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# D3.2 Baseline of Groningen PEDs

**WP3, Task 3.2**

November 2021 [M36]

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| 30-11-2021 | 0.1 | TNO | George Huitema | Preparing final version |
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# Abbreviations and acronyms

| Acronym | Description |
|---|---|
| ATES | Aquifer Thermal Energy Storage |
| BAG | Basisregistratie Adressen en Gebouwen (Dutch database of buildings) |
| BMS | Building Management System |
| CBS | Centraal Bureau voor Statistiek (Dutch statistics organization) |
| EAE | Energy Academy Europe |
| ECN | Energy research Centre of the Netherlands |
| ESDL | Energy System Description Language |
| ESSIM | Energy System Simulator |
| ETM | Energy Transition Model |
| HRB | High Rise Building |
| KPI | Key Performance Indicator |
| NEDU | Nederlandse Energie Data Uitwisseling (Dutch database containing energy profiles) |
| NZEB | Nearly Zero Energy Building |
| PED | Positive Energy District |

# Executive Summary

Objective of WP3 is describing and delivering Lighthouse demonstration actions in Groningen and the design and validation of two Positive Energy Districts, Groningen North and Groningen Southeast. This deliverable (D3.2) describes the results of Task 3.2 which is dedicated to determining the baseline of the Groningen PEDs.

Since there are no measurements at the actual start of the project modelling and simulation tools are used in order to determine the KPIs at the start of the project. These KPIs establish a baseline measurement to which the end results of the project can be compared.

This document describes the data gathering process, from historic data, mostly publicly available, but also provided by the intervention owners. Next the data processing is described in order to get a more reliably scenario. Finally, the simulation process using ESDL and ESSIM are described, and finally the computation of the KPIs.


# Keywords

PED baseline, Modelling, Simulation, KPI

# 1 Introduction

## 1.1 Purpose and target group

This deliverable is part of the MAKING-CITY project, work package 3: Demonstration of PED concept in Groningen. This deliverable is an outcome of task 3.2: Baseline of interventions definition. This document describes the process of gathering and processing data that was available from prior to the start of the project, in order to get a most reliable estimation of the baseline situation.

Where possible, this document attempts to be as self-contained as possible. However, the reader of this document is assumed to have a basic knowledge of the MAKING-CITY project including its goals, and the Groningen PED in particular.

## 1.2 Contribution partners

| Partner no. | Partner | |
|---|---|---|
| 4 | TNO | Editor - All other sections |
| 12 | HUAS | Sections 2 and 3 |

**Table 1 Contribution partners**

## 1.3 Relation to other activities in the project

| Deliverable no. | Relation |
|---|---|
| D2.2 | This is the corresponding document that describes the baseline of interventions for the Oulu PED. |
| D3.1 | Describes the overall design of the PED including all interventions. |
| D3.3 | The modelling and simulation tools that are used in this document are described in D3.3. |
| D5.2 | The project level indicators or the KPIs are defined in D5.2 |
| D5.5 | Documents all datasets that are used in this deliverable. |

**Table 2 Other related activities**

# 2 PED Overview and definition of baseline

To determine the impact of the different interventions on the PED, it is important to have a defined baseline that you can compare against. In this chapter, this baseline definition will be explained.

The impact of the interventions, as well as the baseline definition, can be evaluated on two aggregate levels. One is on the level of individual buildings and the other on the district level. The selected individual buildings are representative for their district and can be classified based on their building type. The district level can only be evaluated on the available information regarding the estimated energy demand based on each building type.

To establish a baseline method, a few choices were made:

- **Date.** The baseline date was set at 01-01-2016.
- **Energy production.** All heating demand is met by using domestic boilers that are supplied with natural gas. All electricity comes from the electricity grid outside the district except for household PV installations.
- **Energy demand intervention buildings.** In case the data for the individual buildings before the intervention was available, this data was used. If this data was not available or if the building did not exist on the baseline date, the energy demand was estimated. For each selected building, the baseline definition is explained in more detail per PED in the next sections.
- **Energy demand district.** The energy demand was estimated based on aggregated information related to the number of the buildings or the total surface area of the corresponding building size, depending on the building type, which is explained in more detail in the next chapter. A distinction between the following building types was made:
    - Residential
    - Education
    - Office
    - Sports
    - Other. This is a combined average of the remaining types which include Gathering, Healthcare, Hotel, Industry, Other, and Shopping.

## 2.1 Groningen North PED

This section shows the relevant characteristics of each selected building for the Groningen North PED. Furthermore, the definition of the baseline for each selection is given. The values and calculations for the corresponding energy demand and production are given in the next chapter. In the Groningen North PED, three intervention buildings were selected:

- 2 Nijestee high-rise buildings (HRB)
- 3 Terraced Houses
- Energy Academy Europe (EAE)

The data used to define the baseline for these buildings is explained in more detail below.

### 2.1.1 Nijestee high-rise buildings

The Nijestee HRBs can be characterized using the following specifications:

- Two high-rise buildings.
- Each building contains 108 apartments with an approximate apartment size of 25 $m^2$ and several common areas. The total surface area is 7400 $m^2$.
- Building type: Residential.

The data for the baseline was provided by Nijestee. This data consisted of the total electricity and gas demand of the common areas and the apartments.

### 2.1.2 Paddepoel terraced houses

The terraced houses can be characterized using the following specifications:

- Three terraced houses:
  - Grote Beerstraat.
  - Neptunusstraat.
  - Zuiderkruislaan.
- Building type: Residential.
- Total surface area of the three houses is 360$m^2$.

For each house, the energy consumption and production of the existing situation was estimated by the energy consultancy firm Invent using the nZEB-tool (nearly zero energy building tool). The total estimated gas and electrical demand were split into several categories, such as heating, domestic hot water (DHW), ventilation, and cooking. This was used as the input values for the baseline calculations.

### 2.1.3 Energy Academy Europe

The Energy Academy Europe (EAE) can be characterized using the following specifications:

- Surface area: 9363 $m^2$.
- Building type: Education.

Since the EAE was built as a highly energy efficient building with more energy production than consumption, there is no reference to compare this building to. To determine a baseline energy consumption, the total surface area was multiplied with the average demand for gas and electricity for this type of building. The resulting values are shown in the next chapter.

## 2.2 Groningen Southeast PED

This section shows the relevant characteristics of each selected building for the Groningen Southeast PED. Furthermore, the definition of the baseline for each selection is given. The values and calculations for the corresponding energy demand and production are given in the next chapter. In the Groningen Southeast PED, four intervention buildings were selected:

- Powerhouse
- Mediacentrale
- Sports Complex Europahal
- Harm Buiterplein

The data used to define the baseline for these buildings is explained in more detail below.

### 2.2.1 Powerhouse

The Powerhouse building is a combination of offices and apartments and can be characterized using the following specifications:

- Offices surface area: 1400 m2.
- Number of apartments: 80.
- Building types: Office and Residential.

Since the Powerhouse building did not exist at the baseline date, there is no reference data available that can be used as the baseline. Therefore, the energy demand was estimated using the average electricity and gas demand for offices and households.

