CHESTER

Compressed Heat Energy Storage for Energy from Renewable sources

D4.3 Report on Monitoring of the Selected Pilot Cases and Development of Annual Energy Profiles

PROJECT	**CHESTER**
PROJECT NO.	**764042**
DELIVERABLE NO.	**D4.3**
DOCUMENT VERSION	**V2.1**
DOCUMENT PREPARATION DATE	**8-04-2020**
RESPONSIBLE PARTNER	**AIGUASOL**
DISSEMINATION LEVEL	**Public**

Type of Deliverable		
R	Document, Report	**X**
DEM	Demonstrator, pilot, prototype	
DEC	Websites, patent fillings, videos, etc.	
OTHER		
ETHICS	Ethics requirements	
ORDP	Open Research Data Pilot	

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 764042.

EC Grant Agreement	No.764042
Project Acronym	CHESTER
Project Title	Compressed Heat Energy Storage for Energy from Renewable sources
Programme	HORIZON 2020
Start Date of Project	01-04-2018
Duration	48 Months

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Version Management			
Filename		Report on Monitoring of the Selected Pilot Cases and Development of Annual Energy Profiles	
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Approved by		N. Fernandez	
Revision No.	**Date**	**Author**	**Modification description**
V1.0	24/03/2020	D. Vaz, A. Carrera and A. Pérez	First version
V1.1	26/03/2020	S. Stark	Review of the deliverable
V2.0	7/04/2020	D. Vaz, A. Carrera	Inclusion of review comments and suggestions
V2.1	8/04/2020	N. Fernandez	Conclusions update. Inclusion of Annex 4 and 5

Contents

List of Figures

List of Tables

Glossary, abbreviations and acronyms

ANN	Artificial Neural Network
CHP	Combined Heat and Power
DH	District Heating
KNN	K-Nearest Neighbors
PTES	Pit Tank Energy Storage
PV	Photovoltaic
S-ARIMA	Seasonal AutoRegressive Integrated Moving Average
STS	Solar Thermal System
TTES	Thermal Tank Energy Storage

Executive Summary

This document presents the analysis of the data from Aalborg's District Heating system and Ispaster's mini electrical grid and District Heating network. The data gathered in this task is used to develop load and availability profiles of electrical and thermal energy for the pilot cases selected in WP2 for further investigation of the CHEST system potential. This energy profiles will be included into the model developed in T4.2 to analyse the performance of the CHEST system in T4.3, as well as optimizing the system performance in the T4.4.

The analysis of Ispaster's pilot case was based on monitored and generated data to fill gaps on the timeseries of monitored variables. The generated data was obtained through a simulation model, based on historical data, monitored data and weather data. The analysis of Ispaster's energy systems suggest the need for an efficient energy management and storage system, once it was clear that a huge amount of thermal and electrical energy is wasted. The losses of energy occur due to the combination of the following factors:

- the mismatch of the demand and supply profiles,
- the weather-dependency of the energy generation systems and
- the incapacity of the available storage systems.

The data that respects to Aalborg's pilot consists of monitored and stored data made available by the DH municipal management company and refers to a one-year period of time from February of 2017 to February of 2018. Data analysis points for a well-balanced demand and supply of energy, justified by the flexibility of available main heat supplier and the available storage and management system.

1. Introduction

1.1. Purpose and Scope

This document presents the results of the work developed in Task 4.1 whose ultimate goal consists of collecting monitored data from the two pilot cases of the project with the highest implementation potential. This is an essential step towards Task 4.4 in which the smart energy management system will be developed based on the annual profiles of thermal and electrical energy demands and availability generated with the monitored data.

The two cases studies selected for this task are the District Heating network of Aalborg and the electrical and heating micro-grid of Ispaster, as explained/justified in D2.1. The collected data is presented and analysed in this report. The architecture of the monitoring system and the features of the visualization platform are described in D4.1.

Complications and unforeseen occurrences that affected data collecting were investigated. The issues found that may have more severe consequences for the aim of the task were studied more attentively in order to find and apply strategies to circumvent them.

1.2. Structure of the document

This document is organized as follows:

- Chapter 2 makes a brief review of each of the monitored pilots and their respective monitoring systems. Incidences that occurred during the monitoring period are also described.
- Chapter 3 describes the methodology used to generate data to fill missing datapoints of the monitoring period and the results obtained.
- Chapter 4 presents an analysis of the energy profiles based on the monitored data.
- Chapter 5 presents the discussion and conclusion of the work developed.

2. Monitored Data

This section reviews the existing monitoring systems for case studies Ispaster and Aalborg and their corresponding monitored data available in the visualization platform.

2.1. Ispaster

This demo-case comprises an electrical micro-grid and a small District Heating system that supplies 11 public buildings of the small town of Ispaster with local renewable energy. Ispaster's DH network is fed by a 90-kW biomass boiler and a solar thermal system of 54 m^2 of absorber area. The biomass boiler is fuelled by wood chips of the surrounding forests and is equipped with a 5000-liter buffer tank and a 2000-liter storage tank. The STS is composed by a gross area of 59 m^2 of vacuum tube and compound parabolic solar collectors and a 2000-liter buffer tank. Even though two of the eleven buildings count on back-up gas boilers that are turned on in periods the buildings have particularly high heat demand, the utilization of the back-up system is rather limited. The electrical demand is partially covered by a 25 kW PV system complemented with a lead-acid battery storage system of 197 kWh of gross capacity. Additional information about the pilot and the energy supply systems can be found in D2.1.

During the monitoring period, a 10-flat residential building was connected to the DH network, increasing the expected heat demand in a range estimated between 60 and 100 %. To cope with this additional heat demand, a new wood chips boiler was installed in the system. This means that the topology of the Ispaster site has changed considerably during the monitoring period, resulting in a set of data that is not representative of the case study, due to the sudden increase of the heat demand. Consequently, the available monitored dataset is not representative of the solar thermal system performance and boiler consumption. Due to this, together with the fact that the monitoring data has suffered an excessive number of incidences, the monitored data has been filled up for a whole one-year period based on the situation of the system (as far as the heat demand is concerned) at the beginning of the monitoring period (which is March 2017).

2.1.1. Implementation of the monitoring system

The monitoring system of the overall grid was nearly inexistent in the beginning of the project. In scope of the CHESTER project, a complete monitoring system that allows to remotely visualize the main variables of the DH network and the electric micro-grid was implemented. Ultimately, these variables are stored as timeseries' datapoints in a database and graphically displayed in a user-friendly platform that is constantly updated to show the variables received with a 10-minute frequency.

The monitored variables of the Ispaster pilot are presented in Table 1.

Table 1: Variables collected from the DH network of Ispaster.

System	Monitored variable	Unit
PV system	Monthly electrical energy supplied by batteries	kWh
	Total electrical energy supplied by batteries	kWh
	Monthly electrical energy supplied to batteries	kWh
	Total electrical energy supplied to batteries	kWh
	Monthly electrical energy supplied by the PV system	kWh
	Total electrical energy supplied by the PV system	kWh
	Status of charge of the batteries	V

	Inverter electrical load (Total system electrical load)	kWh
	Temperature of the batteries	ºC
Thermal solar system	Temperature of supply	ºC
	Solar field outlet temperature	ºC
	Efficiency of the solar thermal system	-
	Daily energy generated by the STS	kWh
	Total energy generated by the STS	kWh
Biomass boiler	Temperature of supply	ºC
	Temperature of return	ºC
Destination grid	General heat demand	kWh
	Heat consumption – City Hall	kWh
	Heat consumption – Bar	kWh
	Heat consumption – Showers	kWh
	Heat consumption – Restaurant	kWh

The monitoring system deployment started during end of summer of 2018, but the system was not fully operative until the end of May of 2019, representing a delay in respect of the foreseen deployment date of 3 months. The reason, as described in the first project reporting period, is the difficulties found in the implementation of the necessary software and hardware and the integration into the municipality local network, which resulted in a delay of the works compared to the planned schedule.

Unfortunately, shortly after the initial deployment in summer 2018, there was a communication failure originated by alterations of the internet connection settings of Ispaster that was not detected and solved until mid-September 2019. At that moment, an alarm system was set to send notifications in the event of failure in data reception.

The monitoring system is operational since then but has been experiencing some short periods of failure in data communication. The data that corresponds to these periods of time is not registered and saved. The periods of failure occur with a random frequency and for random lengths of time and result in gaps on the time series as it can be visualized in Figure 1.

The red vertical dotted lines with a red arrow at the bottom represent the moments the data registering failure is detected and the alarm is sent, while the green ones mark the point of time the system returns to its normal state. Due to the scale of the graph of Figure 1, that represents a 2-month period, the normalization marks overlap the alarm marks, but it can be clearly seen in Figure 2. Data gaps. It is also more visible in Figure 2 that failure on data transmission affects simultaneously all variables of the monitoring system of Ispaster.

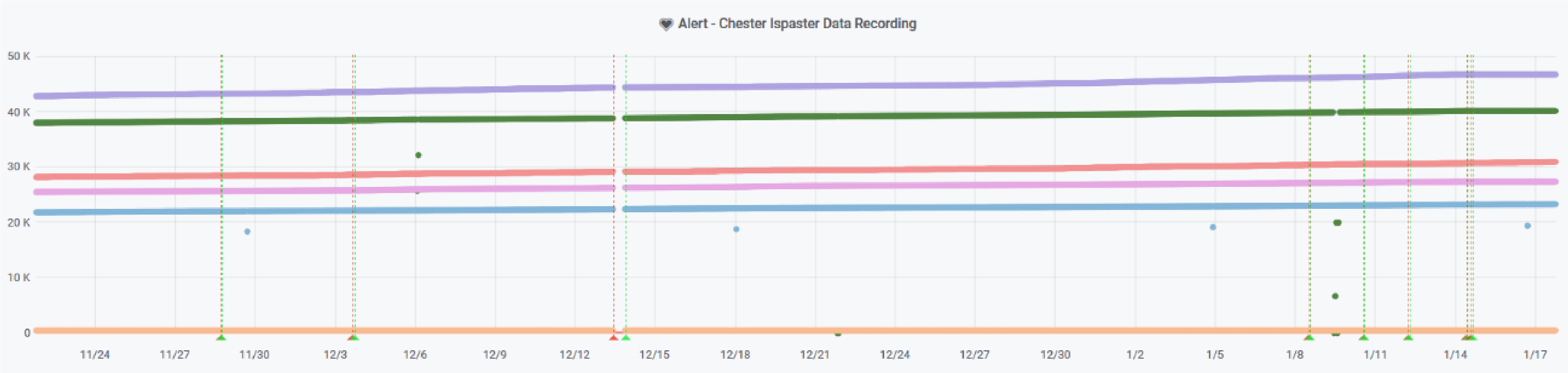

Figure 1. Data gaps on 2-month period

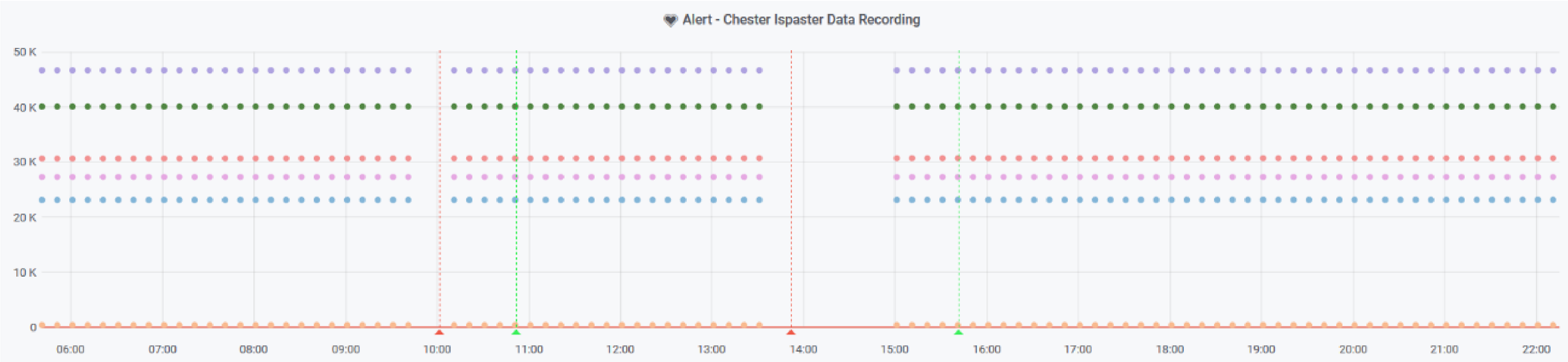

Figure 2. Data gaps

Another incident occurred the first week in January 2020 and lasted until the development of this deliverable. During the implementation of a new boiler to deal with the additional thermal loads connected to the DH network by the end of 2019, the boiler control configuration overwrote most of the IP addresses allocated to the monitoring signals of CHESTER. Up to date, the attempts to get support from the company in charge of the operation and maintenance of the Ispaster system in order to resolve this incident have been unsuccessful.

Given all the problems found with the data gathering at Ispaster, and in order to minimize the impact of the lack of the data in the workflow scheduled for the project, the final data to proceed with WP4 works will be a mix of monitored data, together with synthetically generated data by a hybrid procedure of statistical regression and system dynamic modelling. The description of this procedure is given in Chapter 3.

2.2. Aalborg

Aalborg pilot consists in a large-scale District Heating network. Aalborg is the fourth largest city of Denmark and 98 % of its buildings are connected to the DH network which in total supplies the gross yearly heat demand of 1933 GWh, including Aalborg and the neighbouring suburbs.

The DH is mostly supplied by the excess heat from the cement producer Aalborg Portland, by a combined heat and power (CHP) waste incineration plant (Reno Nord) and by a coal-fired CHP power plant (Nordjyllandsværket).

2.2.1. Monitoring system

The DH System already accounted with a monitoring system. However, unlike the operational procedure designed for the monitoring structure installed in Ispaster, there is not a real-time update of the monitored variables in the project's platform. The monitored variables of Aalborg's DH are stored locally by the municipal company that manages the network. It was not deployed any procedure to send updated data on a regular basis to the monitoring platform developed for the project due to the sensitivity of data and the confidentiality policy of the management company. Instead, the datapoints corresponding to a 1-year period, from the 28th of February of 2017 until the 28th of February of 2018, were disclosed for project purposes only. These timeseries have a 1-hour resolution and are displayed in the platform.

The variables available are listed in Table 2: Variables collected from the DH network of Aalborg..

Table 2: Variables collected from the DH network of Aalborg.

Installation	Monitored variables	Unit
Reno-Nord CHP plant (area L3, L4 and bypass)	Consumed fuel	MWh
	Electricity produced	MWh
	Heat produced	MWh
	Electricity consumed (bypass only)	MWh
Aalborg Portland (VG 1, VG 2 and additional)	Excess heat produced	MWh
	Temperature reduction of the excess heat from Aalborg Portland	MWh
Different small producers	Excess heat produced	MWh
	Consumed fuel	MWh
	Electricity produced	MWh

Coal fired CHP plant of Nordjylland	Heat produced	MWh
	Electricity consumed	MWh
Backup boiler	Heat produced	MWh
	Electricity consumed	MWh
Overall system	Heat transmitted to PTES	MWh
	Heat transmitted from PTES	MWh
	Heat lost to/from PTES	MWh
	Heat content (PTES and TTES)	MWh
	Heat demand	MWh

2.3. Weather data

The monitoring platform includes a page with weather data for each of the pilots' location, due to the weather dependency-character of most of the monitored variables. Moreover, weather data was essential for the data generation process carried out to fill the data gaps of Ispaster's case.

In particular, hourly air temperature and irradiation values from Ispaster from 2019 to 2020 were used in the TRNSYS model to generate missing data.

The weather data presented and used for data generation was retrieved from the history+ product of Meteoblue [1]. History+ is a product that offers historical weather data with high spatial resolution and accuracy. Weather data provided by history+ is generated through simulation based on measured data. The high-quality of the data is assured by regular and extensive verifications of the simulation models.

