peak loads

Month	School 6 Thermal Energy peak load [kWh]
January	429.638
February	480.6686
March	419.4958
April	308.8339
May	266.8535
June	149.9825
July	74.08084
August	77.55477
September	252.0671
October	281.8639
November	313.2314
December	348.5825

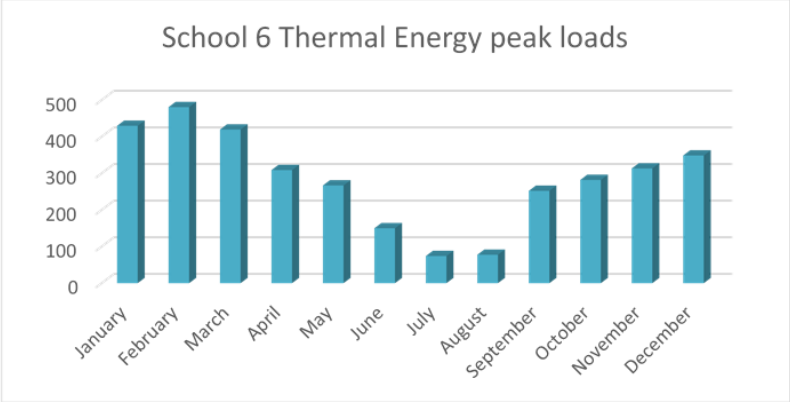

Figure 54: School 6 thermal energy peak loads

4.4.3.2 E2: Electrical energy peak load reduction (simulation)

Electrical energy peak load, as shown in Figure 55 to

Month	School 6 Electrical Energy peak load [kWh]
January	278.91
February	331.21
March	281.75
April	324.44
May	306.25
June	247.53
July	229.19
August	285.87
September	284.63
October	252.13
November	356.93
December	301.90

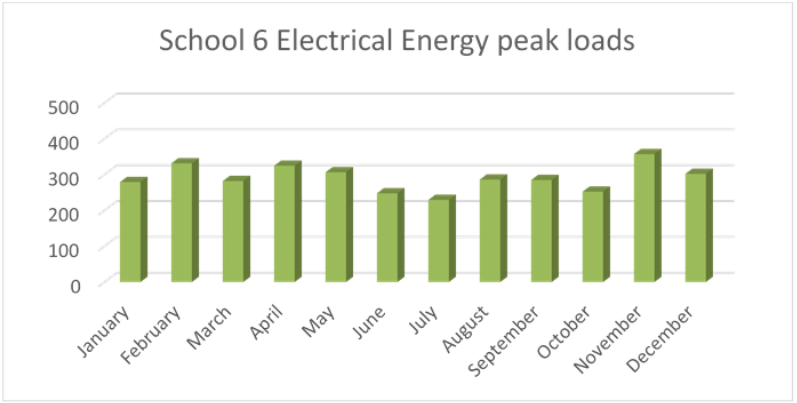

Figure 60, displays simulation of the maximum electrical energy demand in each building per month.

Month	Sivakka 1 Electrical Energy peak load [kWh]
January	27.49
February	30.28
March	25.52
April	26.38
May	25.83
June	25.02
July	23.55
August	23.85
September	24.61
October	23.225
November	31.62
December	29.61