### 2.2.2 Mediacentrale

The Mediacentrale can be characterized using the following specifications:

- Surface area: 14400 m2.
- Building type: Office.

### 2.2.3 Sports complex Europahal

The Sports complex Europahal is a combination of offices and sports facilities and can be characterized using the following specifications:

- Offices surface area: 1107 m2.
- Sports surface area: 4208 m2.
- Building types: Office and Sports.

Since the Europahal building did not exist at the baseline date, there is no reference data available that can be used as the baseline. Therefore, the energy demand was estimated using the average electricity and gas demand for office and sport building types.

### 2.2.4 Harm Buiterplein

At the Harm Buiterplein an office of the Groningen municipality is located, which was newly built in 2014. It is a very well insulated building and was built very ecologically friendly. An optimal use of daylight and an ATES, PV panels and an ecological green roof, an extremely low energy usage is realised.

- Surface area: 17000 m2.
- Building type: Office.

# 3 Data sources and processing

This chapter explains the approaches to gather the data, their corresponding sources, and it presents the resulting consumption and production values, only considering building-based consumption. These values are used as input to the simulation models for the baseline scenario. The chapter starts with a description of the data used to calculate the consumption and production values. This is followed by two sections describing the resulting values for each district, divided into the selected buildings and district. The decisions and baseline definitions are presented in the previous chapter.

Three different approaches were used to collect the data and obtain the consumption and production values:

- **Known data.** This was only used for the selected buildings. If consumption or production values before interventions were known, this was used as input to the baseline scenario. The previous chapter describes where this information was available.
- **CBS data.** For households, CBS data containing average yearly consumption values of gas and electricity are available for each neighbourhood in the Netherlands [CBS2015_1]. Additionally, there is data available of the total capacity of solar PV for each neighbourhood [CBS2015_2]. This data can be converted to annual energy consumption and production values of which the calculation method is explained below.
- **Area + ECN data.** For service buildings there is no CBS data available for each neighbourhood. To obtain values for the baseline, estimates were made based on the surface area of different building types, which was collected from the BAG database. This was used in combination with the average yearly consumption values [ECN2016] to obtain an estimate for the total demand per each type. The calculation method is explained in more detail below.

## 3.1 Calculation methods

To obtain the input for the baseline simulation models, first the total energy consumption and production must be calculated. From this, the energy consumption can be divided into several categories using average estimates. By adding the relevant categories, the building-based consumption can be obtained. The following two sections provide the methods for calculating these values.

### 3.1.1 Total energy consumption and production

As a first step the total energy consumption and production values are calculated for the unknown selected buildings and estimations for each district. This section explains the method for calculating this, starting with the calculations for the households, followed by the method for the rest of the building types. The fixed parameters that are necessary for some of the calculations are shown in Table 3.

| Parameter | Symbol | Value |
|---|---|---|
| Heating value of natural gas [kWh/m3] | $HV_{gas}$ | 9.769 |
| Average annual solar hours [h] | $t_{sol}$ | 850 |

**Table 3 Fixed parameters for the calculations**

CBS has many datasets available for all the neighbourhoods in the Netherlands. Relevant for determining the consumption and production are the housing stock as well as the average gas and electricity consumption [CBS2015_1]. Additionally, the capacity of solar PV for each district is provided by CBS as well [CBS2015_2]. The values for these are shown in Table 4 for both districts.

| | Symbol | North PED | Southeast PED |
|---|---|---|---|
| Housing stock [-] | $n_h$ | 5027 | 870 |
| Average gas consumption [m3] | $v_{gas}$ | 1492 | 996 |
| Average electricity consumption [kWh] | $c_{el}$ | 2094 | 2649 |
| Solar PV capacity [kWp] | $p_{pv}$ | 559 | 151 |

**Table 4 Households' stock, average gas and electricity consumption, and solar PV capacity in 2016 [CBS2015_1, CBS2015_2]**

Using the values given in Table 4, the total consumption and production values can be determined. The total energy consumption from gas ($C_{gas}$, in kWh) can be calculated by multiplying the number of houses in the district ($n_h$) with the average gas consumption ($v_{gas}$, in m3) and the corresponding heating value of the gas ($HV_{gas}$). Since the average electricity consumption ($c_{el}$) is already expressed in kWh, this value needs only to be multiplied with the number of houses in the district to obtain the total electricity consumption ($C_{el}$). To calculate the yearly production of the solar PV ($P_{pv}$) from the households, the capacity of the PV in the district ($p_{pv}$) was multiplied with an estimation for the number of full solar hours in the Netherlands ($t_{sol}$). Mathematically, this can be expressed as:

$$C_{gas} = n_h \cdot v_{gas} \cdot HV_{gas}$$

$$C_{el} = n_h \cdot c_{el}$$

$$P_{pv} = t_{sol} \cdot p_{pv}$$

Since the CBS data is not provided on a neighbourhood level for service buildings, a different approach was taken to estimate the consumption of these types. This was done by obtaining the surface area per building type using the BAG database, which is shown for the two districts in Table 5.

| Building type | North PED [m2] | Southeast PED [m2] |
|---|---|---|
| Education | 353508 | 37397 |
| Gathering | 48505 | 52520 |
| Healthcare | 16353 | 2194 |
| Hotel | 311 | 2741 |
| Industry | 34538 | 841945 |
| Office | 74580 | 212495 |
| Other | 82233 | 68882 |
| Shopping | 21185 | 193977 |
| Sports | 2931 | 16139 |

**Table 5 Surface area per building type ($A_i$) for each PED.**

A study performed by ECN [ECN2016] has provided average specific gas and electricity consumption estimates for the different service building types, which are shown in Table 6.

| Building type | Gas [m3/m2] | Electricity [kWh/m2] |
|---|---|---|
| Education | 14.33 | 38.33 |
| Gathering | 16.00 | 84.00 |
| Healthcare | 20.00 | 54.75 |
| Hotel | 28.00 | 120.00 |
| Industry | 12.80 | 456.00 |
| Office | 17.00 | 60.00 |
| Other | 19.22 | 135.55 |
| Shopping | 18.00 | 177.00 |
| Sports | 27.67 | 94.33 |

**Table 6 Yearly specific gas ($v_{gas,i}$) and electricity demand ($c_{el,i}$) of service buildings [ECN2016]**

The gas ($v_{gas,i}$) and electricity ($c_{el,i}$) demands for each building type can be multiplied with the corresponding areas ($A_i$) from Table 5 to determine the total gas and electricity consumption ($C_{gas,i}$ and $C_{el,i}$):

$$C_{gas,i} = A_i \cdot v_{gas,i} \cdot HV_{gas}$$

$$C_{el,i} = A_i \cdot c_{el,i}$$

Considering that the selected buildings in the Groningen PEDs do not contain all the building types shown in Table 5, the service building types were limited to a subset containing Education, Office, Sports, and Other. Here, Other includes the types Gathering, Healthcare, Hotel, Industry, Other, and Shopping. To calculate the consumption values for the Other category, the sum of the surface areas of these types ($\sum A_i$) was multiplied with the average gas and electricity consumption of these types ($\bar{v}_{gas,i}$ and $\bar{c}_{el,i}$).