3. Data Generation

This section explains the methodology to generate the missing monitored data at Ispaster case study, and presents examples of data generated and their alignment with the monitored data. In the case of Aalborg pilot case, the data at the monitoring platform is complete so there is no needed to complete the missing information.

3.1. Methodology

The methodology to develop the missing data from the Ispaster time series is based on a time-series regression approach. This uses the information available at the monitoring platform to forecast the relevant time series to a full year data set. The results are compared with historical data provided by Goiener of aggregated energy invoices, as well as the hourly data from the photovoltaic production for a full year (2017). The next figure shows the data availability for the year 2019 on the monitoring platform. The data resolution is in 10 minutes timesteps.

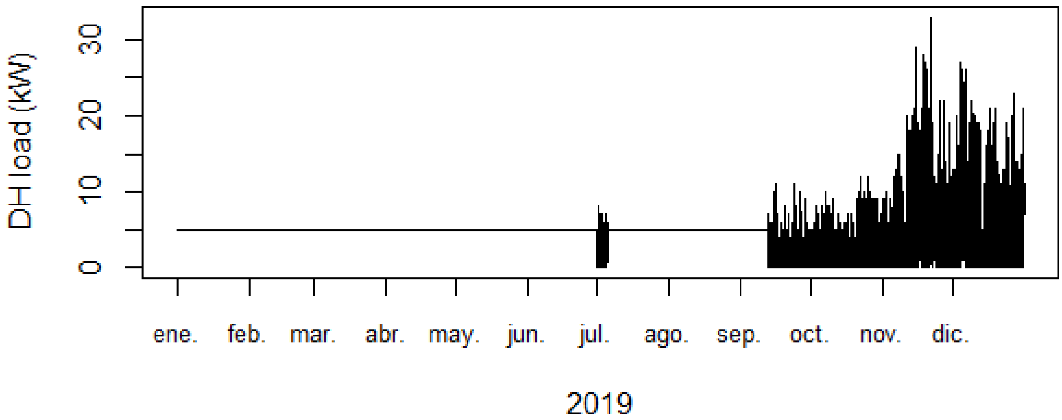

Figure 3: Overview of Ispaster DH load data available

In the Figure 3, a straight horizontal line indicates that the data for this period is missing, while the obvious oscillations in the graph correspond to the periods where the data is available, complete and plausible. The data available is from the second week of September until the end of the year, and there is also an area of one week of data in the month of July. In total, there is just 4 full months of data available, from which is necessary to generate the data for a full year. Fortunately, the data covers from relatively mild weather seasons to the coldest winter, allowing to infer the performance under different climatic conditions. For example, the PV production available data in Figure 4 shows the variation of the PV system electrical production from summer to winter:

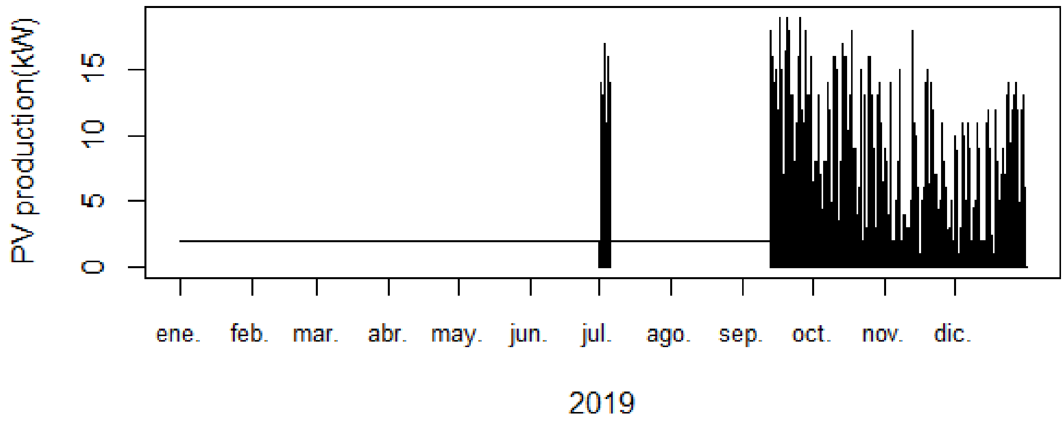

Figure 4: Overview of Ispaster PV production data available

A relevant point in the process of forecasting the time series for the Ispaster case study is the fact that the physical variables are intimately coupled between them, what means that a pure statistical approach for rebuilding all of them is not a feasible approach. This can be better explained by means of an example; suppose that we want to forecast the PV production based on the available data in Figure 4. The PV production at Ispaster is strongly curtailed (see for example D2.1), thus the PV production at any timestep is dependent not only on the meteorological conditions (radiation) but also depends on the electrical load at the current time step as well as the SoC (State of charge) of the battery. Since any regression/statistical model of the data has an inherent error, a pure implementation of a statistical (black-box) model will yield an inconsistent energy balance of the system due to the superposition of errors. Due to this, the process of filling the data available has followed a two-step approach. Initially, only the system electrical and thermal loads have been regressed, and in a second stage, this load data have been used to feed a simple dynamic model of a solar thermal system coupled with DH and a biomass boiler, as well as a PV system with inverter and batteries connected to the forecasted electrical load.

3.1.1. Electrical and thermal loads

To build the time-series regressions of the thermal and electrical loads, several statistical approaches have been tested and compared. The following approaches where tested:

- Time-series periodic decomposition
- S-ARIMA
- ANN
- KNN
- Linear time-dependent regression with periodic functions

The comparison was done based on the total energy forecasted (the integral of the time series), but also, the distribution of the forecasted values of the time series was compared with the distribution of the values of the monitored data. This ensures that not only the total energy is properly represented, but most importantly, the time-series characteristics (frequencies, noise) are properly represented.

The approach finally selected for the development of the thermal and electrical loads has been the KNN regression. KNN is a non-parametric method that has a very fast calculation time, easy interpretation and good predictive performance. The idea underlying the method is simply to calculate the numerical value of a time series in the future based on K previous data that are the closer to the evaluated point according to a similarity measure.

In our case, the first step is to define the similarity (or distance) between any two sample points. To determine the variables used to construct the similarity between any two points of the time series, we analysed several combinations of the most relevant variables according to the correlation matrix. After an iterative process, the most appropriate variables to construct the similarity between two pints of the time series were found to be the following:

1. Hour of the day
2. Solar horizontal radiation
3. Ambient temperature
4. Day of the week (1-7)

So, according to the KNN approach, the forecast of the thermal and electrical loads at any point of time will be the average value of the time series at the closer points according to the previous variables.

The second point in the development of the method is the definition of the distance metric between two points. This is necessary because of the different range value of the involved variables; for example, the hour of day varies between 0 and 23, while the solar radiation has a range between 0 and 1000 approximately, so the second one would always have a higher weight on the determination of the neighbour points than the former. To avoid this, sample values have to be normalized, and the most usual distance measure on KNN regression is the so called Mahalanobis distance. This is simply the number of standard deviations of a given variable from the mean of the value of the variable for all the distribution points.

The last step is to set the value of K, representing the number of neighbours to incorporate in the determination of the mean value which is used to determine the forecasted value. This is also done iteratively, and although is specified the last, it has been analysed in parallel to the determination of the similarity function. Although values of K in the range of the square root of the sample points often yield the smaller error in the forecast, they do so at the cost of deteriorating the forecast precision in the boundaries of the sample input space (the most distanced values to the distribution centre, in our case, the higher temperatures and radiations). According to the results, the value of K was set to 11 for the electrical loads and to 4 for the thermal loads forecast.

3.2. Results

In the regression process, the monitored data is first divided into two data subsets: the sample data, which is the amount of values used for the regression calculations, and the contrast data, which is used to assess the performance of the regression by comparing the real monitored values with the values forecasted by the regression. In our case, the sample data consist of 70% of the points and the contrast data is the rest, 30 % of the points. Once a parameterization is selected by comparing the contrast observations with the results from the regression, this is built once again but with the full data sets as regression parameters.

To assess the performance of the regressions, we use the accuracy of the regression, the confusion matrix of the contrast results, and the total energy loads generated by the regression results. Finally, the aggregated data is compared with the data provided by Goiener corresponding to the invoiced energy during the years 2014 to 2017.

The Figure 5 shows the comparison of the predicted DH load (black line) to the monitored value (red line) for the 2019 year:

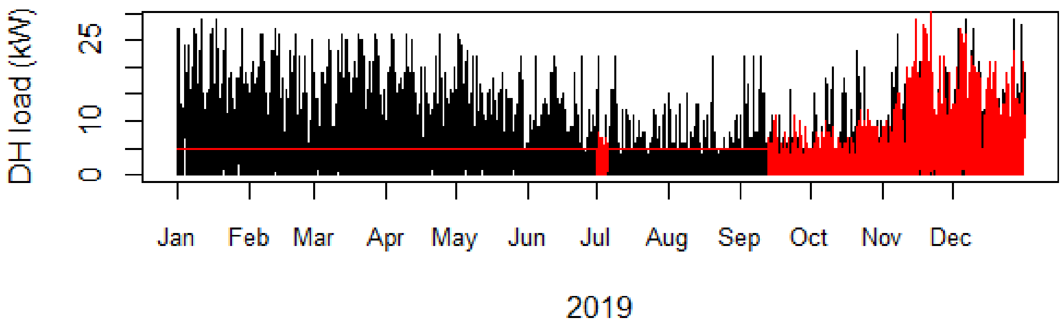

Figure 5: Predicted (black) vs monitored (red) DH load

In the Figure 6 we can see the zoom of the Figure 5 in a winter week:

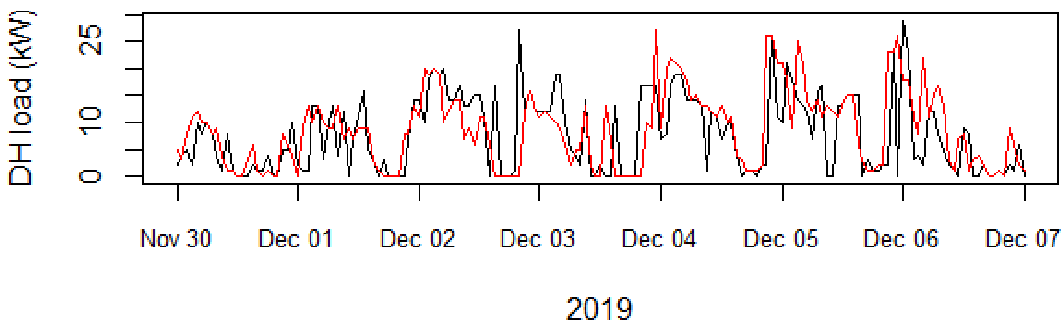

Figure 6: Predicted (black) vs monitored (red) DH load for a winter week

As we can see, the regression of the DH load follows the overall pattern of the real series, although the exact values do not coincide in most of the evaluated points. The contrast data accuracy is just 64 %, that is, the exact value of the load is evaluated correctly in 64 % of the points, however, the monitored total energy demand in the contrast sample is 3528 kWh, while the regression for the total energy demand in the contrast yields a result of 3535 kWh, yielding a total error in the aggregated value of 0.2 %. The next table shows the confusion matrix for the contrast of the DH load:

Table 3: Confusion matrix for the DH load regression

		Monitored values for DH load (kW)																								
		0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**25**	**26**	**29**
Predicted values for DH load (kW)	**0**	119	34	12	7	2	6	2	4	2	1	4	2	0	0	0	2	0	0	1	0	0	0	0	0	0	0
	1	35	24	9	4	6	4	3	2	0	2	1	1	2	2	1	0	0	1	0	0	0	1	0	0	0	0
	2	12	15	20	15	7	5	3	6	2	3	0	2	2	0	0	0	2	1	0	0	1	0	0	0	0	0
	3	5	9	15	12	3	6	1	1	3	1	0	1	0	0	0	1	2	0	0	0	0	0	0	0	0	0
	4	5	4	6	4	4	4	4	1	3	3	0	2	1	4	0	1	0	0	0	0	0	0	0	0	0	0
	5	3	1	5	2	6	9	3	4	2	3	0	5	2	0	0	2	0	0	0	1	0	0	0	0	0	1
	6	0	2	4	2	2	5	0	1	0	1	2	2	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	7	4	0	1	1	1	0	2	1	0	3	2	0	0	1	0	1	0	1	1	0	1	0	0	0	0	0
	8	5	4	2	2	4	4	0	1	3	2	1	2	0	0	0	1	1	0	1	0	0	0	0	0	0	0
	9	3	4	1	2	1	2	0	0	1	1	2	1	1	2	0	1	0	2	0	0	0	1	0	0	0	0
	10	0	1	0	0	3	0	1	1	2	1	2	1	2	0	1	0	1	0	0	0	0	0	0	0	0	0
	11	3	4	0	0	2	1	3	0	1	1	2	1	3	0	2	1	1	0	1	0	1	0	0	0	1	0
	12	1	1	1	0	0	1	1	1	0	3	0	2	1	1	0	0	0	0	1	0	0	0	0	0	0	0
	13	2	1	3	2	1	1	0	0	2	1	2	1	0	2	1	1	0	1	0	0	0	0	0	0	0	0
	14	0	0	1	1	1	1	0	1	1	1	0	1	1	0	1	1	0	0	2	0	1	0	0	0	0	0
	15	0	0	0	1	1	0	1	1	1	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0
	16	0	0	0	0	0	0	1	0	0	0	0	2	4	2	1	0	0	0	0	0	0	0	0	0	0	0
	17	2	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0	0	1	0	0	0	0	0	0
	18	0	0	0	0	0	0	0	2	0	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0
	19	0	0	0	0	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	1	0	0	0
	20	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	1	1	0	0	0	0	0
	21	0	0	1	0	0	0	0	0	0	1	2	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0
	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	1	0
	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

The confusion matrix compares the monitored data against the fitted data in a compact form. The table contains data for the contrast period only. The intersection at any point of the matrix indicates what is the number of times that a given monitored value matches with a regression value. For example, the first column corresponds to a monitored value equal to 0, and the regression yields 119 times a result of 0, 35 times gives us a value of 1, 12 times a value of 2 and so on. A good regression is characterized by having a high value on the diagonal matrix, but also, to have a symmetric behaviour around the diagonal. In this case, we predict 35 times a value of 1 when the monitoring data is 0, but we predict 34 times a value of 0 when the monitored data is 1, so the errors cancel each other. Given the stochastic behaviour of the load data in most applications, we consider that the regression model has a good accuracy, with very good prediction capacity for long periods and an appropriate representation of the DH load demand dependence on time.