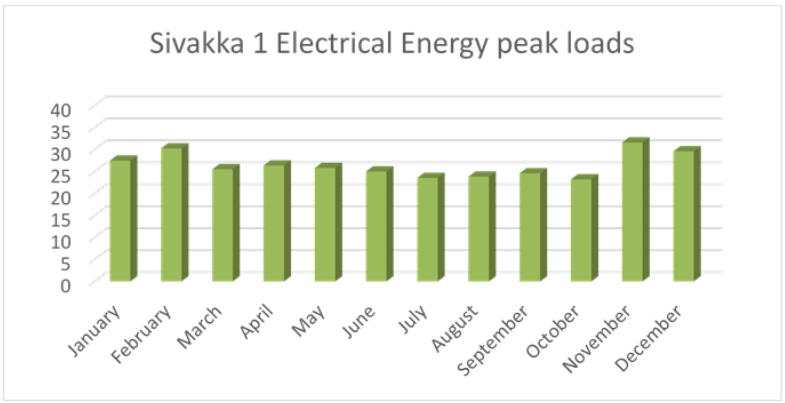

Figure 55: Sivakka 1 electrical energy peak loads

Month	Sivakka 2.1 Electrical Energy peak load [kWh]
January	29
February	26.8
March	25
April	26.6
May	21.6
June	17.8
July	18.42
August	19.4
September	19.34
October	29.2
November	27.6
December	26.4

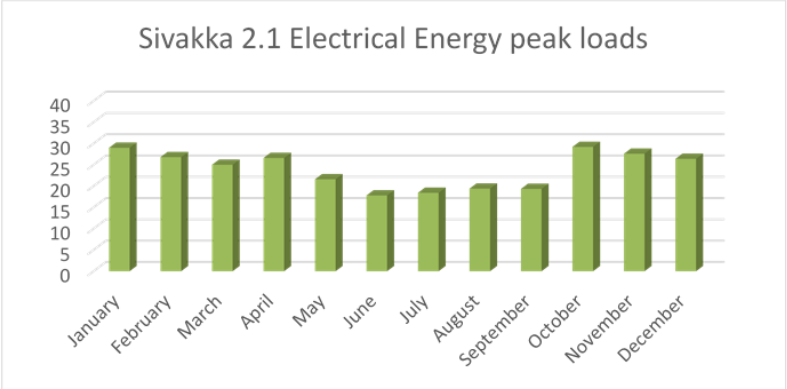

Figure 56: Sivakka 2.1 electrical energy peak loads

Month	Sivakka 2.2 Electrical Energy peak load [kWh]
January	24.810
February	35.994
March	27.809
April	29.292
May	23.108
June	21.148
July	20.454
August	21.477
September	22.223
October	35.962
November	32.975
December	29.825

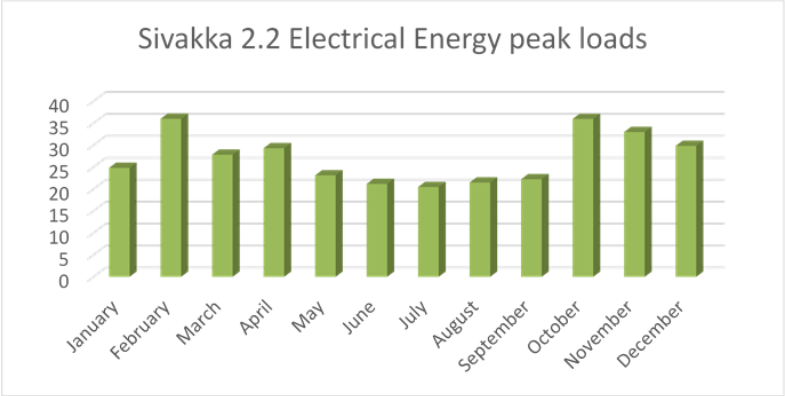

Figure 57: Sivakka 2.2 electrical energy peak loads

Month	YIT 3 Electrical Energy peak load [kWh]
January	26.905
February	31.397
March	26.404
April	27.946
May	22.354
June	19.474
July	19.437
August	20.438
September	20.781
October	32.581
November	30.287
December	28.112