$$A_{other} = \sum A_i$$

$$C_{gas,other} = A_{other} \cdot \bar{v}_{gas,i} \cdot HV_{gas}$$

$$C_{el,other} = A_{other} \cdot \bar{c}_{el,i}$$

### 3.1.2 Building-based consumption

With the method described in the previous section, the total consumption values for the different building types can be obtained for the two districts. However, for the purpose of this study, only the building-based consumption is of interest, which includes the following categories:

- Cooling and/or Ventilation
- Domestic hot water (DHW)
- Lighting
- Space heating
- Other (supporting systems, BMS)

The Energy Transition Model provides data that includes the average distribution of gas and electricity for different categories [ETM2021], which is shown in Table 7 for households and in Table 8 for service buildings. By multiplying the total consumption of gas ($C_{gas}$) and electricity ($C_{el}$) with the corresponding distribution factor ($x_{gas,i}$ and $x_{el,i}$), the total consumption for each category can be calculated ($C_i$):

$$C_i = C_{gas} \cdot x_{gas,i} + C_{el} \cdot x_{el,i}$$

| Category | Electricity [-] | Gas [-] |
|---|---|---|
| Cooking | 0.06 | 0.05 |
| Cooling / Ventilation | 0.08 | 0.00 |
| DHW | 0.05 | 0.16 |
| Lighting | 0.12 | 0.00 |
| Space heating | 0.08 | 0.79 |
| Appliances | 0.61 | 0.00 |

**Table 7 Average electricity and gas distribution in the Netherlands for households [ETM2021]**

| Category | Electricity [-] | Gas [-] |
|---|---|---|
| Cooling / Ventilation | 0.16 | 0.00 |
| Lighting | 0.36 | 0.00 |
| Space heating | 0.01 | 1.00 |
| Appliances | 0.47 | 0.00 |

**Table 8 Average electricity and gas distribution in the Netherlands for buildings [ETM2021]**

## 3.2 Consumption and production values

Knowing the input for the baseline and the calculation method, the resulting energy consumption and production values for the selected buildings and building types can be calculated. The actual profiles in the simulation, to get the specific hourly data of consumption or production of the assets are taken by using yearly averages from the NEDU dataset. This is the same way as done in deliverable D3.3.

The following two sections show these results for each of the PEDs.

### 3.2.1 Groningen North PED

The building type(s) and calculation method(s) for the Groningen North PED can be summarized as:

- Three terraced houses. Residential. Known data.
- Two Nijestee high-rise buildings. Residential. Known data.
- Energy Academy Europe. Education. Area + ECN method.
- District. Residential, Education, Office, Sports, and Other. CBS data and Area + ECN method.

Using the baseline definition and calculation methods, the resulting values for each building-based category can be calculated. These are shown in Table 9 for the selected buildings and in Table 10 for the district.

| | Heating [kWh] | DHW [kWh] | Cooling / Ventilation [kWh] | Other [kWh] | Lighting [kWh] | Generation [kWh] | Balance |
|---|---|---|---|---|---|---|---|
| Terraced House 1: Neptunusstraat | 13931 | 1915 | 0 | 200 | 316 | 0 | 16362 |
| Terraced House 2: Zuiderkruislaan | 14507 | 4318 | 644 | 200 | 301 | 0 | 19970 |
| Terraced House 3: Grote Beerstraat | 5099 | 3380 | 333 | 0 | 310 | -2799 | 6323 |
| Nijestee HRB1 | 1002960 | 203131 | 13306 | 0 | 70759 | 0 | 1290156 |
| Nijestee HRB2 | 735417 | 148945 | 13306 | 0 | 69223 | 0 | 966891 |
| EAE | 1311029 | 0 | 57426 | 0 | 129209 | 0 | 1497664 |

**Table 9 Baseline building-related consumption for the selected buildings in the PED North**

| | Heating [kWh] | DHW [kWh] | Cooling / Ventilation [kWh] | Other [kWh] | Lighting [kWh] | Generation [kWh] | Balance |
|---|---|---|---|---|---|---|---|
| Education | 49634526 | 0 | 2168182 | 0 | 4878410 | 0 | 56681118 |
| Offices | 12430472 | 0 | 715968 | 0 | 1610928 | 0 | 14757368 |
| Residential | 58721439 | 12248751 | 842198 | 0 | 1263296 | -475150 | 72600534 |
| Sports | 794943 | 0 | 44239 | 0 | 99537 | 0 | 938719 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Other | 38058287 | 0 | 5564553 | 0 | 12520244 | 0 | 56143084 |

**Table 10 Baseline building-related consumption for the PED North**

## 3.2.2 Groningen Southeast PED

The building type(s) and calculation method(s) for the Groningen Southeast PED can be summarized as:

- Mediacentrale. Office. Known data.
- Europahal. Office and Sports. Area + ECN method.
- Harm Buiterplein. Office. Area + ECN method.
- Powerhouse. Residential and Office. CBS data and Area + ECN method.
- District. Residential, Education, Office, Sports, and Other. CBS data and Area + ECN method.

Using the baseline definition and calculation methods, the resulting values for each building-based category can be calculated, which are shown in Table 11 for the selected buildings and in Table 12 for the district.

| | Heating [kWh] | DHW [kWh] | Cooling / Ventilation [kWh] | Other [kWh] | Lighting [kWh] | Generation [kWh] | Balance |
|---|---|---|---|---|---|---|---|
| Mediacentrale | 1212000 | 38160 | 636000 | 263600 | 209200 | 0 | 2358960 |
| Europahal | 1321163 | 0 | 74140 | 0 | 166815 | 0 | 1562118 |
| Harm Buiterplein | 2823241 | 0 | 163200 | 0 | 367200 | 0 | 3353641 |
| Powerhouse apartments | 635923 | 128794 | 18752 | 0 | 28128 | 0 | 811597 |
| Powerhouse offices | 2391451 | 0 | 138240 | 0 | 311040 | 0 | 2840731 |

**Table 11 Baseline building-related consumption for the selected buildings in the PED Southeast**

| | Heating [kWh] | DHW [kWh] | Cooling / Ventilation [kWh] | Other [kWh] | Lighting [kWh] | Generation [kWh] | Balance |
|---|---|---|---|---|---|---|---|
| Education | 5250751 | 0 | 229368 | 0 | 516079 | 0 | 5996198 |
| Offices | 35417179 | 0 | 2039952 | 0 | 4589892 | 0 | 42047023 |
| Residential | 6870528 | 1469396 | 184386 | 0 | 276578 | -128350 | 8672538 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Sports | 4377203 | 0 | 243591 | 0 | 548080 | 0 | 5168874 |
| Other | 217765349 | 0 | 31839762 | 0 | 71639466 | 0 | 321244577 |

**Table 12 Baseline building-related consumption for the PED Southeast**

# 4 Simulation outcomes

## 4.1 ESDL model PED North

Based on the gathered data, a simulation model of the energy system is developed using MapEditor. For more information about ESDL Toolsuite, as well as the legend of modelling icons refer to deliverable 3.3 (sections 2.2 and 4.1, respectively). Figure 1 shows ESDL model of the district as defined in the baseline. The blue area indicates the borders of the district, while everything outside is imported or exported. The grey icons model the intervention buildings, which are modelled in more detail, and separately. The rest of the district is modelled on an aggregate level and represented with blue icons (energy demands).