We follow a similar analysis for the electrical load data. The figure 7 shows the predicted electrical load (black line) to the monitored value (red line) for the year 2019:

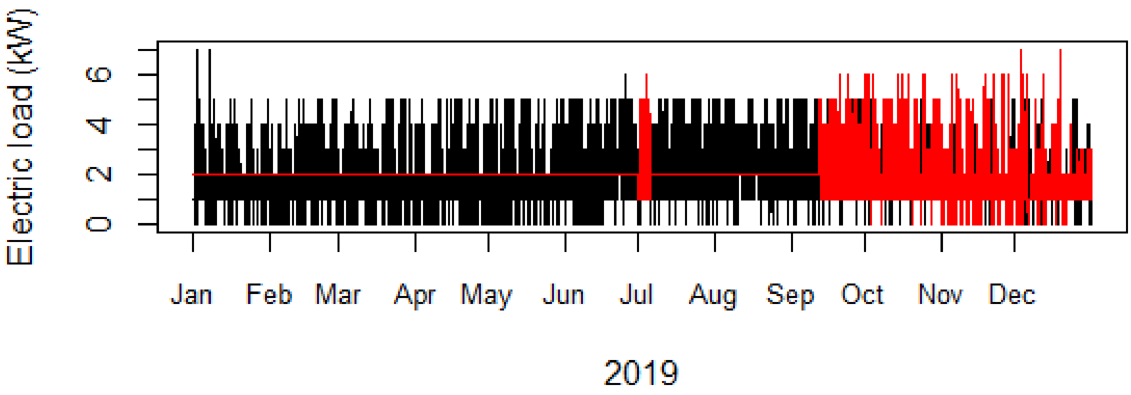

Figure 7: Predicted (black) vs monitored (red) Electric load

To get a better impression of the results, we zoom over one week on the previous graph; this can be seen in Figure 8:

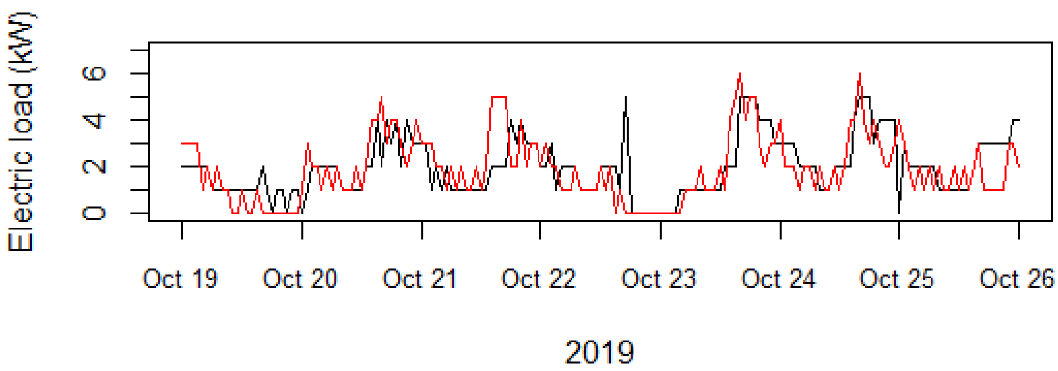

Figure 8: Predicted (black) vs monitored (red) Electric load for an autumn week

We can see that the regression model for the electric load follows the overall pattern of the monitored data, although in general does not match the monitored data precisely. The accuracy of the regression model is a 43 %, and the total energy predicted for the contrast data is 1585 kWh while the total energy monitored for the contrast data is 1620 kWh, which accounts for an error on the total aggregated electricity load of 2.1 %. In the Table 4, we can see the confusion matrix for the regression of the electric load:

		Monitored electrical load (kW)							
		0	1	2	3	4	5	6	7
Predicted electrical load (kW)	0	20	6	13	6	4	1	2	0
	1	19	153	95	12	4	1	0	1
	2	19	69	90	32	17	4	0	0
	3	15	6	21	37	16	5	1	1
	4	5	2	8	27	27	13	1	0
	5	5	0	4	1	8	18	3	1
	6	0	0	0	0	0	0	0	0
	7	0	0	0	0	0	0	0	0

As in the previous case, the regression model properly represents the behaviour of the electrical load at Ispaster, although the exact values at a given time of the day will be only exact in 43 % of the points. This is acceptable in the current context, since the stochasticity of the electrical load is high and the monitored data shows a noticeable white noise.

To finalize the analysis of the load data, we compare the data modelled for the year 2019 with the historical data of load available at Ispaster. In the case of the thermal load, the historical data compared to the modelled data is shown in Figure 9:

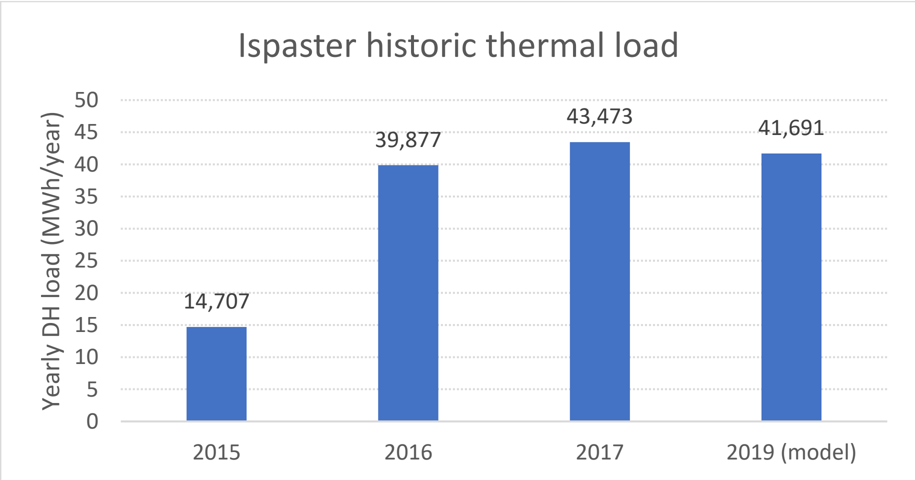

Figure 9: Historic data of DH load compared with modelled load

We can see that the modelled thermal load is in the same order of magnitude as the historically monitored one, so the model is plausible . The same graph, in the case of the modelled electrical load is shown in Figure 10:

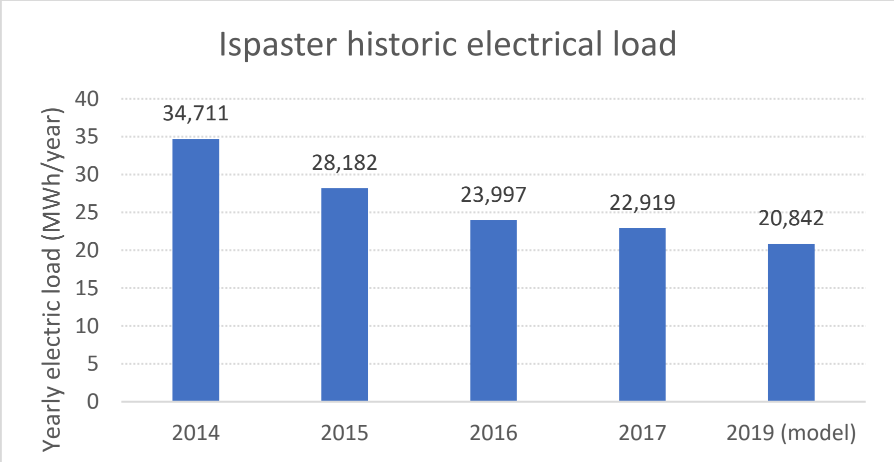

Figure 10:Ispaster historic data of electric load compared with modelled load

The model prediction is slightly lower than the historic data, but this is in line with the tendency of decreasing electrical loads seen in the period from 2014 to 2017. This is explained by the investments done in the electrical efficiency of the system done in the recent years, as is described in D2.1.

4. Analysis of Energy Profiles

This chapter presents an analysis of a yearly set of variables that characterize Ispaster and Aalborg energy networks. The variables analysed and presented in the following subsections were retrieved from the monitoring platform.

4.1. Ispaster

The monitoring platform of Ispaster shows at the top of the page some statistics panels with general figures that characterize the micro-grid demand and supply, namely the yearly demands and production values of the different systems that compose the grid. These values will be summarized in subchapter 4.1.3. The initial section is followed by a set of panels that display the profile along one year of the variables that concern to the PV system. Next, the variables with respect to heating supply are presented, grouped by type of heat production system: STS and biomass boiler. At last, the heat demand timeseries are shown.

4.1.1. Electricity supply

The daily and monthly electricity consumption profiles can be observed in the graphs of the inverter load, depicted, respectively in Figure 11. Daily electricity load of the inverter and Figure 12. Inverter's monthly total electricity load. It is easily perceptible an increment of the inverter load, and thus of the electricity consumption, in the summer months.

Figure 14 and Figure 13 present the electricity produced by the PV system that is directly consumed or stored in batteries in contrast to the PV electricity wasted due to cumulative lack of demand and lack of battery capacity and the electricity purchased from the grid. The graphs of Figure 13 and Figure 14 represent, respectively, daily and monthly totals.

It shall be mentioned that the monthly totals represented in the graphs do not present exactly the total values of the natural months. Instead, the so-mentioned monthly totals consist of automatic aggregation of data of 30 consecutive days.

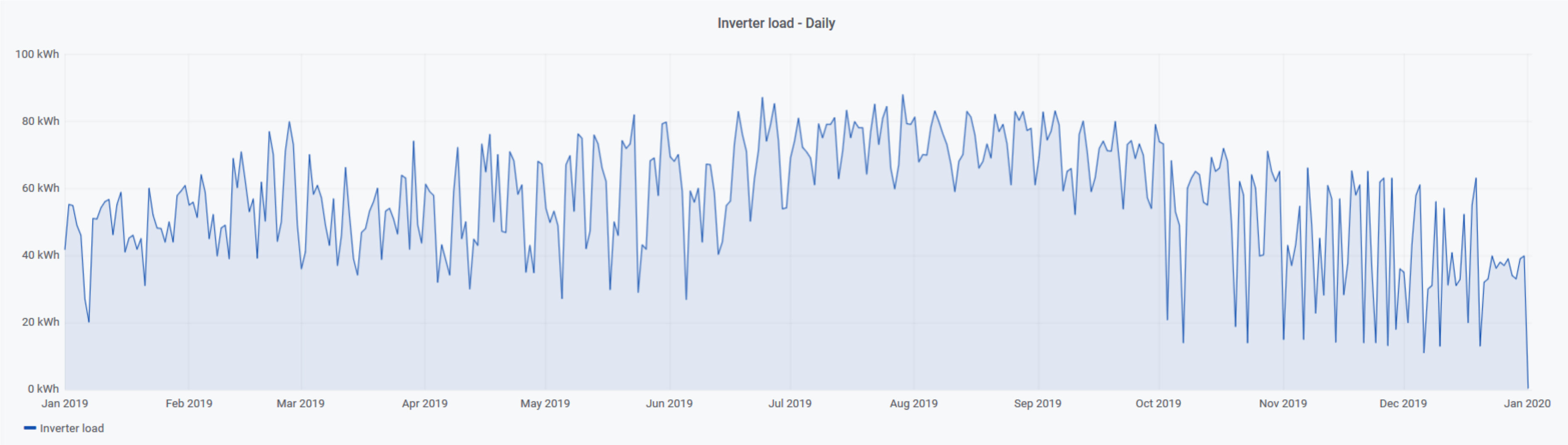

Figure 11. Daily electricity load of the inverter

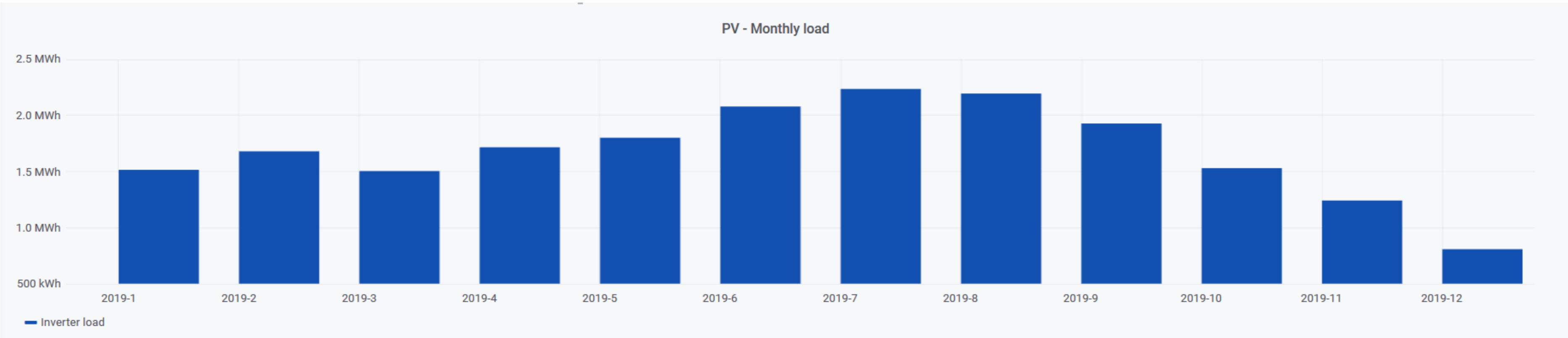

Figure 12. Inverter's monthly total electricity load

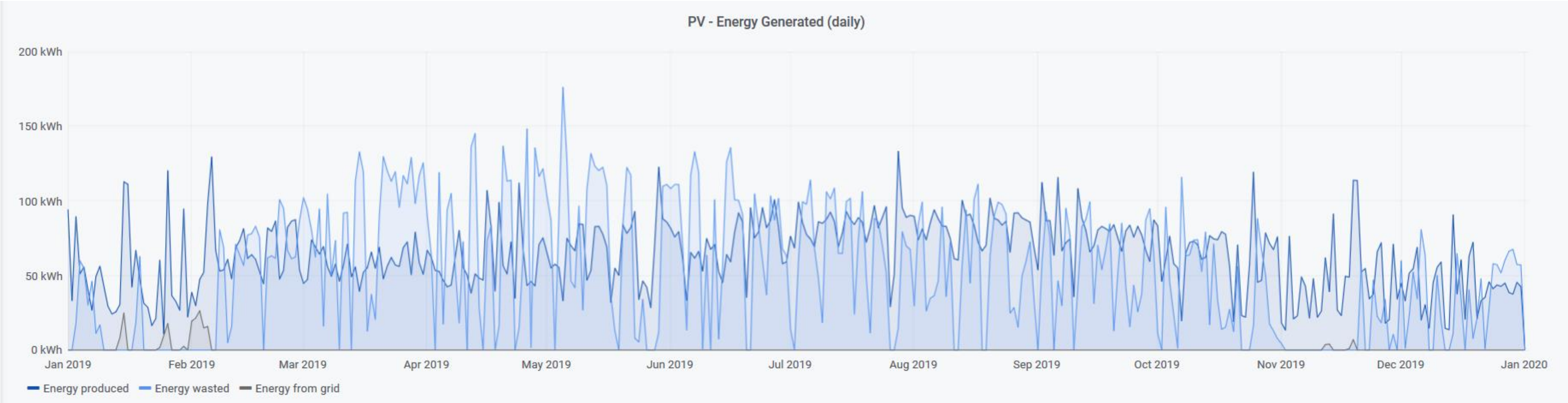

Figure 13. Electricity produced daily by the PV system, PV electricity wasted and electricity from grid.

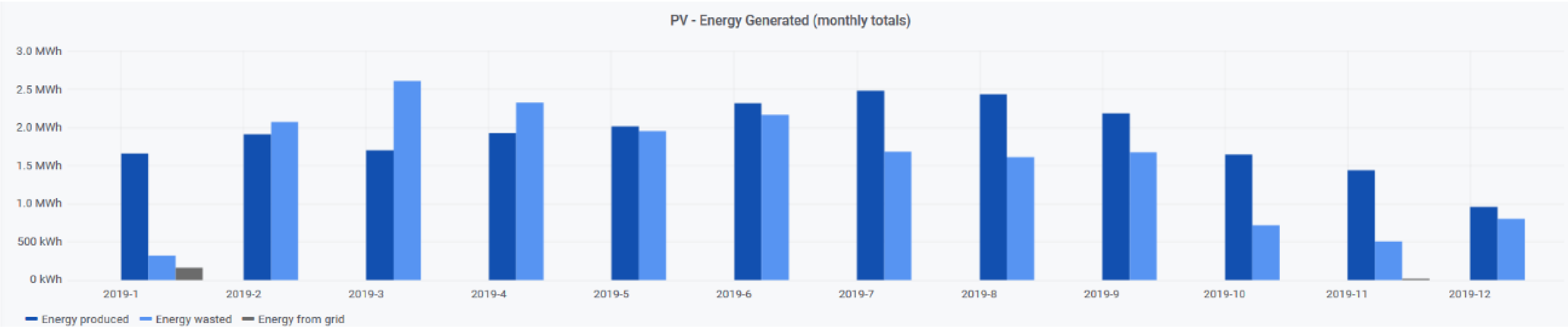

Figure 14. Electricity produced monthly by the PV system, PV electricity wasted and electricity from grid.

On the one hand it is clear the electrical micro-grid is close to self-sufficiency. Along the 1-year period of analysis, the connected buildings only resort to grid-electricity in January and November. The energy purchased represents less than 1 % of the total yearly electricity consumption of the micro-grid, as shown in the pie chart of Figure 15.