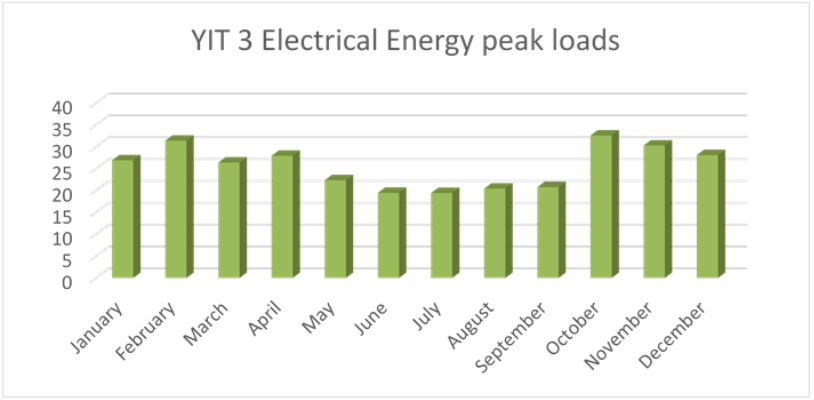

Figure 58: YIT 3 electrical energy peak loads

Month	Arina 5 Electrical Energy peak load [kWh]
January	370.67
February	455.87
March	348.48
April	360.78
May	315.77
June	385.97
July	412.95
August	369.29
September	339.63
October	314.73
November	413.63
December	409.86

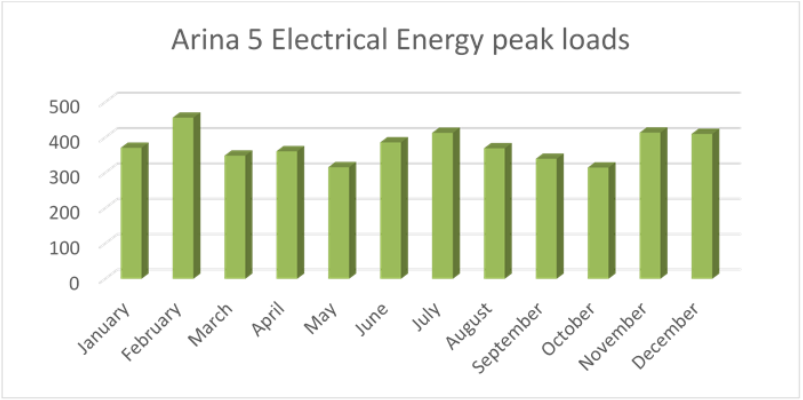

Figure 59: Arina 5 electrical energy peak loads

Month	School 6 Electrical Energy peak load [kWh]
January	278.91
February	331.21
March	281.75
April	324.44
May	306.25
June	247.53
July	229.19
August	285.87
September	284.63
October	252.13
November	356.93
December	301.90

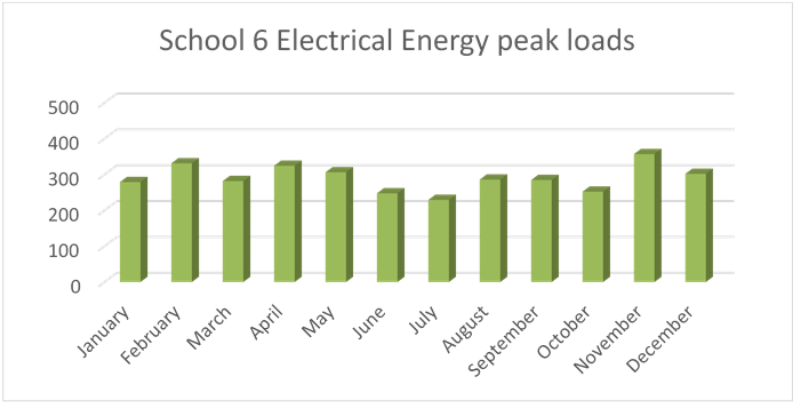

Figure 60: School 6 electrical energy peak loads

4.5 Baselines for society and residents indicators

The following Table 14 presents the society and residents KPIs for the Kaukovainio PED. The calculation procedure follows in the sections below.

Table 14: Baseline for society and residents KPIs in Kaukovainio PED

Society and residents KPIs	
Indicator	Estimated value
S1: Energy poverty	0
S2: Consciousness of residents	-
S3: Resident engagement / empowerment to climate conscious actions	-

4.5.1S1: Energy poverty

Description and calculation of the quantitative indicator:

Percentage of households by definition, or Energy bill as % of total household disposable income.