PED North has a gas and an electricity connection to the Dutch main grids, through which these commodities are imported.

## 4.2 Simulation outcomes PED North

This section presents ESSIM simulation outcomes for PED North. These outcomes show network balances for each of the energy carriers (electricity, heat and gas), on an hourly basis, for a period of one year. Energy assets and their aggregate yearly production or demand are shown on the right-hand of the dashboard, while the graphs visualize hourly values. Energy production is indicated by a negative sign, while energy demand is indicated by a positive sign.

Here, balances and energy models of the district on an aggregate level are shown, as the baseline version of individual intervention buildings are similar in models.

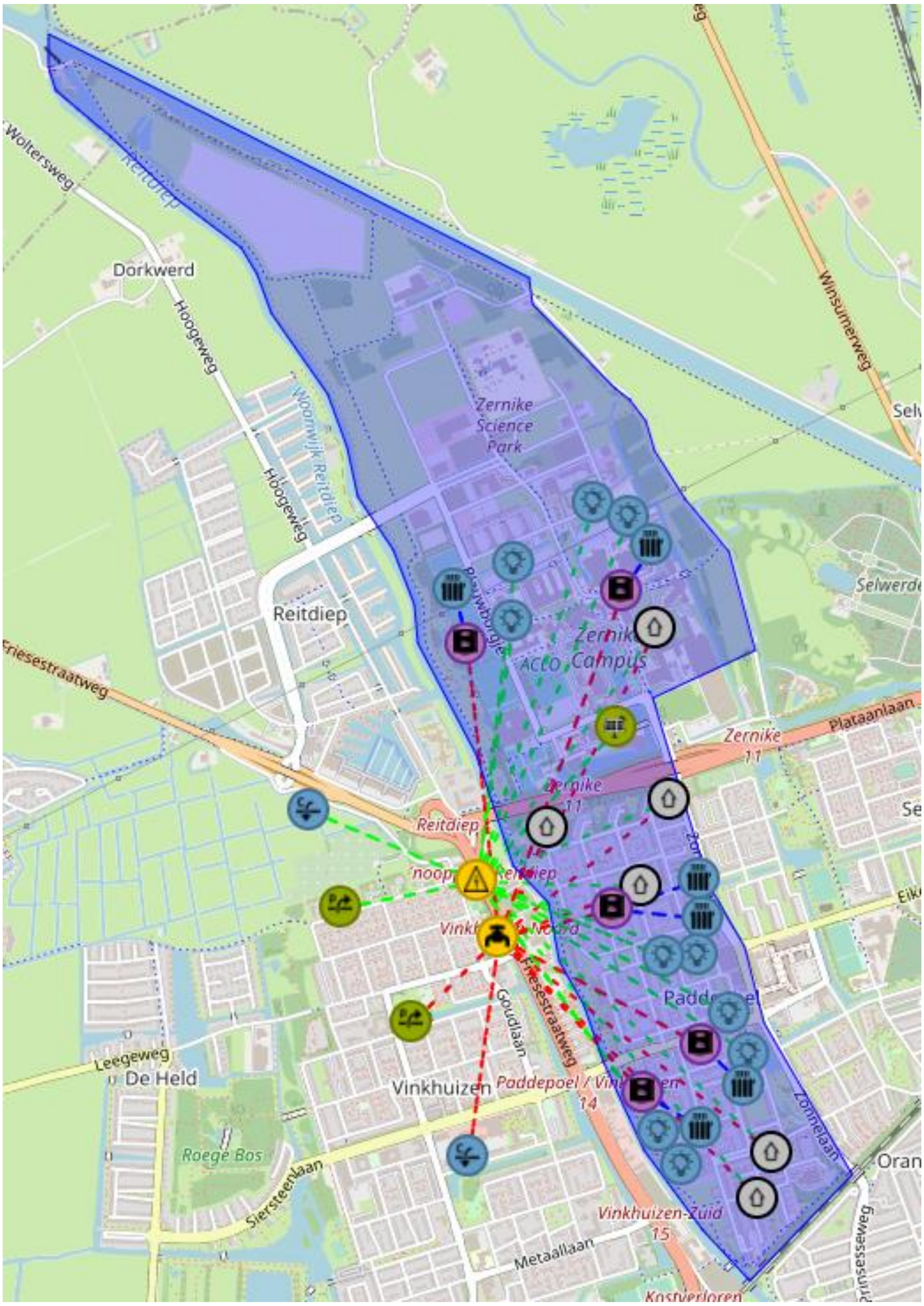


**Figure 1 ESDL model of PED North Baseline**

## 4.2.1 PED North gas network

PED North imports gas from the Dutch national gas network. Figure 2 shows gas network balances. *SourceProducer* indicates gas import into the district, and *SinkConsumer* indicates export from the district. As there are no local gas sources, all the gas is imported from outside the district.

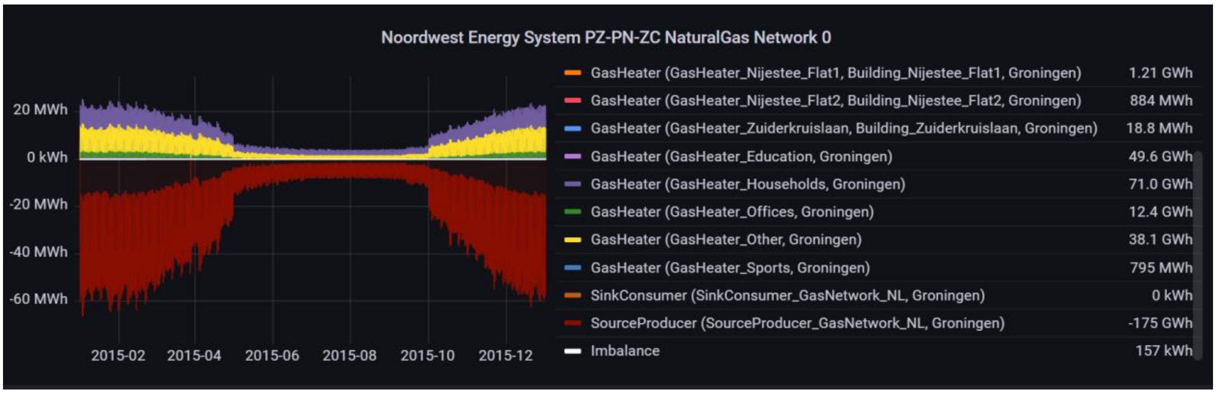


**Figure 2 PED North gas network balances**

Figure 3 shows transport loads of PED North gas network. Transport loads show energy flow through the gas connections of each of the intervention buildings, as well of the district. Both the intervention buildings, as well as the district only consume gas, therefore the positive energy flow.