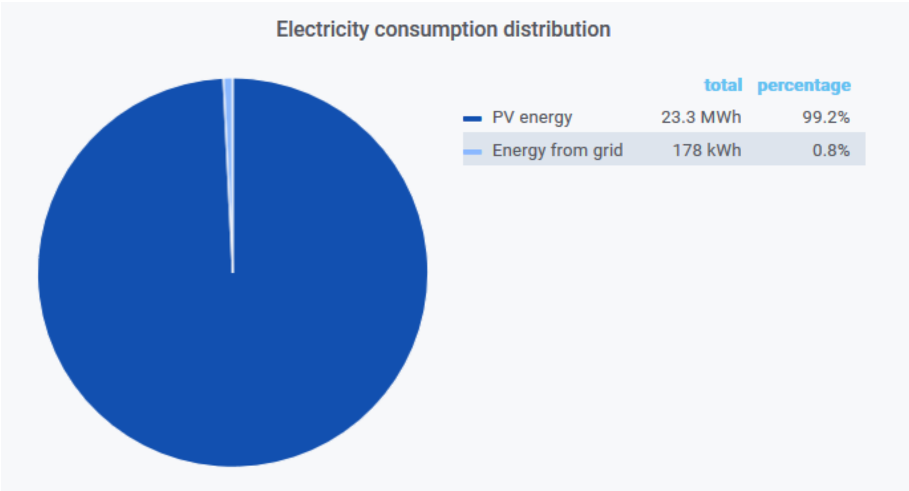

Figure 15. Distribution of electricity consumption by source of supply

On the other hand, it can also be observed in Figure 14 that the amount of dumped electricity is staggering. In February, March and April the proportion of wasted energy is so high that it even surpasses the amount of useful PV energy. Along the one-year of analysis, the wasted electricity represents almost half of the PV energy generated by Ispaster's PV system, as shown in Figure 16.

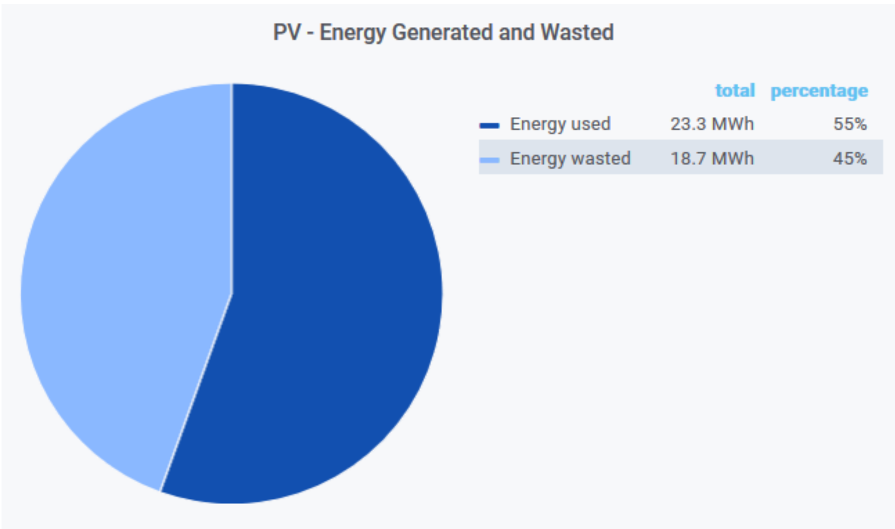

Figure 16. Distribution of useful and wasted PV energy

Additonally, Figure 17 displays the monthly energy exchange with the batteries. The monthly values of energy stored and consumed from the batteries present a similar tendency to the monthly values of energy consumed, previously shown in Figure 12. Inverter's monthly total electricity load, and to the monthly values of energy produced, presented in Figure 14. Although, a deviation can be found in the first month: there is an excess of production in relation to the consumption that is amortized by a higher flow of energy to the batteries, which can also be noted on the reduced amount of energy wasted in this month.

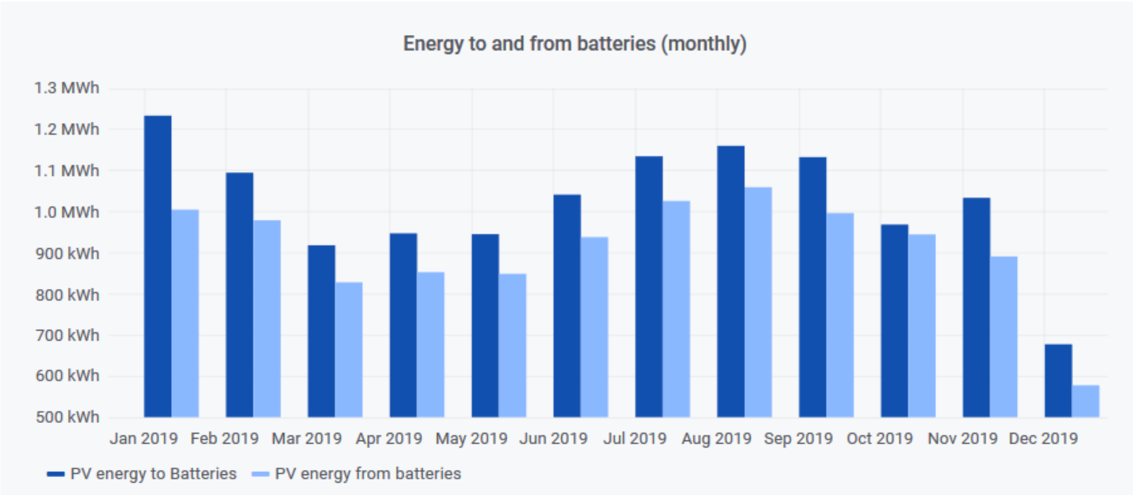

Figure 17. Total monthly energy exchange with the batteries

Finally, Figure 18 shows the daily variation of the voltage of the batteries. The voltage is mostly maintained between 45 V and 50 V, with some punctual valleys. In the graph, it is visible two periods of particular unstability of the voltage levels of the battery that correspond to January and November.

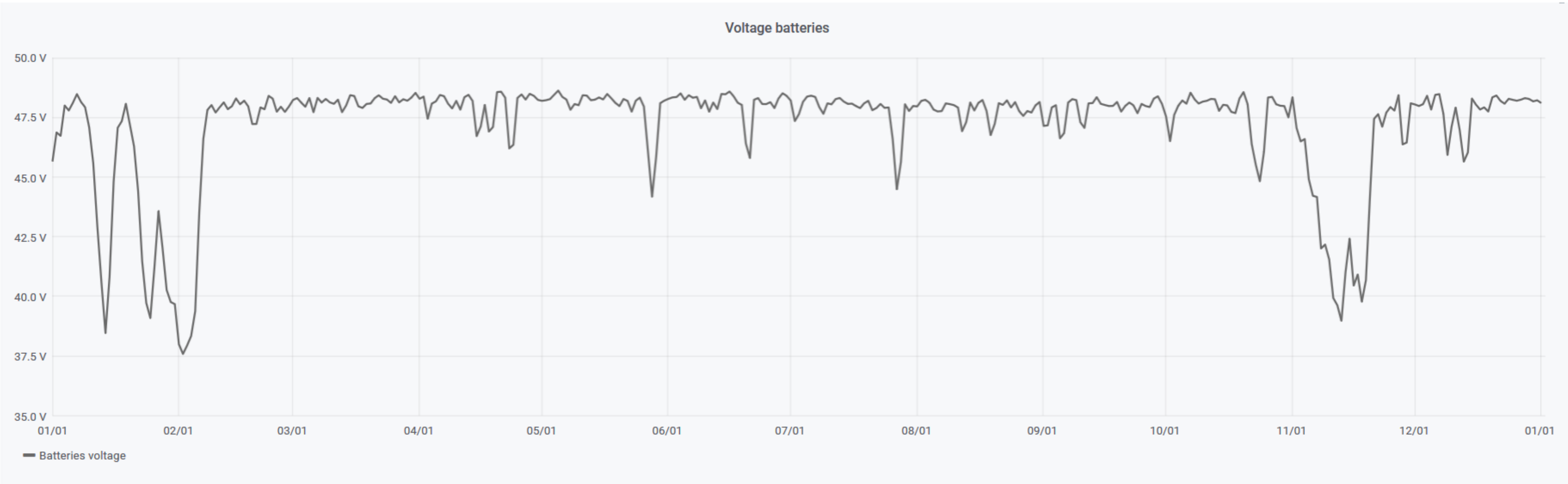

Figure 18. Daily variation of the voltage of the batteries

4.1.2. Heat supply and demand

The small DH network of Ispaster is supplied by an STS and a biomass boiler. Figure 19 and Figure 20 display, respectively, the daily and monthly heat production from the STS. It is particularly noticeable a sharp drop of heat production in January, October, November and December. The decrease of production is aligned with the weather conditions of these months that affect the performance of the system.

Heat production of the STS is lower for the months where the heat demand for space heating is higher. The demand is met with the support of the biomass boiler whose heat production is particularly high in the cold months, as shown by the graphs of daily heat production and total monthly heat production presented, respectively by Figure 21 and Figure 22. The monthly heat production is shown by the dark blue bars of Figure 22. The light blue bars represent the add on of energy consumed by the boiler to produce heat

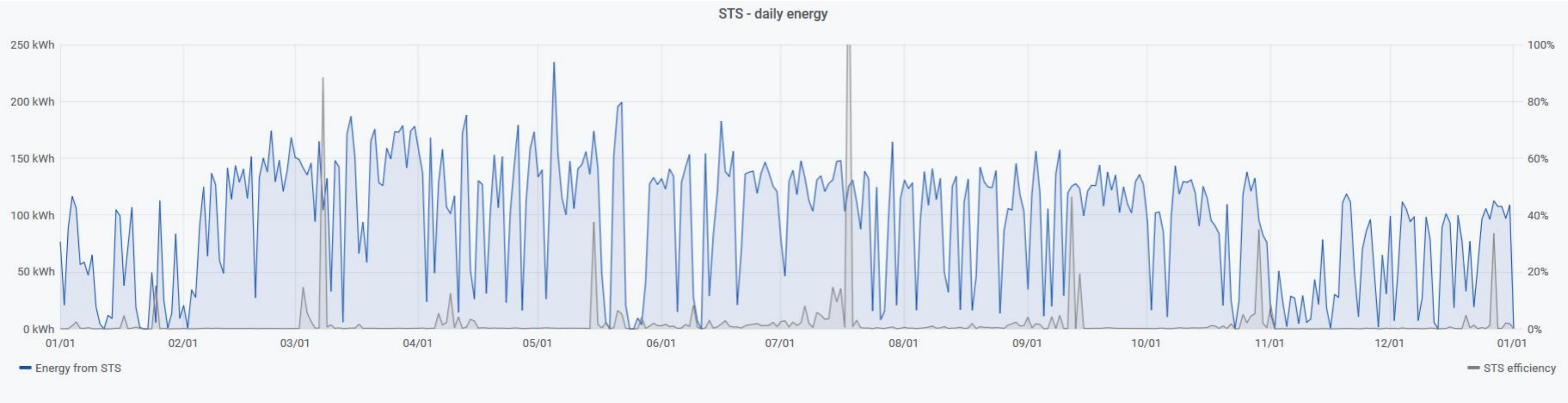

Figure 19. STS daily heat production and efficiency

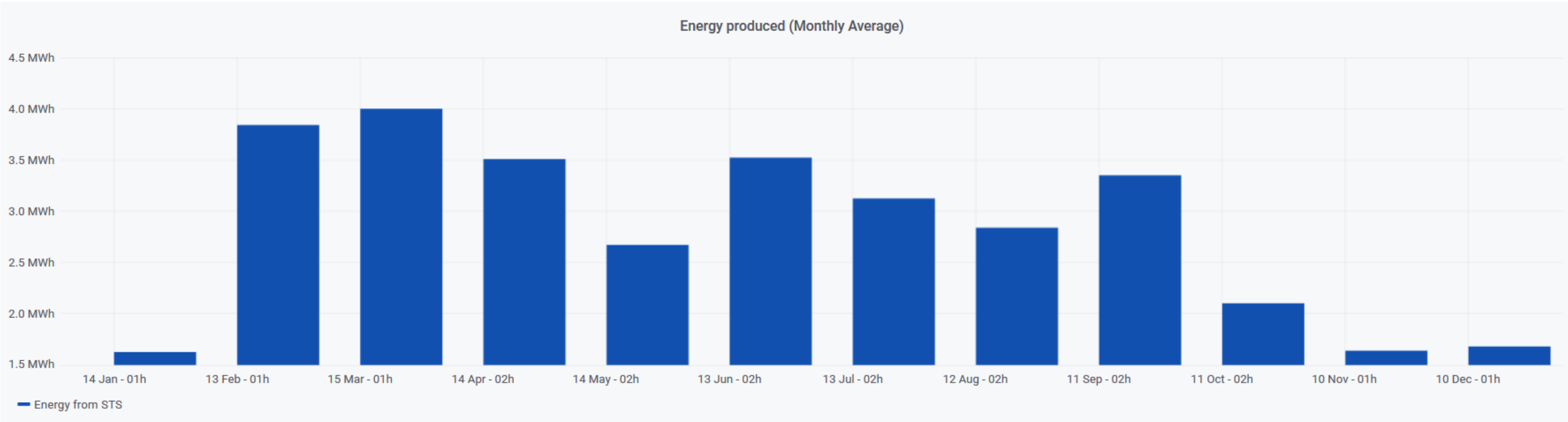

Figure 20. STS monthly heat production

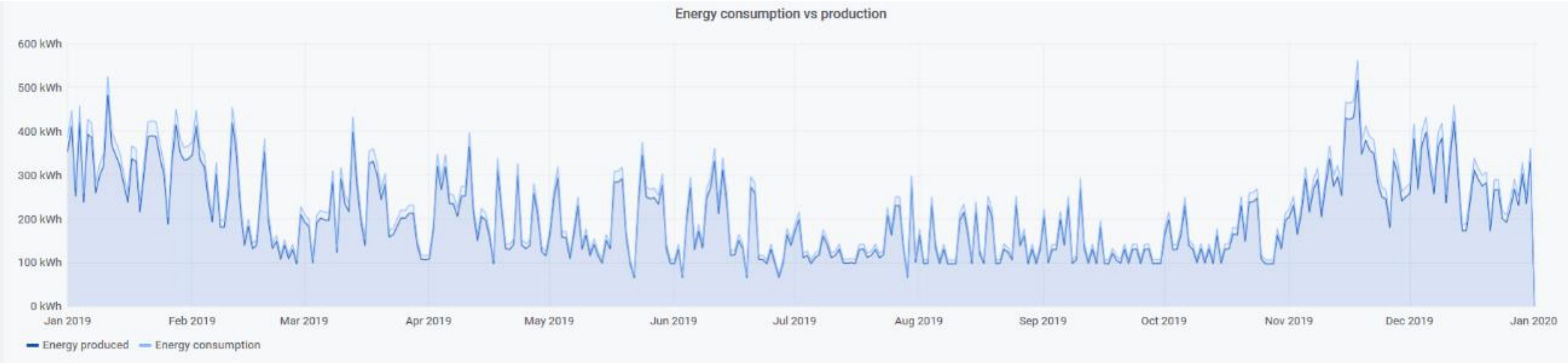

Figure 21. Biomass boiler daily heat production

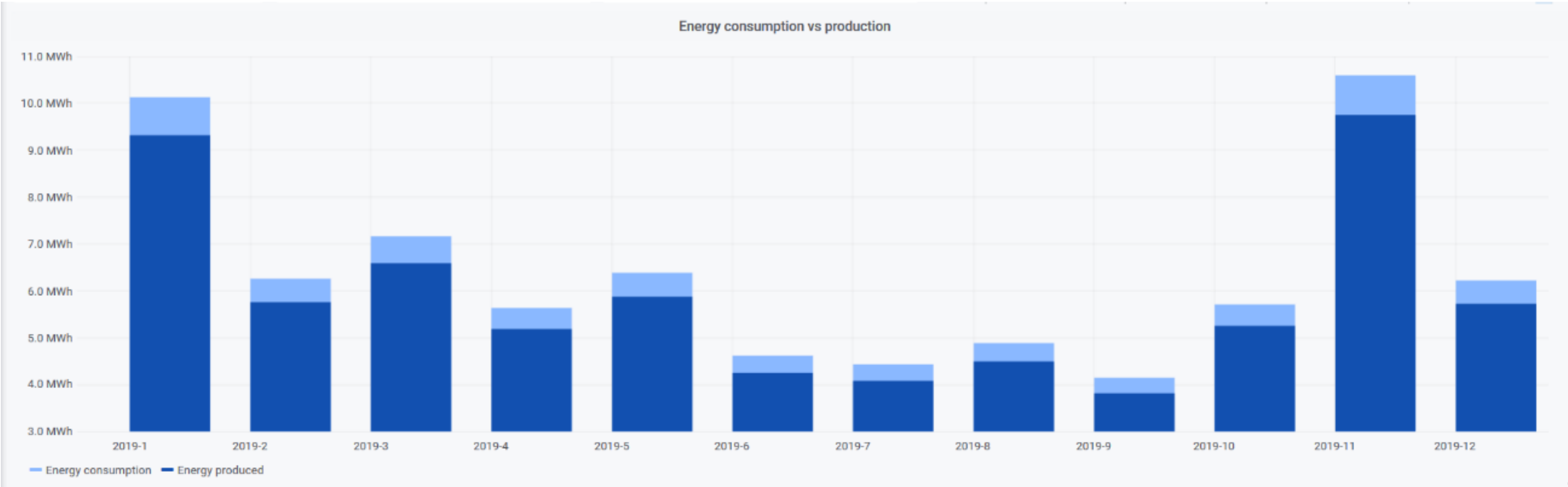

Figure 22. Biomass boiler monthly heat production

Furthermore, Figure 23. Daily heat production distribution by magnitude of energy generated by the biomass boiler exhibits a heatmap that represents the distribution of heat produced by the biomass boiler divided in buckets according to the amount of energy produced daily. Darker "buckets" encompass a higher number of daily values within the values that limit the bucket. From the heatmap panel it is possible to conclude the daily heat production from the boiler is steadier along the third quarter of the year. On the other side, in the first and fourth quarters of the year, the total amount of heat produced each day falls within a wide range of values.