Energy poverty has not been studied much in Finland, mainly due to a lack of research data, leading it to be partly hidden as a phenomenon. Energy poverty is not formally mentioned in the public debate in Finland, nor is there any definition of or approach to energy poverty within policymaking. This is also mainly because current indicators used to analyse energy poverty are inadequate for application in the Finnish context. It is estimated, that in 2016, only 1.7% of the population suffer from energy poverty in Finland. (Castaño-Rosa, 2021).

According to Leirimaa (2020), Energy poverty (EPOV) is a phenomenon with multiple potential causes leading to a wide range of policies needed in order to alleviate it. Also, energy poverty has multiple dimensions and factors. Leirimaa (2020) mentions at least issues related to:

- socio-economic status; i.e. unemployment and income classes of different groups,
- cost of goods; naturally energy prices, and
- living and habits of individuals; energy use, living distances, type of housing etc.

Leirimaa (2020) also points out, that energy poverty estimates differ quite much in Finland depending on the region or province, hence the location inside the country. Considering the whole country, energy poverty levels are estimated at below 5% of the population on average. The EPOV data shows that energy poverty indicators in Finland are between 2–4 % (European Commission 2019.)

These reference estimates are very well in line with the results of the first city-wide survey conducted in the Making-City project. The project level survey has not yet been conducted, and therefore an estimate based on several reference values will be used for baseline. The baseline value for S1: **4 %**

4.5.2S2: Consciousness of residents

Description of the qualitative indicator:

Consciousness of residents in the area on the defined issues (project interventions, energy, environment, climate, personal/communal consumption, carbon footprint and handprint, etc.).

Baseline definition using Likert scale:

No consciousness – 1 – 2 – **3** – 4 – 5 – High consciousness

Since the project level survey for residents of the area has not yet been conducted, the baseline value has been assessed by the same group of experts that determined the qualitative values for the city level indicators in D5.1. The baseline value for S2 is **3**.

4.5.3S3: Resident engagement / empowerment to climate conscious actions

Description of the qualitative indicator:

Appreciation of the benefits of project actions; Energy empowerment at home, satisfaction, happiness of people. The indicator provides a qualitative measure, and the evaluation is rated on a five-point:

1. No increase: The project has not increased civic/resident engagement.

2. Small increase: The project has increased civic/resident engagement with regards to one of the five factors mentioned.

3. Some increase: The project increased civic/resident engagement with regards to two of the factors mentioned.

4. Significant increase: The project has increased civic/resident engagement with regards to three of the factors mentioned.

5. High increase: The project has increased civic/resident engagement with regards to four or more of the factors mentioned.

The baseline will be determined with Likert scale:

No engagement – 1 – 2 – **3** – 4 – 5 – High engagement

Since the project level survey for residents of the area has not yet been conducted, the baseline value has been assessed by the same group of experts that determined the qualitative values for the city level indicators in D5.1. The baseline value for S3 is **3**.

Conclusions

The main objective of reporting the baselines for all KPI categories, both quantitative and qualitative indicators (Energy & Environment, System Flexibility, Mobility, Economy and Social & Residents) is to use this information to evaluate the development and final impacts of the implemented actions during the monitoring period (finally in D5.11 Evaluation for both city and project level) and choose the most effective actions and interventions that can be implemented in interested follower cities to achieve smart city and environmental goals.

There are several different approaches to estimate the baseline for a variety of different type key performance indicators. The objective was to utilize actual data sets as much as possible. Data was collected from the demo-buildings themselves (historic data before interventions), but also from reference buildings that represent actual demos as accurately as possible (same type, construction period and norms, purpose, consumption profile, owner etc.). Also references from literature were utilized in the case of energy poverty related indicator. As for the qualitative indicators, same approaches and methods were utilized as with the city level indicators that were estimated for the baseline already in D5.1. We will get more detailed information and data during the monitoring period that is about to start, including information from the PED level survey targeted for residents. This more accurate data will be utilized in KPI calculations (D5.10) and finally in the overall evaluation of city and project level that will be reported in D5.11.

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