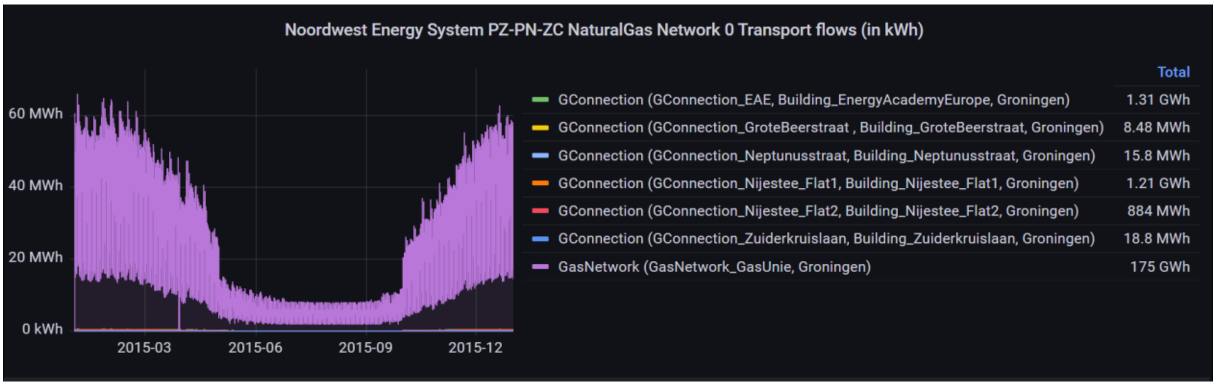


**Figure 3 PED North gas network transport loads**

## 4.2.2 Electricity network

Figure 4 shows electricity network of PED North. The local PV generation from residential rooftop is rather small (see Figure 5) and almost all the electricity must be imported from the national grid.

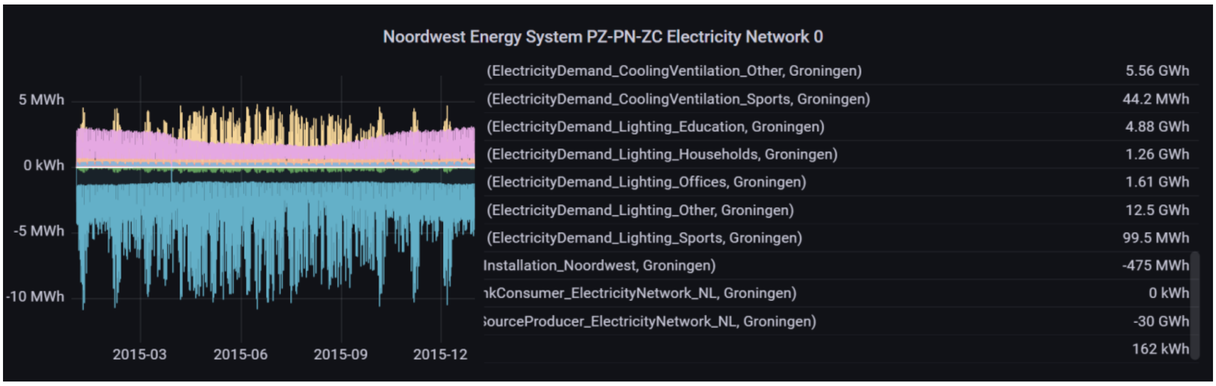


**Figure 4 PED North electricity grid network balances**

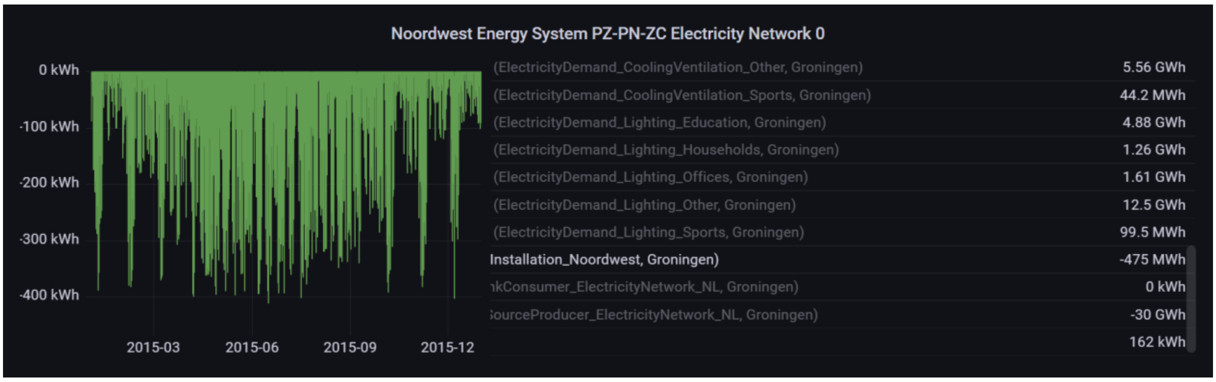


**Figure 5 Local electricity production in PED North**

Figure 6 shows transport loads of PED North electricity grid. All the intervention buildings, excluding Grote Beerstraat, have a positive energy flow, meaning that their total annual consumption is always greater than the total annual production. It is interesting to notice that even in the baseline, Grote Beerstraat has a negative energy flow for electricity commodity, meaning that when considered throughout the year, its PV panels produce more than the total of its electricity demand (see also Figure 7).