Through contrast with Figure 24 that presents the same kind of representation of the heat demand distribution as explained above, it is understood the heat production of the boiler follows the same tendency as the heat demand of the DH network.

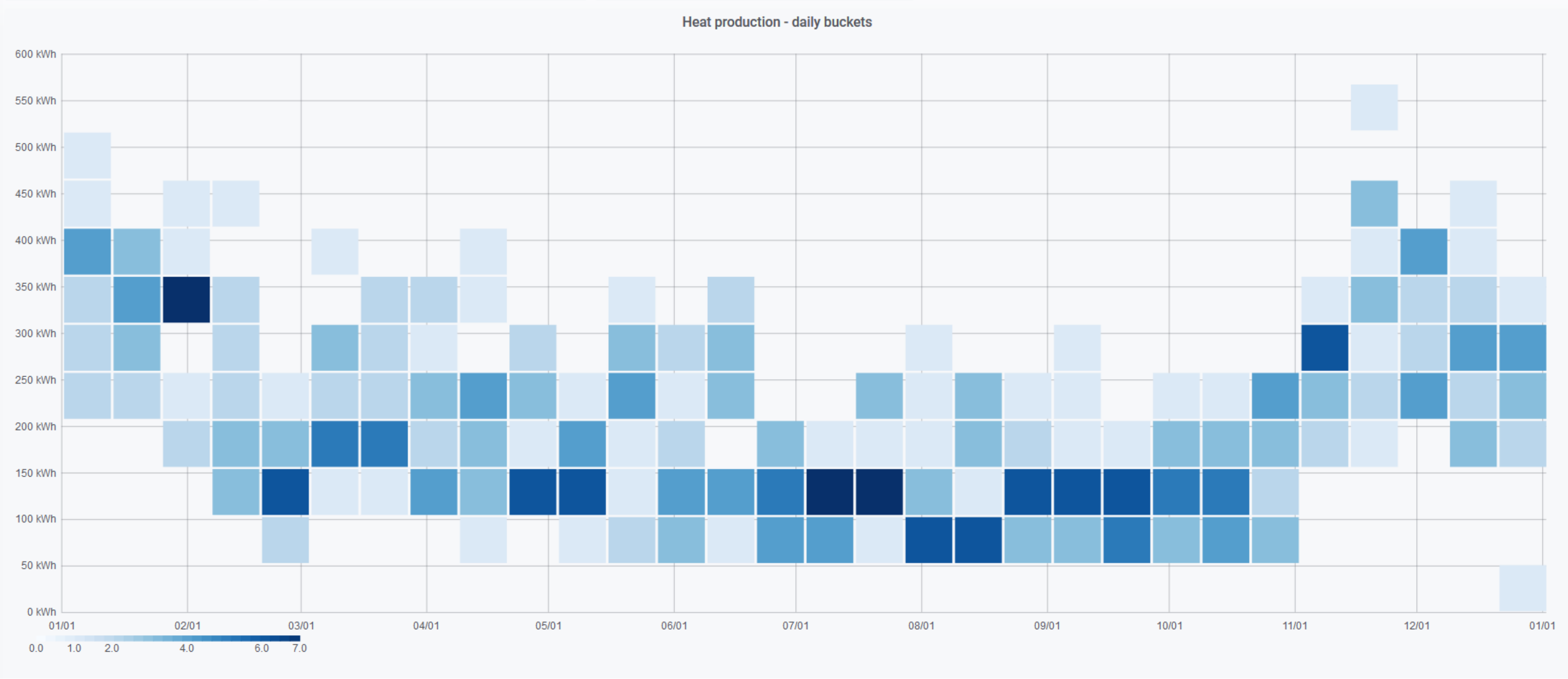

Figure 23. Daily heat production distribution by magnitude of energy generated by the biomass boiler

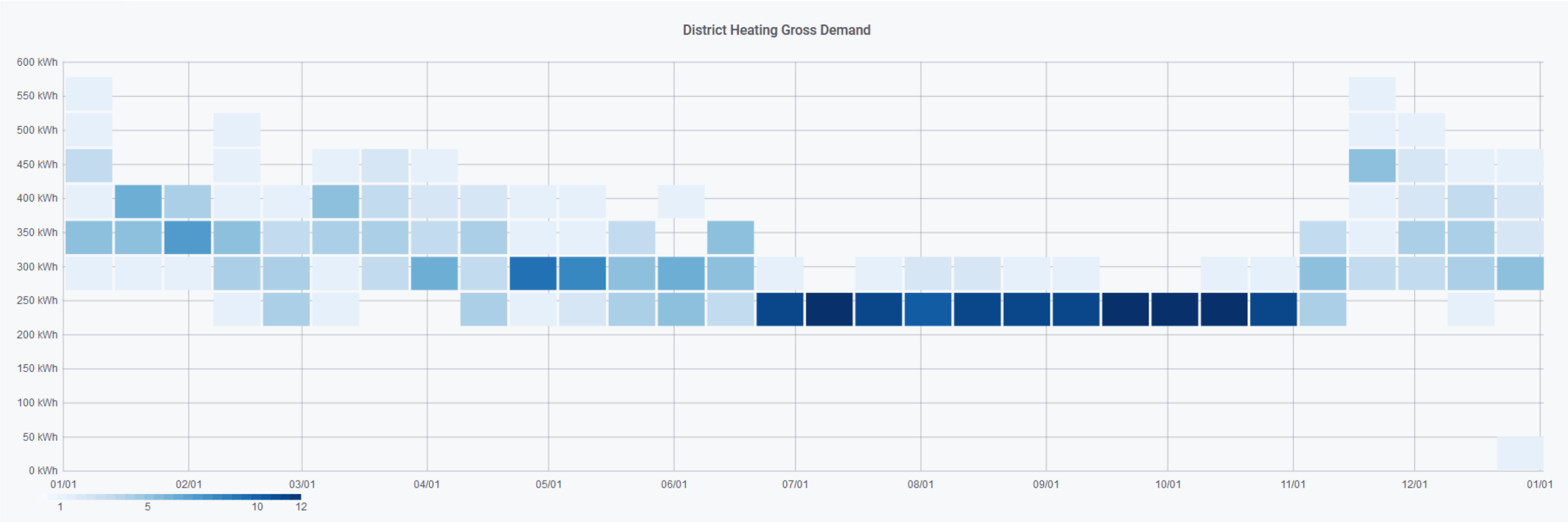

Figure 24. Daily heat demand distribution by magnitude of energy demanded

In short, the heat demand of Ispaster DH system is mostly covered by the biomass boiler whose heat production increases in the colder months.

The comparison between the amount of energy supplied by the biomass boiler and the STS is particularly visible through the bar graph in Figure 25 and in the pie chart as shown in Figure 26 that shows that, in yearly terms the biomass boiler accounts for 68 % of the heat supplied to the DH network in contrast to the 32 % of heat delivered by the STS.

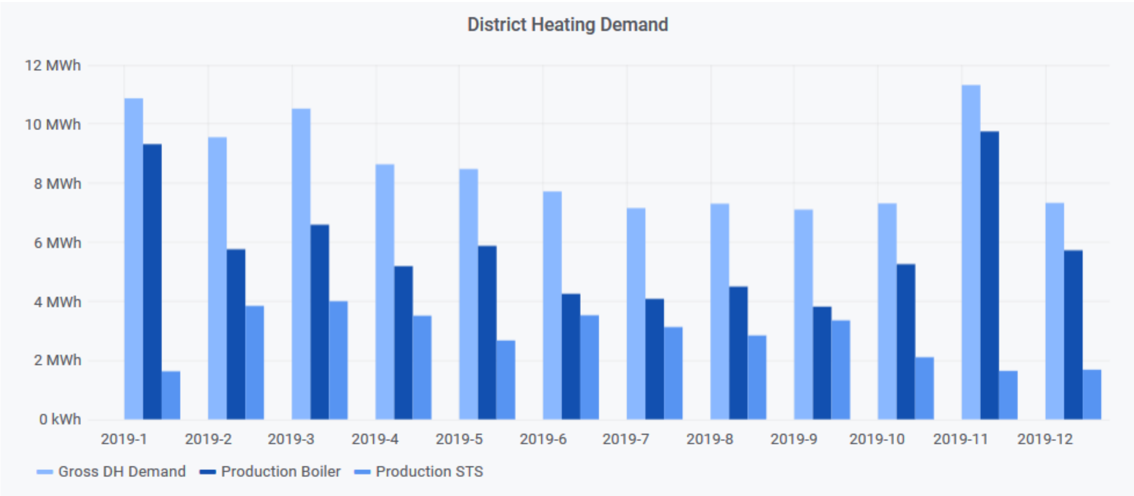

Figure 25. Monthly heat production by supply system

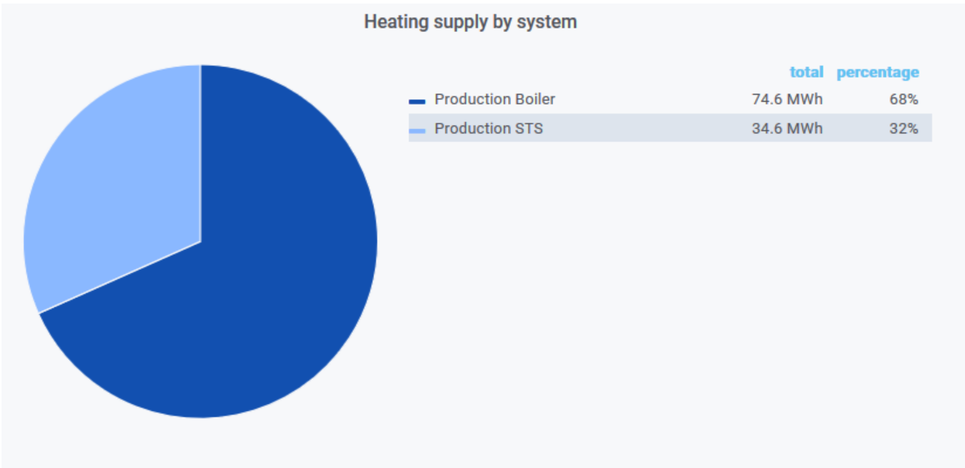

Figure 26. Distribution of heat production by supply system

At last, a pronounced difference between net and gross demand of the DH system can be identified through Figure 27 and Figure 28 that present, respectively, the daily and monthly net and gross heat demand of Ispaster's DH network.

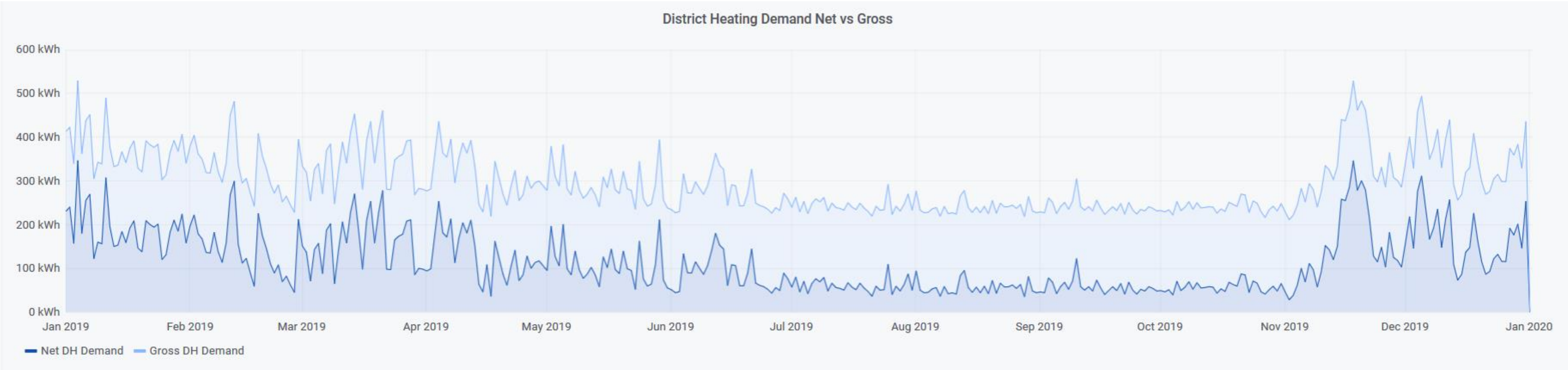

Figure 27. Daily net and gross heat demand

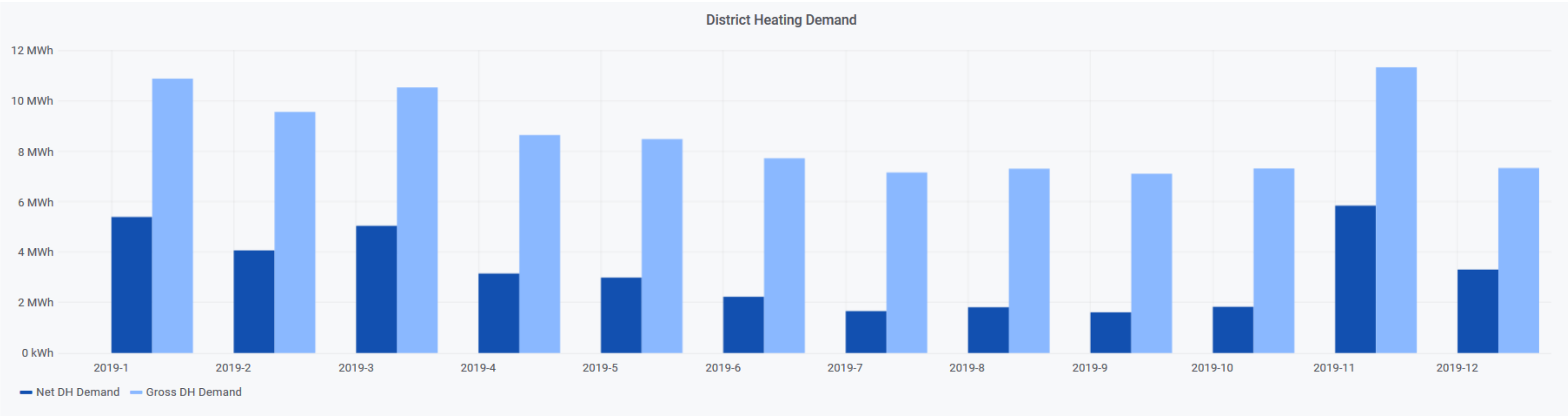

Figure 28. Monthly net and gross heat demand

The two graphs put in evidence the significant heat losses the overall network experiences.

4.1.3. Yearly totals and monthly averages

The monthly average of the most relevant variables generated for Ispaster micro-grid and DH network are listed in Table 4. Monthly averages of the main variables of Ispaster micro-grid and DH and the corresponding totals of the 1-year period of monitoring data are presented in Table 5. Yearly totals of the main variables of Ispaster micro-grid and DH.

Table 4. Monthly averages of the main variables of Ispaster micro-grid and DH

Variable	Monthly averages	Unit
Total electricity delivered by the inverter	1.7	MWh
Useful energy produced by the PV system	1.9	MWh
Electricity supplied by the batteries	0.9	MWh
Electricity sent to batteries	1.0	MWh
Gross heat demand	8.6	MWh
Net heat demand	3.2	MWh
Thermal energy supplied by the STS	2.8	MWh
Thermal energy supplied by the biomass boiler	5.8	MWh
Total Energy consumed by the biomass boiler	6.3	MWh

Table 5. Yearly totals of the main variables of Ispaster micro-grid and DH

Variable	Annual totals	Unit
Total electricity delivered by the inverter	20.8	MWh
Useful energy produced by the PV system	23.3	MWh
Electricity supplied by the batteries	11.4	MWh
Electricity sent to batteries	12.7	MWh
Total Gross heat demand	108.4	MWh
Total Net heat demand	41.7	MWh
Thermal energy supplied by the STS	34.6	MWh
Thermal energy supplied by the biomass boiler	74.6	MWh
Total Energy consumed by the biomass boiler	81.1	MWh

4.2. Aalborg

The monitoring platform of the Aalborg case starts to displays some general figures of the overall DH network. A more detailed analysis of supply and demand is available organized by type of energy: informative panels concerning heat demand and supply appear in the first place, followed by the section that concerns to electricity. The energy balance page is bottomed by the panels that analyse fuel figures.

4.2.1. General figures

Figure 29 shows some of the yearly totals calculated by the platform through data aggregation.

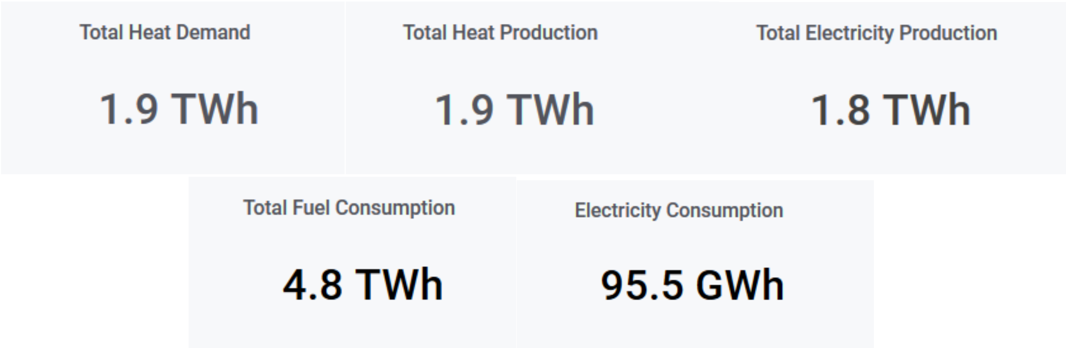

Figure 29. Yearly total figures of Aalborg

The visualized values are coherent with the initial review of the DH system. The heat demand falls within the expected range and is properly met by the heat production. The magnitude of the unit dilutes the residual share of heat losses that differentiate the two variables. In other words, the heat losses are very low and thus not recognizable here.

Likewise, the total electricity production of the 1-year period monitored adds up to the known information about the system.

4.2.2. Heat demand and availability

Heat demand and availability timeseries along the one-year period of data available are presented in Figure 30. Aalborg's heat demand and production time series. The hourly values were aggregated to present daily totals. As expected, the heat demand (represented with the darker blue) is significantly higher in the cooler months and the production (in lighter blue) follows the demand's trend.

Figure 31 and Figure 32 display, respectively, the heat flow to and from the Pit Tank Energy Storage (PTES) and Thermal Tank Energy Storage (TTES) of the network that balances the observed unevenness between heat demand and production. Heat from the TTES and PTES is represented by positive values while heat entering the TTES and PTES is represented with negative values.

The response of the storage systems according with the necessities of the DH network is particularly clear in the graphs that show these variables broken down by month. It shall be mentioned once again that the monthly totals represented in the graphs do not present exactly the total values of the natural months. Instead, the so-mentioned monthly totals consist of automatic aggregation of data of 30 consecutive days. Figure 33 exhibits the monthly totals of heat demand and availability while Figure 34 and Figure 35 present the monthly heat flow from and to PTES and the TTES, respectively.

The heatmap in Figure 36 represents the average daily level of heat content of the TTES. The periods of time between July and October show a large count of days for which the heat content threshold of the TTES is stabilized within a high bucket of values.