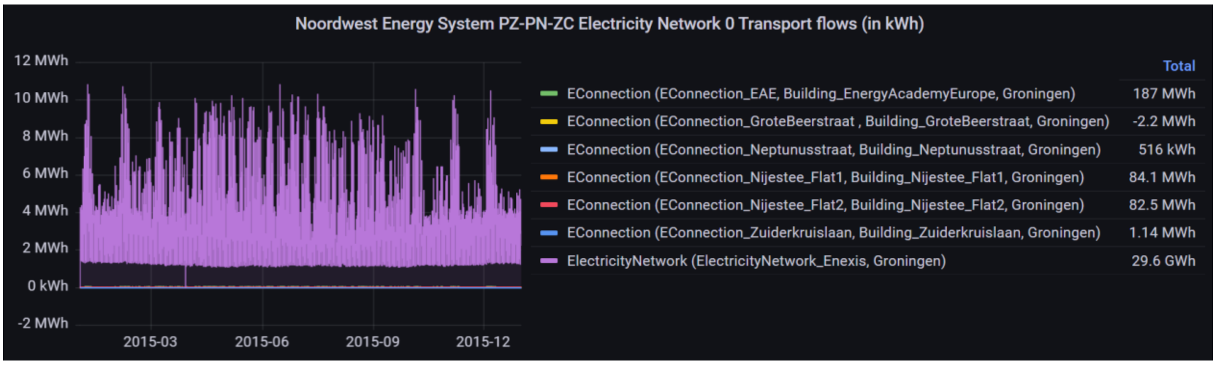


**Figure 6 PED North electricity network transport loads**

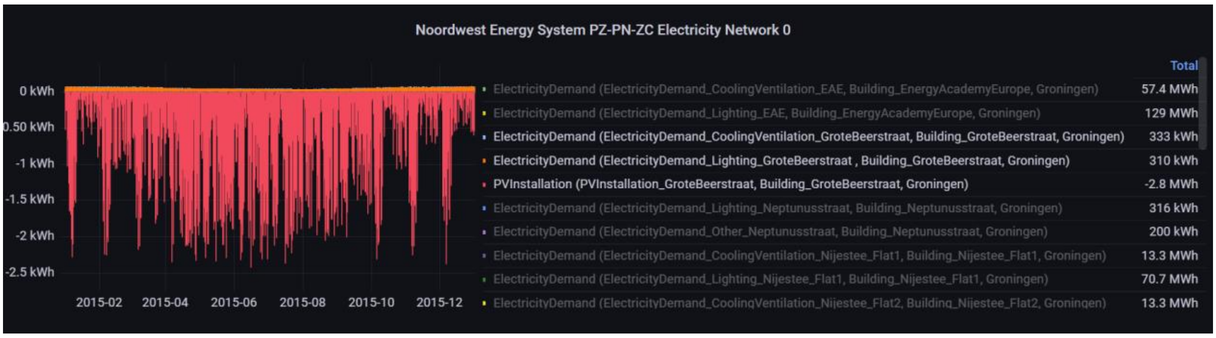


**Figure 7 Electricity balance of Grote Beerstraat**

Table 13 shows the total simulated energy flows per intervention building in PED North, per energy carrier. A positive energy flow indicates that, on an aggregate yearly level, the intervention house consumed more than it produced (if it produced at all), and a negative glow indicates that it produced more than it consumed.

| | Natural gas transport load [kWh] | Electricity transport load [kWh] |
|---|---|---|
| Energy Academy Europe | 1 310 000 | 187 000 |
| Nijestee Flat 1 | 1 210 000 | 84 100 |
| Nijestee Flat 2 | 884 000 | 82 500 |
| Terraced House 1: Neptunusstraat | 15 800 | 516 |
| Terraced House 3: Grote Beerstraat | 8 480 | 2 200 |
| Terraced House 2: Zuiderkruislaan | 18 800 | 1 140 |
| **Total** | **3 447 080** | **357 456** |

**Table 13 Electricity and gas transport loads of intervention buildings in PED North**

## 4.3 ESDL model PED South

Figure 8 shows ESDL model of the district as defined in the baseline. The blue area indicates the borders of the district, while everything outside is imported or exported. The grey icons model the intervention buildings, which are modelled in more detail, and separately. The rest of the district is modelled on an aggregate level and represented with blue icons (energy demands).

PED South has a gas and an electricity connection to the Dutch main grids, through which these commodities are imported.

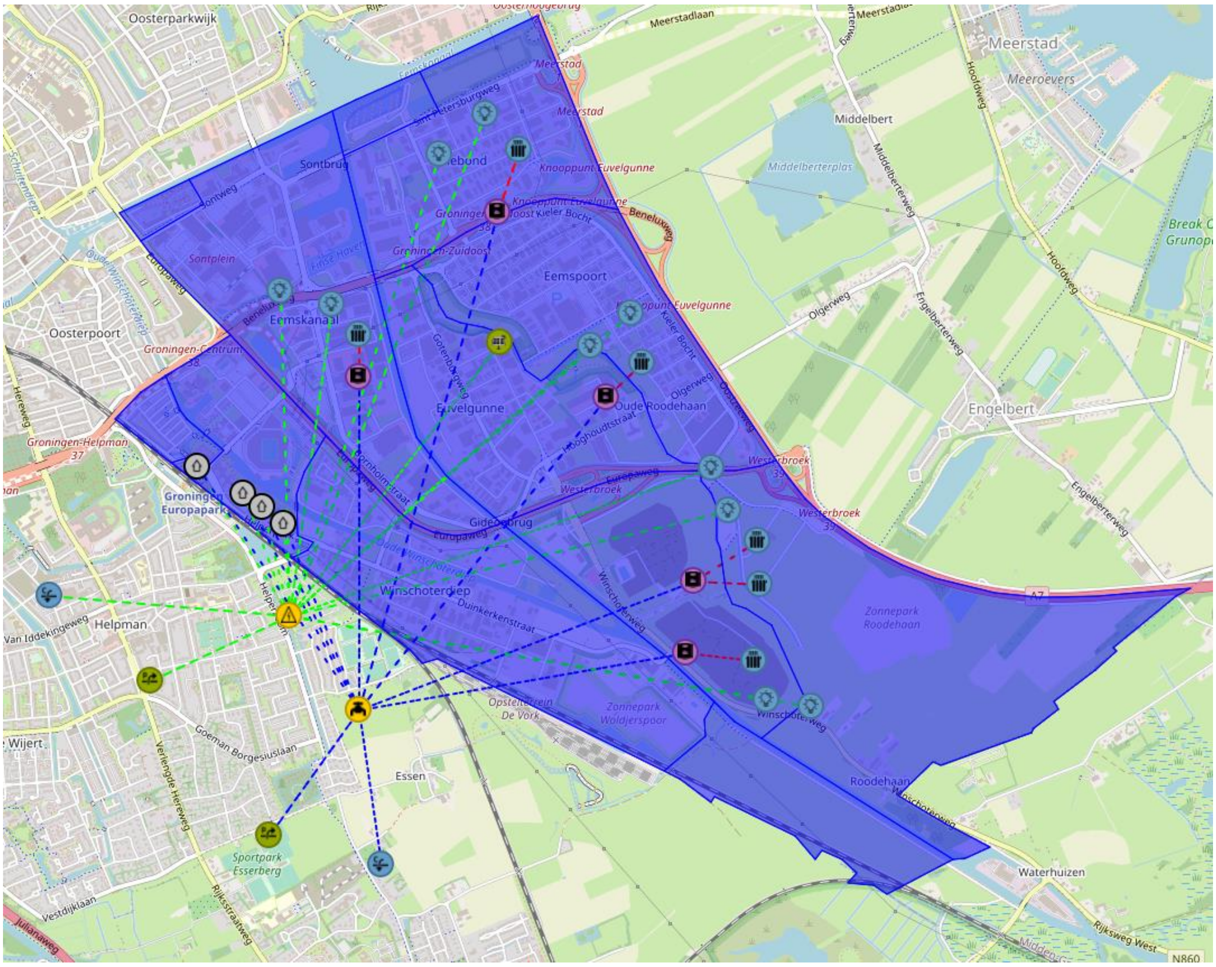


Figure 8 ESDL model of PED North South Baseline

## 4.4 Simulation outcomes PED South

### 4.4.1 Gas network

PED South imports gas from the Dutch national gas network. Figure 9 shows gas network balances. *SourceProducer* indicates gas import into the district, and *SinkConsumer* indicates export from the district. As there are no local gas sources, all the gas is imported from outside the district. Gas, though gas heaters, is used for heating in the whole district.