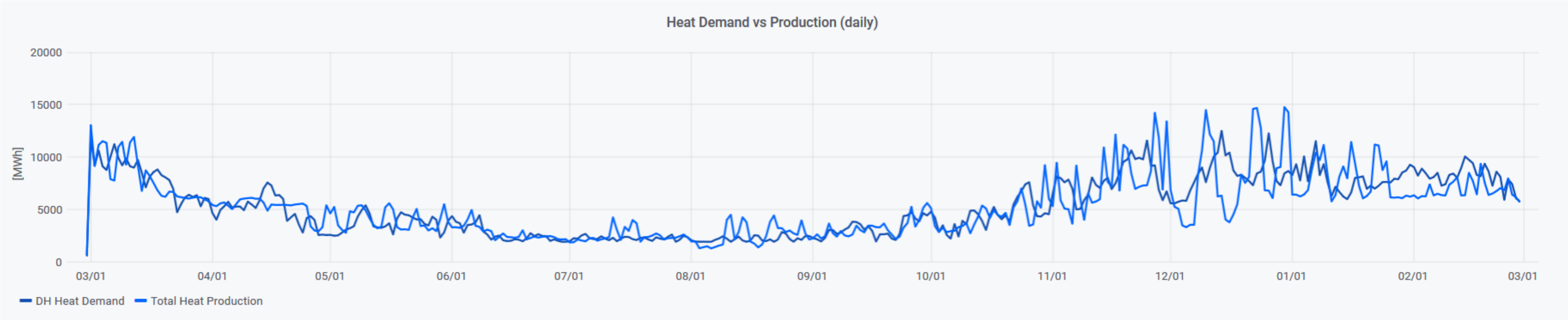

Figure 30. Aalborg's heat demand and production time series

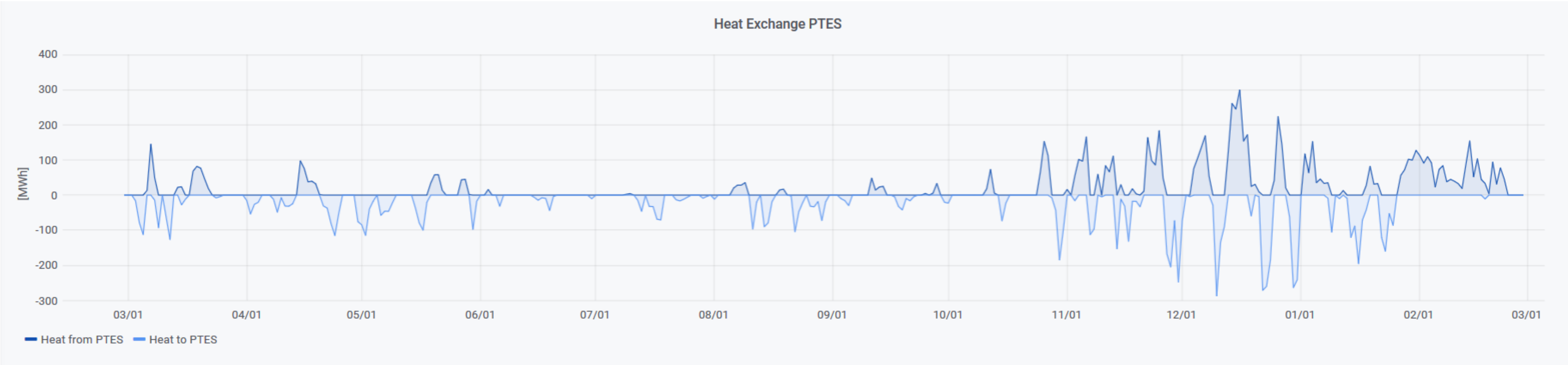

Figure 31. Heat exchange of Aalborg's DH with Pit Thermal Energy Storage

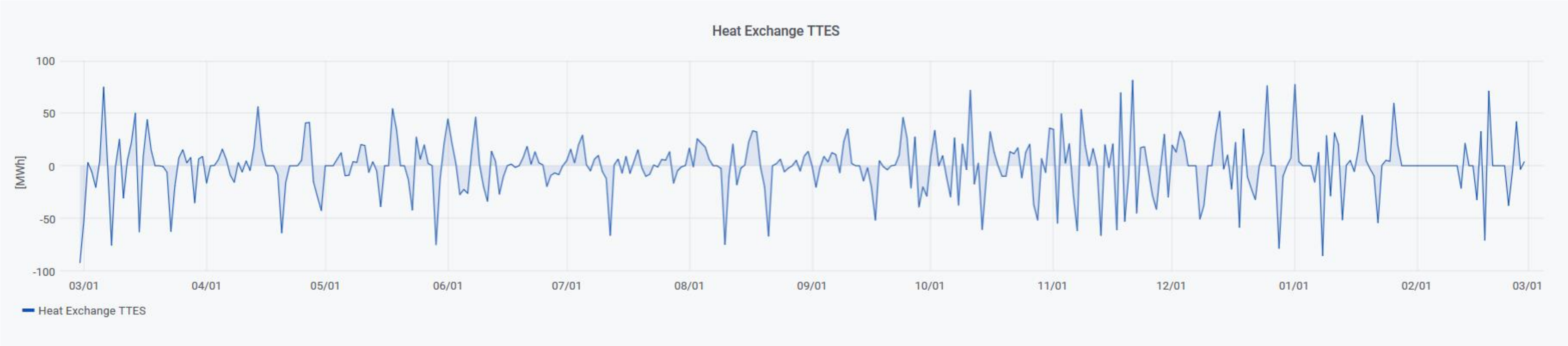

Figure 32. Heat exchange of Aalborg's DH with Tank Thermal Energy Storage

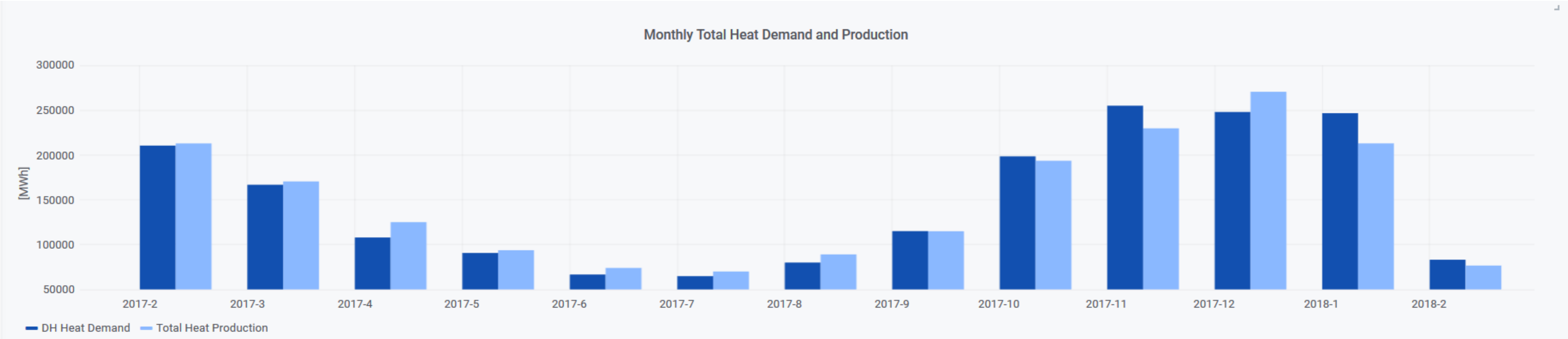

Figure 33. Aalborg's monthly heat demand and production

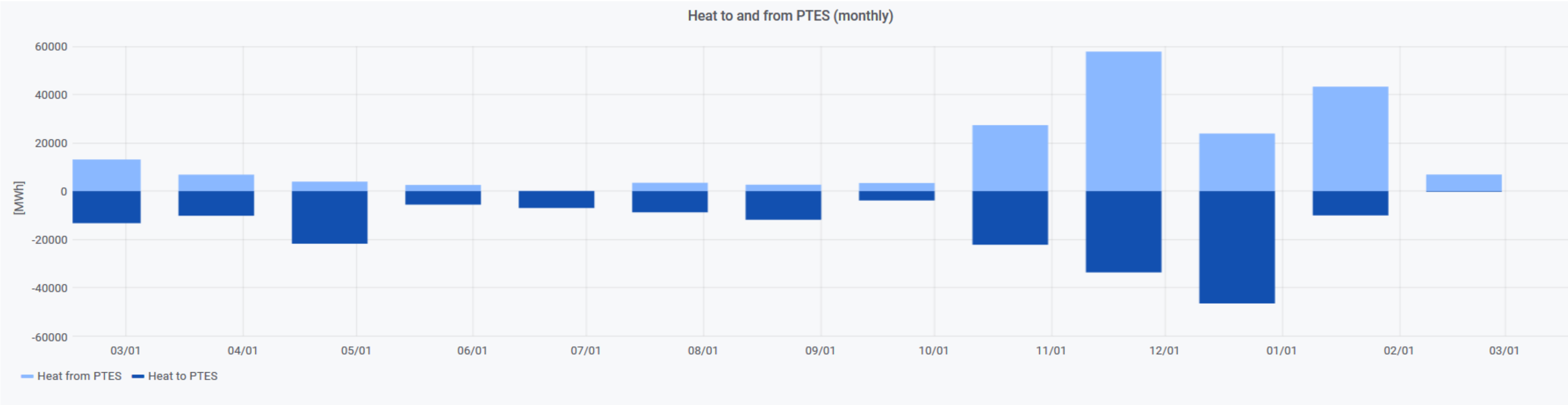

Figure 34. Monthly heat from (+) and to (-) PTES

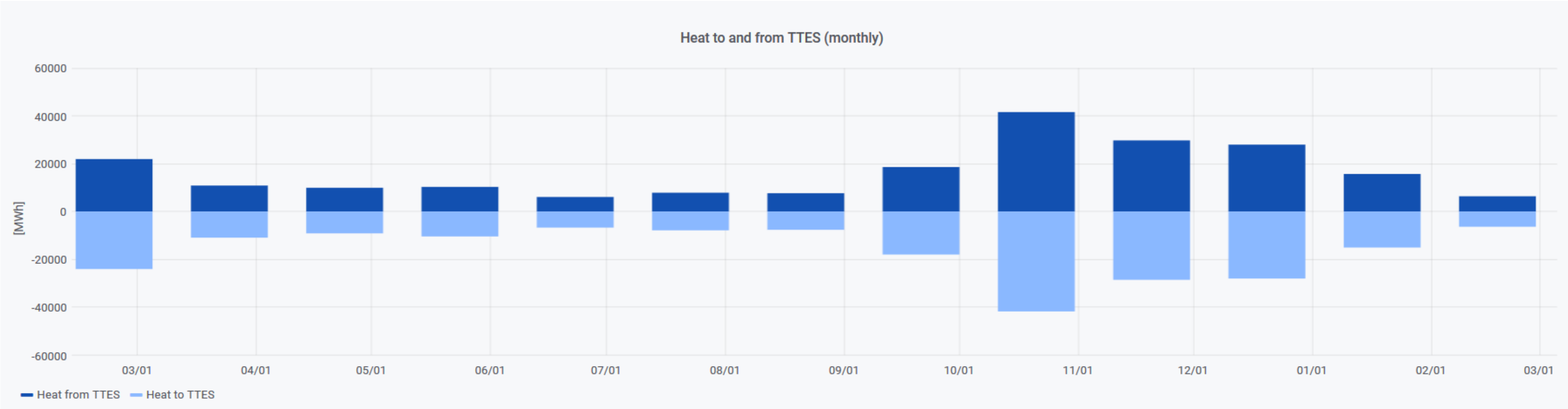

Figure 35. Monthly heat from (+) and to (-) TTES

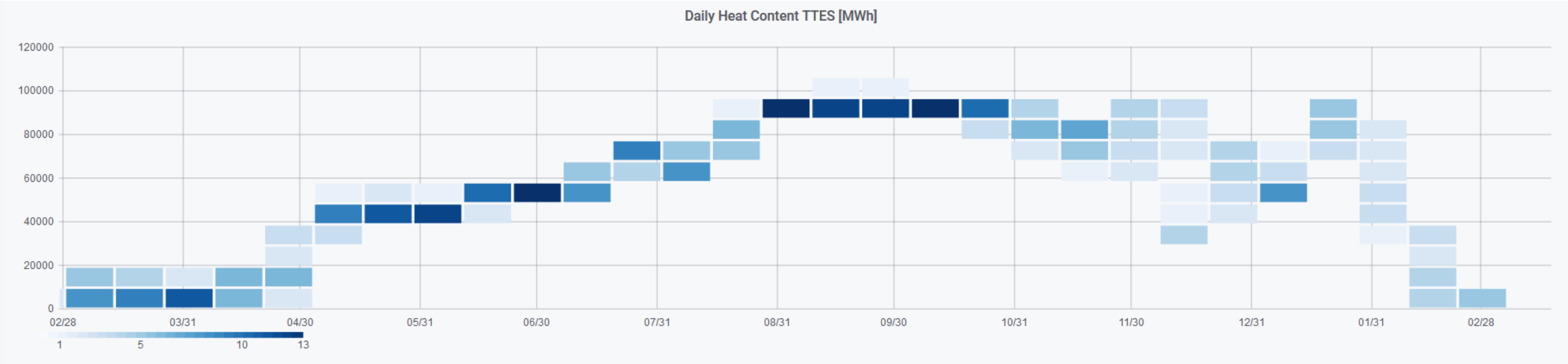

Figure 36. TTES heat content heatmap

The contribution distribution regarding heat supply is shown in Figure 37. Nordjylland Power Station is the main supplier of heat of the DH, responsible for supplying almost half of the heat consumed over the one-year period of analysis. Aalborg Portland and Reno Nord Power Station cover almost equitably most of the remaining heat demand. Different heat producers contribute with a small percentage of the total heat supply. Based on the analysis of this data, the operation of the back-up boiler was residual.

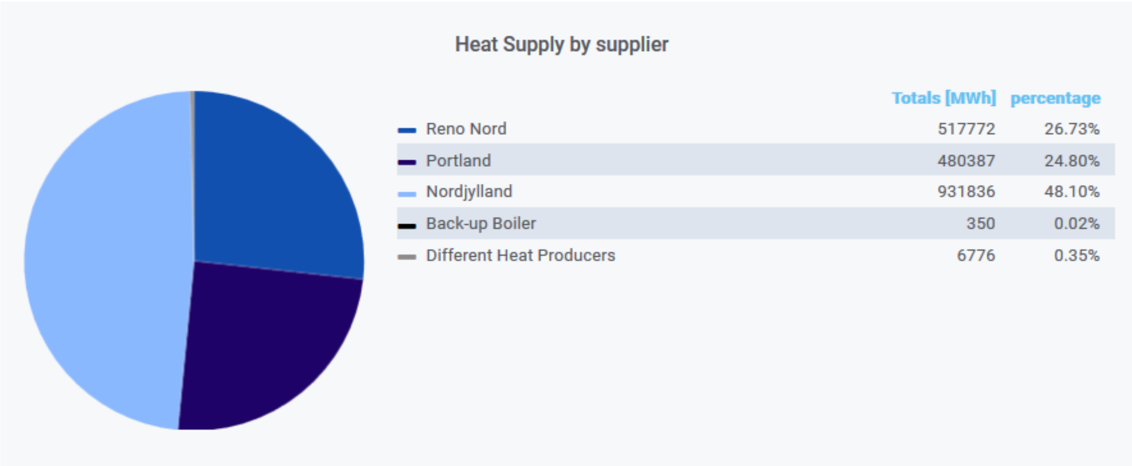

Figure 37. Heat supply share by supplier

The monthly analysis from Figure 38 shows that although the heat supply from Reno Nord and Portland increases slightly in the months of higher demand, it is relatively stable along the year. On the other hand, Nordjylland's supply seems to be adjusted to the need for heat, balancing the available heat and the surplus demand.

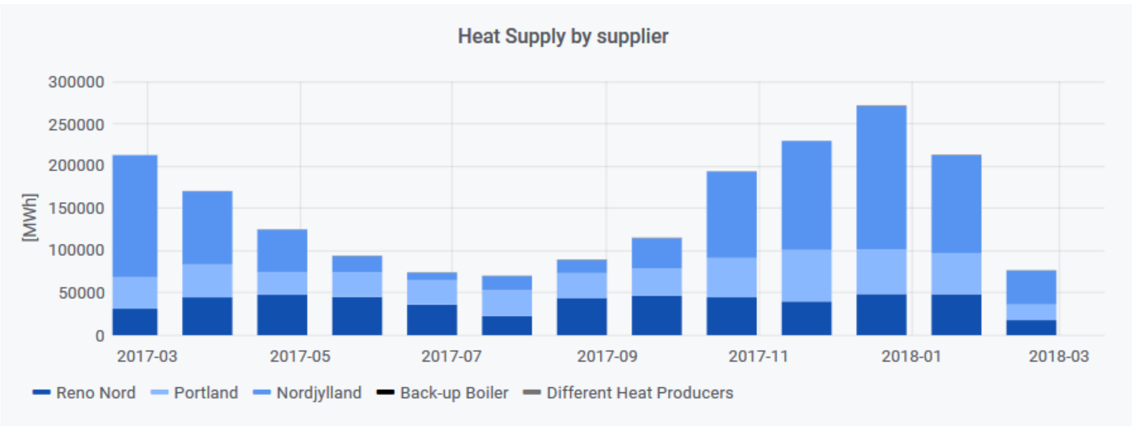

Figure 38. Monthly heat supply by supplier

This interpretation is backed-up by Figure 39, Figure 40 and Figure 41 that exhibit availability of waste heat and heat production from, respectively, Reno Nord Power Station, Aalborg Portland and Nordjylland Power Station. It is clear the heat produced by Reno Nord Power Station exhibits a quite constant trend while the profile of heat produced by Aalborg Portland and Nordjylland Power Station present accentuated variations with a particularly sharp increase in the colder months. The values shown in these graphs consist of daily totals.

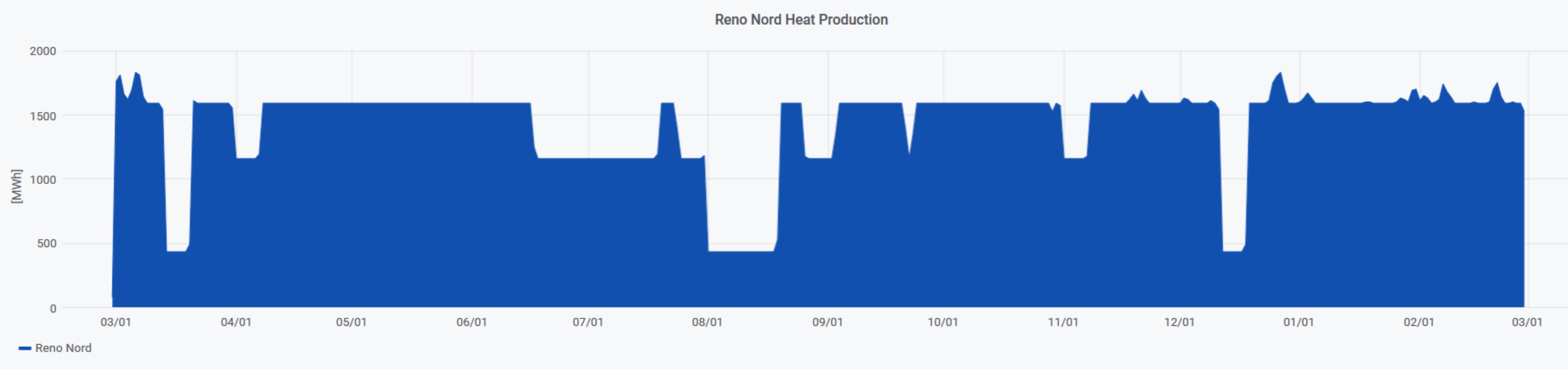

Figure 39. Reno Nord heat production

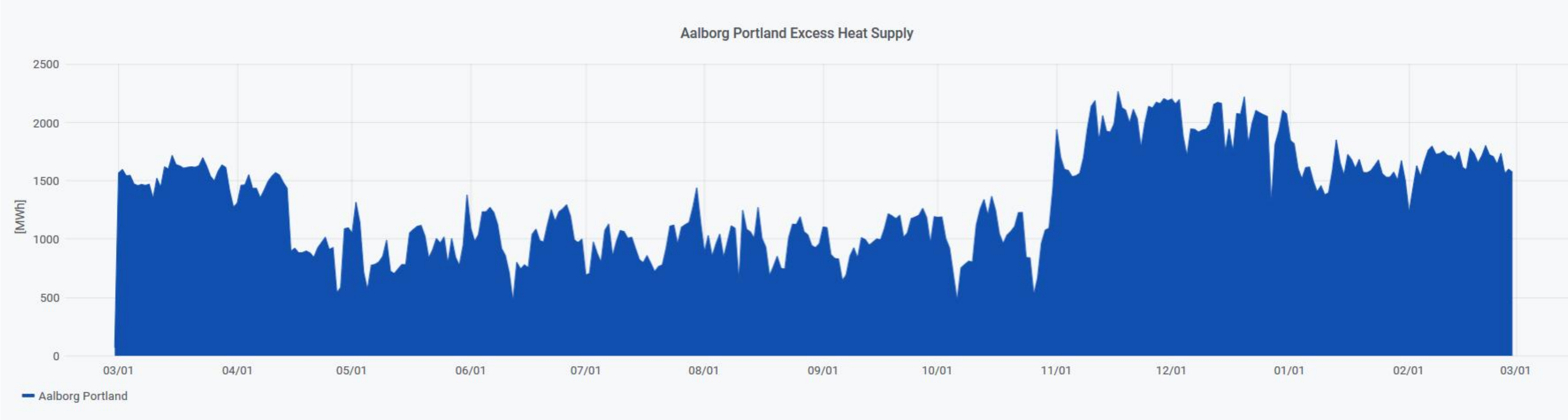

Figure 40. Aalborg Portland excess heat supply

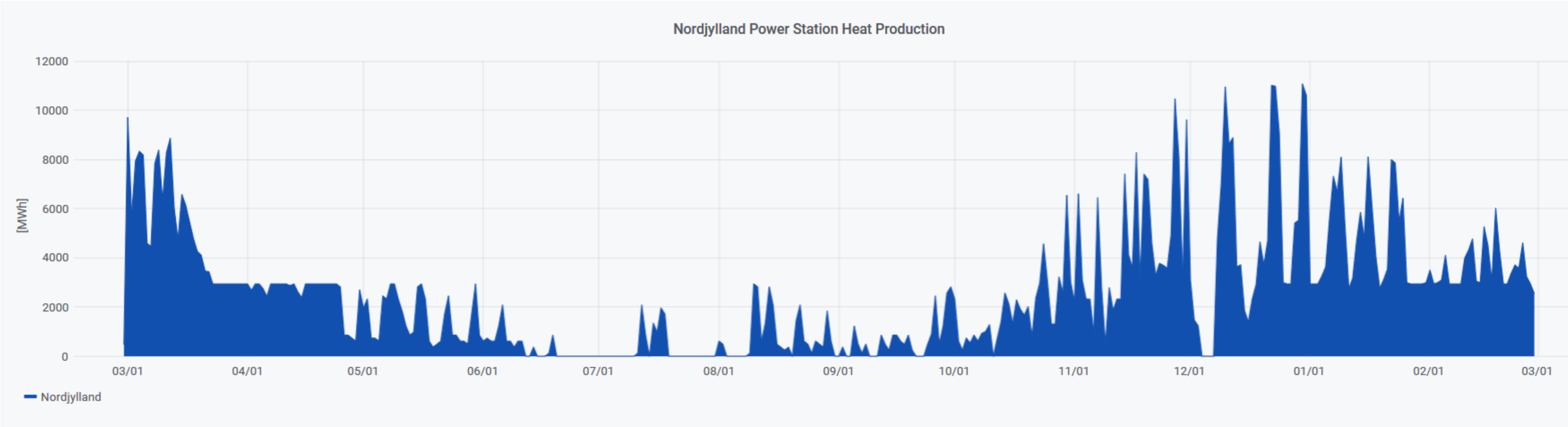

Figure 41. Nordjylland Power Station heat production

In terms of the type of heat generation system, it can be seen in Figure 42 that three quarters of the heat consumed by the DH is generated through combined heat and power processes, while the remaining demand is covered by excess heat. The heat supply by the back-up electric boiler is residual.

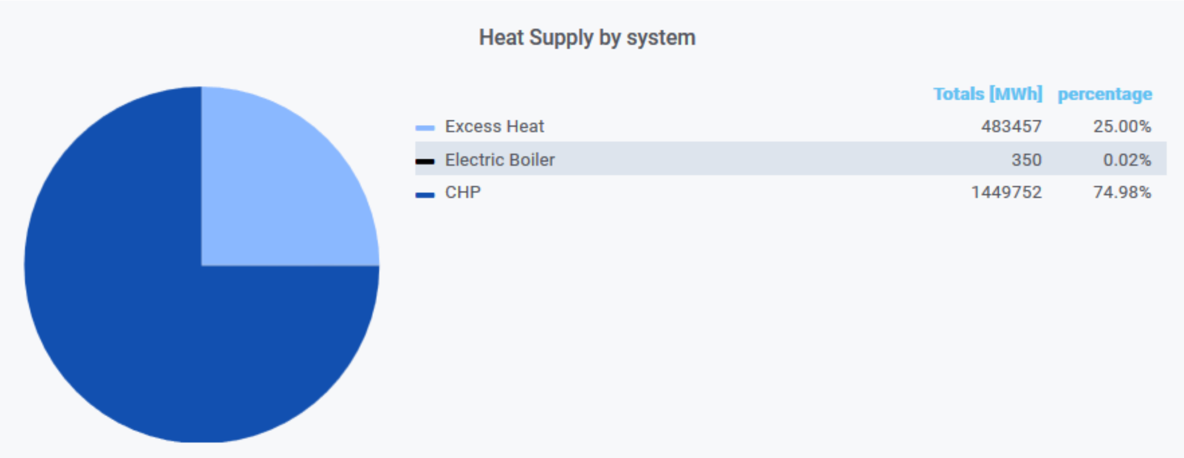

Figure 42. Heat supply share by type of heat generation process

Additionally, excess heat supply is relatively steady when compared with heat from CHP systems, as shown by Figure 43.