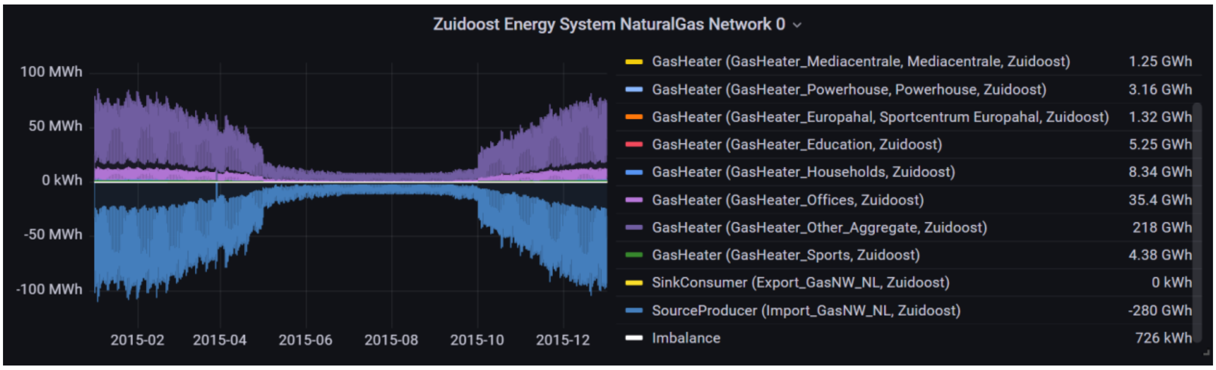


Figure 9 PED South gas network balances

Figure 10 shows transport loads of PED South gas network. Transport loads show energy flows through the gas connections of each of the intervention buildings, as well of the district. Both the intervention buildings, as well as the district only consume gas, therefore the positive energy flows.

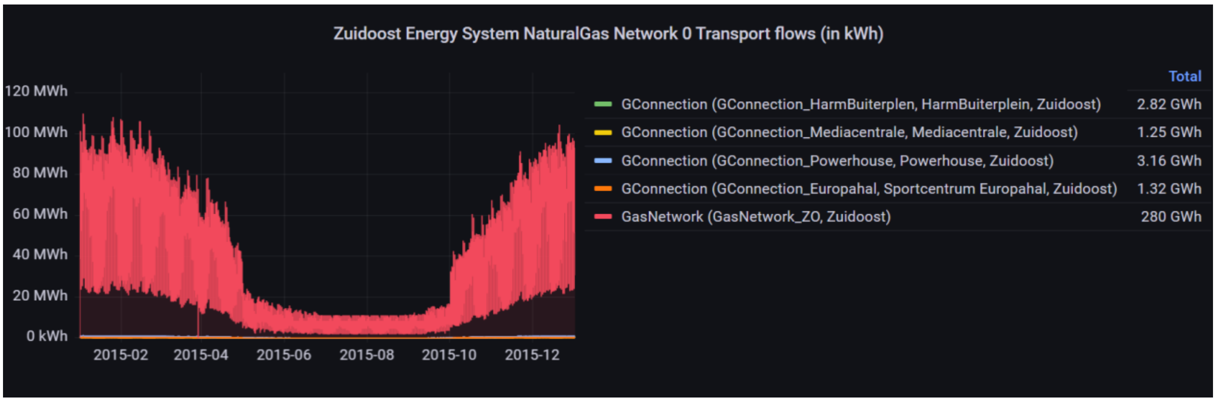


**Figure 10 PED South gas network transport loads**

## 4.4.2 Electricity network

Figure 11 shows electricity network of PED South. The local PV generation from residential rooftop is rather small (see Figure 11), and almost all the electricity must be imported from the national grid.

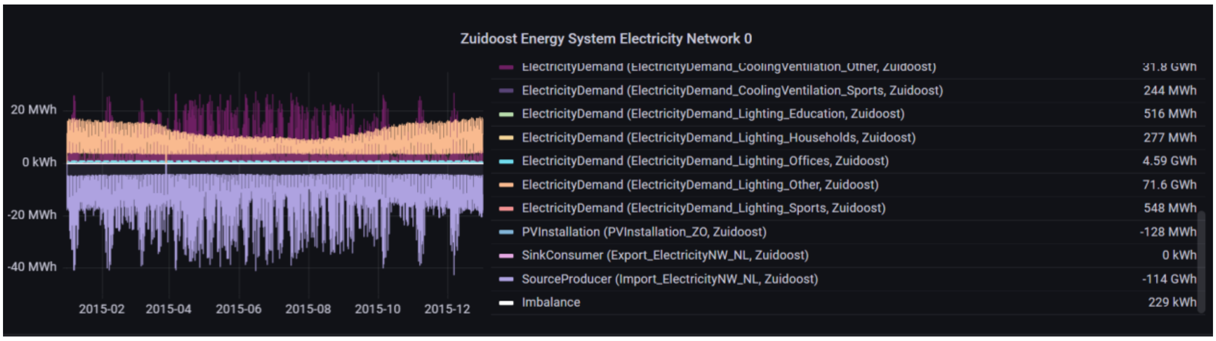


**Figure 11 PED South electricity network balances**

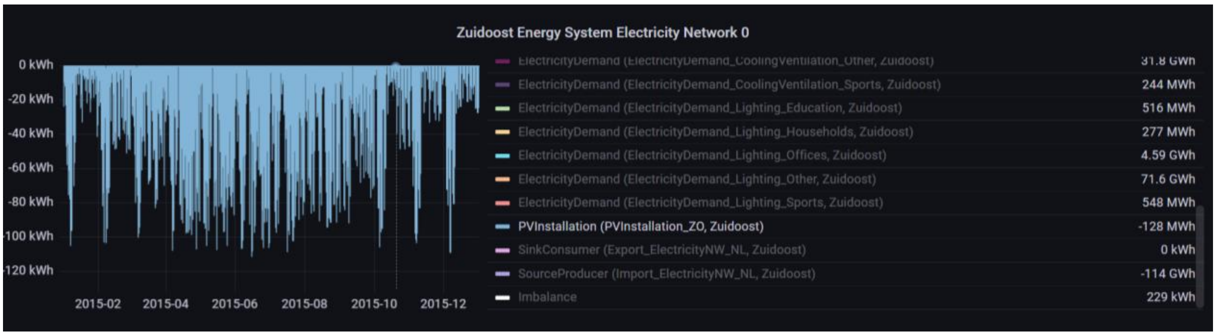


**Figure 12 Local electricity production of PED South**

Figure 13 shows transport loads of PED South electricity grid. All the intervention buildings have a positive energy flow, which means that their total annual consumption is always more than the annual production.

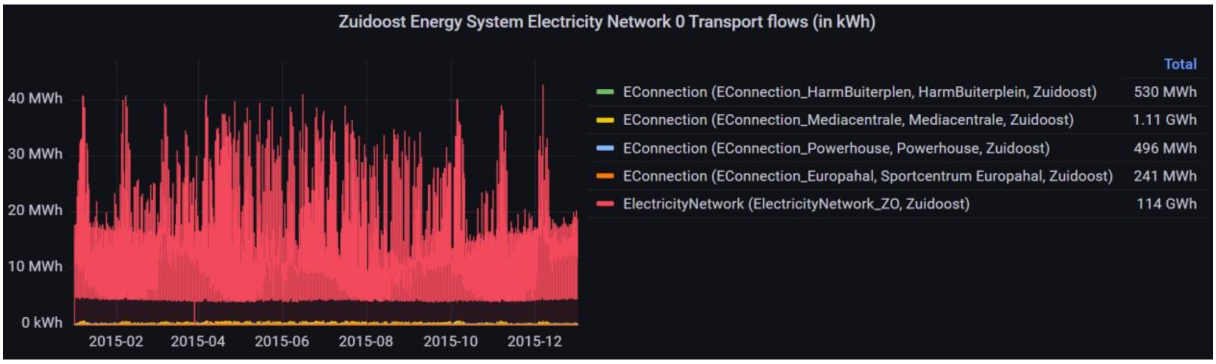


**Figure 13 PED South electricity network transport loads**

Table 14 shows the total simulated energy flows per intervention building in PED South, per energy carrier. Positive energy flows indicate energy consumption.

| Intervention building | Natural gas transport load [kWh] | Electricity transport load [kWh] |
|---|---|---|
| Mediacentrale | 1 250 000 | 1 110 000 |
| Powerhouse | 3 160 000 | 496 000 |
| Europahal | 1 320 000 | 241 000 |
| Harm Buiterplein | 2 820 000 | 530 000 |
| Total | 8 550 000 | 2 377 000 |

**Table 14 Electricity and gas transport loads of intervention buildings in PED South**

# 5 Key Performance Indicators

The key performance indicators are what the status of the project is measured upon. In order to conclude anything about possible improvements of the project, it is important to get the most realistic as possible baseline KPIs. In order to make any future comparison in this section we will list the project level indicators as specified in D5.2.

The social & residents' category is left out, as there are no measurements taken from questionnaires, and such values are not simulated by the tools. Currently there are questionnaires being held, which can be used for comparison at the end of the project (M60). However, they will not be a true baseline, but hopefully will indicate some progress being made during the project.

*Note:* The KPIs below are computed taken only into account the intervention buildings, and not the rest of the PED buildings.

## 5.1 Simulated projection of KPIs for PED North

| PED Energy profile | | |
|---|---|---|
| Indicator | Calculation parameters | Estimated value |
| E1: Final energy consumption | 3 447 080 $kWh_{gas}$/a,<br>357 456 $kWh_e$/a,<br>17 123 $m^2$ | 3 804 536 kWh/a<br>222 $kWh/m^2a$ |
| E2: Primary energy consumption | $PEF_{gas}$=1.03, $PEF_e$=2.5,<br>3 550 492 $kWh_{gas}$/a,<br>893 640 $kWh_e$/a | 4 444 132 kWh/a<br>259 $kWh/m^2a$ |
| E3: Energy imported to PED | | 3 804 536 kWh/a<br>222 $kWh/m^2a$ |
| E4: Energy exported from PED | | 0 kWh/a<br>0 $kWh/m^2a$ |
| E5: RES production | | 2 799 kWh/a<br>0.07 % of E1 |
| E6: PED energy balance | E1 - E5 | 4 437 134 kWh/a |
| E7: Energy savings in the PED | | Not applicable |

**Table 15 Baseline for Energy KPIs in PED North**

| Environment KPIs | | |
|---|---|---|
| Indicator | Calculation parameters | Estimated value |
| E8: GHG Emissions | Values from E2,<br>0.182 $kg/kWh_{gas}$,<br>0.450 $kg/kWh_{e}$,<br>646 189 $kg_{gas}$,<br>402 138 $kg_{e}$ | 1 048 327 $kgCO_2$-eq/a<br>61 $kgCO_2$-eq/$m^2$a<br>0.23 $kgCO_2$-eq/(kWh a) |
| E9: Reduction of emissions | | Not applicable |

**Table 16 Baseline for Environment KPIs in PED North**

| Mobility related technologies | |
|---|---|
| Indicator | Estimated value |
| M1: Number of public EV charging stations | 0 |
| M2: Energy delivered for EV charging | Not applicable |

**Table 17 Baseline for Mobility KPIs in PED North**

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

**Table 18 Baseline for Economic KPIs in PED North**

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

**Table 19 Baseline for System Flexibility KPIs in PED North**

## 5.2 Simulated projection of KPIs for PED Southeast

| PED Energy profile | | |
|---|---|---|
| **Indicator** | **Calculation parameters** | **Estimated value** |
| E1: Final energy consumption | 8 550 000 $kWh_{gas}$/a,<br>2 377 000 $kWh_e$/a,<br>44 515 $m^2$ | 10 927 000 kWh/a<br>245 $kWh/m^2a$ |
| E2: Primary energy consumption | $PEF_{gas}$=1.03, $PEF_e$=2.5,<br>8 806 500 $kWh_{gas}$/a,<br>5 942 500 $kWh_e$/a | 14 749 000 kWh/a<br>331 $kWh/m^2a$ |
| E3: Energy imported to PED | | 10 927 000 kWh/a<br>245 $kWh/m^2a$ |
| E4: Energy exported from PED | | 0 kWh/a<br>0 $kWh/m^2a$ |
| E5: RES production | | 0 kWh/a<br>0 % of E1 |
| E6: PED energy balance | E1 - E5 | 14 749 000 kWh/a |
| E7: Energy savings in the PED | | Not applicable |

**Table 20 Baseline for Energy KPIs in PED Southeast**

| Environment KPIs | | |
|---|---|---|
| **Indicator** | **Calculation parameters** | **Estimated value** |
| E8: GHG Emissions | Values from E2,<br>0.182 $kg/kWh_{gas}$,<br>0.450 $kg/kWh_e$,<br>1 602 783 $kg_{gas}$,<br>2 674 125 $kg_e$ | 4 276 908 $kgCO_2$-eq/a<br>96 $kgCO_2$-eq/$m^2a$<br>0.29 $kgCO_2$-eq/(kWh a) |
| E9: Reduction of emissions | | Not applicable |

**Table 21 Baseline for Environment KPIs in PED Southeast**

| Mobility related technologies | |
|---|---|
| Indicator | Estimated value |
| M1: Number of public EV charging stations | 0 |
| M2: Energy delivered for EV charging | Not applicable |

**Table 22 Baseline for Mobility KPIs in PED Southeast**

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

**Table 23 Baseline for Economic KPIs in PED Southeast**

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

**Table 24 Baseline for System Flexibility KPIs in PED Southeast**

# Conclusions

In this document the process was defined of establishing a reliable baseline for the Groningen PEDs in the MAKING-CITY project. Since the monitoring programme was not operational prior to the start of the project, we use modelling and simulation tools in order to get the measurements required. But before any modelling can be done, the process of data gathering and pre-processing needs to be done.

We set January 1st, 2016 as the date of the baseline measurements. From several historic databases, some of which publicly available such as the CBS and ECN, combined with BAG data, we can get much information of the Groningen PEDs from 2016. With the correctly adjusted data for the surface area, correcting for building related energy usage, based on the ETM model, we can get a good idea of the true input parameters for the ESDL models.

After simulations in ESSIM, we can see the resulting energy consumption and production profiles, but also the annual totals. Using these numbers we can compute the KPIs that can be used as comparison for the eventual final project results.

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