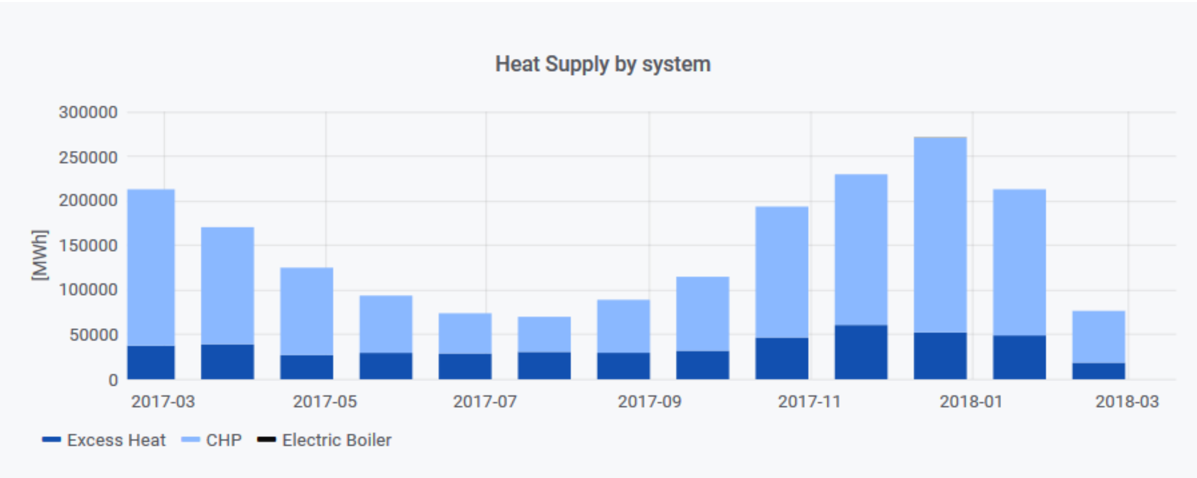

Figure 43. Monthly heat supply by system

4.2.3. Electricity supply

Concerning electricity production, Nordjylland is a much more representative supplier than Reno Nord, being accountable for more than 90 % of the overall electricity production, as it can be seen in Figure 44.

Figure 44. Electricity supply share by supplier

The daily totals of electricity supplied by each power station are shown for all the year of monitoring data in Figure 45 and Figure 46. Both the power stations exhibit a very similar production trend. Two sharp decreases in the electricity production values can be identified in the two graphs. The valleys correspond to a few days in the months of July and August. Given that Reno Nord and Nordjylland are CHP power plants the decrease of electricity production may be attributed to the adjustment of the plants' operation to the head demand that is considerably lower during the summer period.

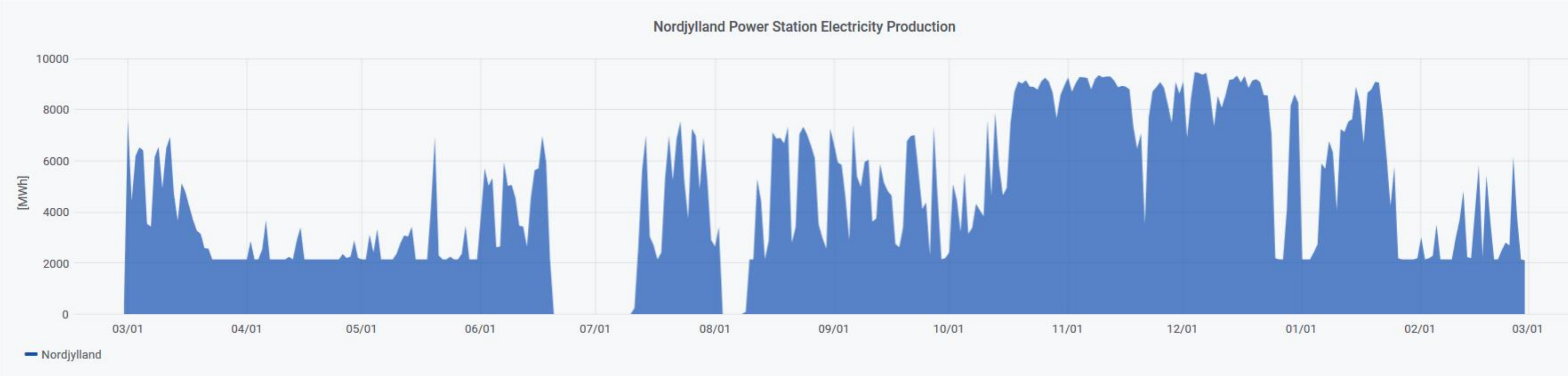

Figure 45. Nordjylland Power Station electricity supply

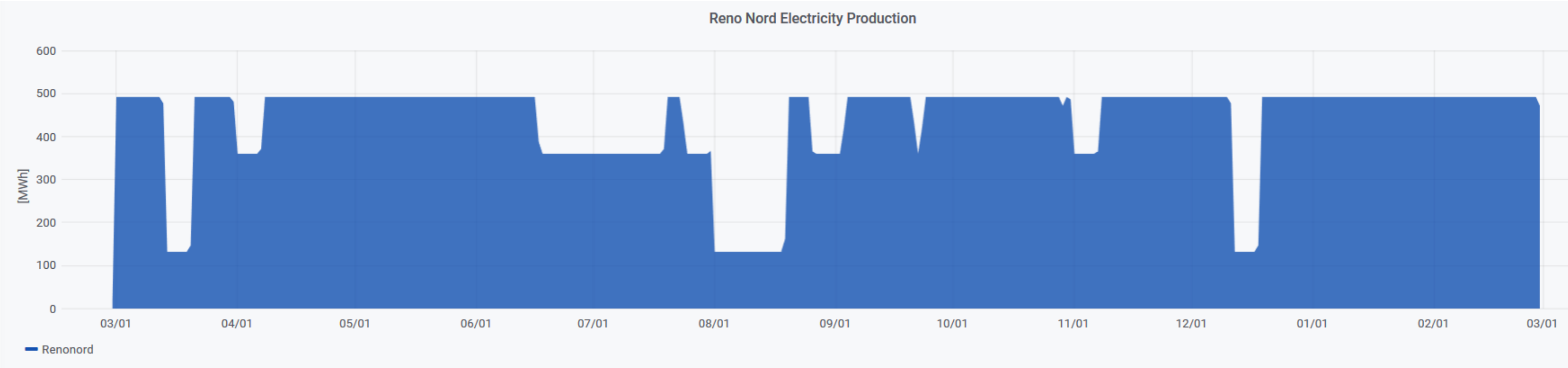

Figure 46. Reno Nord Power Station electricity supply

4.2.4. Fuel and electricity consumption

In a year, 4.8 TWh of fuel is consumed to supply the system every month, which represents a monthly average of 371 GWh, as pictured in Figure 47, printed from the visualization platform.

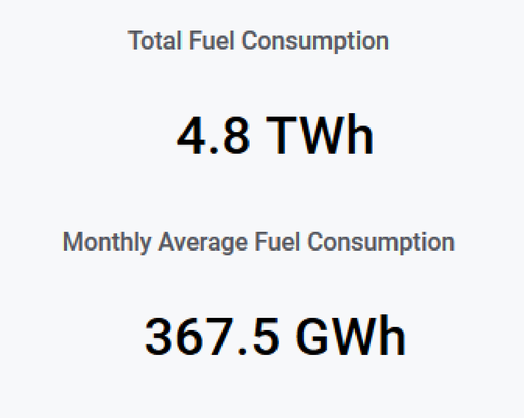

Figure 47. Fuel consumption figures

Figure 48 presents the share of fuel consumption of Nordjylland and Reno Nord. It was previously observed that Aalborg's DH is mostly powered by Nordjylland, a coal-fired CHP plant. So, it is not surprising to verify that Nordjylland is the highest fuel consumer of Aalborg's DH network.

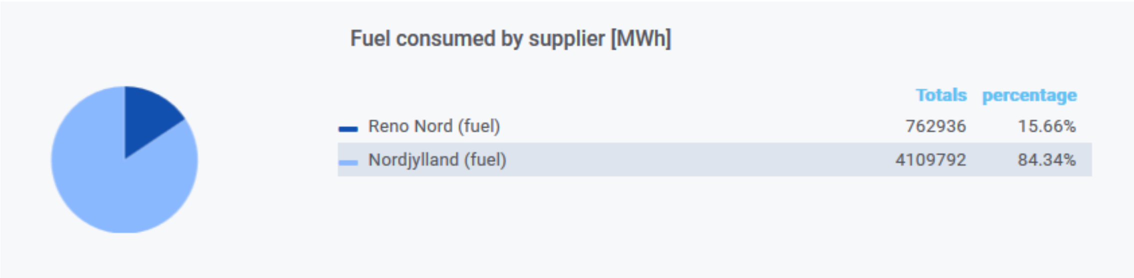

Figure 48. Fuel consumption by supplier

The electricity consumed by Reno Nord and the back-up electric boiler of the DH system is also available for analysis. As displayed in Figure 49, the electricity consumption of the waste incineration CHP plant is insignificant when compared with its fuel consumption. Most of the consumption of electricity concerns to Reno Nord activity while the remaining (ca. 9%) is related to the operation of the back-up electric boiler, as pictured in Figure 50.

Figure 49. Energy consumption of Reno Nord

Figure 50. Electricity consumption by supplier

4.2.5. Yearly totals and monthly averages

The monthly average of the most relevant variables monitored from Aalborg DH network are summarized in Table 6. Moreover, the totals of the 1-year period of monitoring data are presented in Table 7.

Table 6. Monthly averages of the main variables of Aalborg's DH

Variable	Monthly averages	Unit
Heat demand	148.7	GWh
Heat production	148.7	GWh
Electricity production	142.0	GWh
Fuel consumption	371.3	GWh
Electricity consumption	6.9	GWh
Heat from PTES	15.0	GWh
Heat to PTES	15.0	GWh
Heat from TTES	16.5	GWh
Heat to TTES	16.5	GWh

Table 7. Yearly totals of the main variables of Aalborg's DH

Variable	Annual totals	Unit
Heat demand	1.9	TWh
Heat production	1.9	TWh
Electricity production	1.8	TWh
Fuel consumption	4.8	TWh
Electricity consumption	95.5	GWh
Heat from PTES	195.1	GWh
Heat to PTES	195.1	GWh
Heat from TTES	214.6	GWh
Heat to TTES	214.6	GWh

5. Discussion and conclusions

The outcome of the work developed in Task 4.1. *Monitoring of pilot cases*, was presented in this document. The data from the selected two case studies, Aalborg and Ispaster, that was monitored and stored, has been exhibited and analysed in this document.

The collection of monitoring data of Ispaster along a whole year is not complete because some loss of communication with the monitoring system and due to modifications of the grid and the energy systems comprised. In any case, the energy network was analysed through the data that was possible to collect and the data generated to fill the gaps on the timeseries of monitored variables. The analysis carried out considered the conditions of the micro-grid and DH system at the beginning of the monitoring period (March 2019).

From the analysis of the data of Ispaster's case study, it was observed that a considerable amount of PV energy is wasted due to a mismatch between generation and demand of electricity and a simultaneous lack of capacity of the batteries to store a great portion of electricity generated. Additionally, a huge waste of thermal energy due to heat losses of the DH system was also identified. Both observations point to the necessity of a more efficient thermal and electrical energy storage and management system.

On the other hand, Aalborg's DH system shows a high balance between heat supply and demand. The balance of demand and supply is explained by the configuration of Aalborg's DH supply chain. While a small share of the heat demand is covered by a fairly stable amount of excess heat, the most significant share of heat is delivered by a combined heat and power coal-fired station that adjusts the amount of generated heat according to the needs of the system without being conditioned by weather or operational conditions. Moreover, the DH network counts with a storage system that has the capacity to meet the system's storage requirements.

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Appendix 1 – Registered variables in Ispaster

Table 8 lists all the variables monitored in Ispaster along with the metrics and tags that identifies them in the database. The elements in the table are featured as they are database: one single word without spaces or special characters, all lower cases.

All variables are stored with four more tags than the shown in the table, with tag-values common to all of them: lat, long (respectively, the latitude and longitude of the corresponding installation), location ("ispaster" for all of them) and provider (the provider responsible for data sending).

Table 8: Variables monitored in Ispaster – metrics and tags

Metric's designation	Tags (Value/Key) System	Tags (Value/Key) Installation	Description
energy.out.monthly	pv	battery	Monthly energy supplied by the batteries
energy.out.total			Total energy supplied by the batteries
energy.in.monthly			Monthly energy received by the batteries
energy.in.total			Total energy received by the batteries
energy.monthly		pv	Monthly energy generated by the PV system
energy.total			Total energy generated by the PV system
energy.load.monthly		inverter	Monthly load of the PV system
energy.load.total			Total load of the PV system
voltage		battery	Status of charge of the batteries
temperature			Temperature of the batteries
temperature.sup	sts	solarcollector	Temperature of supply of the STS
temperature			Temperature of the collector of the STS
efficiency			Efficiency of the collector
energy.daily			Daily energy generated by the STS
energy.total			Total energy generated by the STS
temperature.sup	boilerroom	boiler	Supply temperature of the boiler
temperature.ret			Return temperature to the boiler
energy.heating	hx	boilerroom	Total heat demand (measured at the boiler room)
energy.heating		cityhall	Heat consumption measured at the city hall
energy.heating		herrikotaberno	Heat consumption measured at the bar
energy.heating		frontonduchas	Heat consumption measured at the showers
energy.heating		areitzbi	Heat consumption measured at the restaurant

Appendix 2 – Generated variables of Ispaster case study

Table 9 contains all the variables generated by simulation to fill the data gaps of Ispaster case study. Each variable is presented along with the respective metrics and tags that identifies it in the database. The elements in the table are featured as they are database: one single word without spaces or special characters, all lower cases.

All variables are stored with four more tags than the shown in the table, with tag-values common to all of them: lat, long (respectively, the latitude and longitude of the corresponding installation), location (“ispaster” for all of them) and provider (that in this particular case indicates the variables were generated by a simulation model).

Table 9. Variables generated for Ispaster energy system – metrics and tags

Metric’s designation	Tags (Value/Key)		Description
	System	Installation	
energy.in	pv	battery	Energy received by the batteries
energy.out			Energy supplied by the batteries
voltage			Voltage of the batteries
energy.load		inverter	Electrical energy demand
energy.dumped		pv	Energy dumped
energy.total			Total energy generated by the PV system
efficiency	sts	solarcollector	Efficiency of the STS
energy.instant			Energy generated by the STS
temperature.sup	boilerroom	boiler	Supply temperature of the boiler
temperature.ret			Return temperature to the boiler
energy.production			Heat energy produced by the boiler
energy.consumption			Energy consumed by the boiler
energy.in	dm	grid	Electrical energy provided by the grid
energy.heating	dh	net	Net heat demand of the DH
energy.heating		gross	Gross heat demand of the DH

Appendix 3 – Registered variables in Aalborg

Table 10 presents all the variables that concern to Aalborg DH system that are stored in the database. The panels available in the presentation data system and the data analysed in this document are built upon these variables. The table also presents the metric and tags that identifies each variable.

All variables are presented in MWh. Three more tags are linked to each variable: lat, long (respectively, the latitude and longitude of the corresponding installation) and location ("aalborg" for all of them). The elements in the table are presented as they are database: one single word without spaces or special characters, all lower cases.

Table 10: Variables registered in Aalborg – metrics and tags

Metric's designation	Tags (Value/Key)		Description
	System	Installation	
fuel	chp	renonordl4	Fuel used to generate heat and electricity to area L4 of the Reno-Nord CHP plant
electricityproduction	chp	renonordl4	Electricity produced at area L4 of the Reno-Nord CHP plant
heatproduction	chp	renonordl4	Heat produced at area L4 of the Reno-Nord CHP plant
fuel	chp	renonordl3	Fuel used to generate heat and electricity to area L3 of the Reno-Nord CHP plant
electricityproduction	chp	renonordl3	Electricity produced by area L3 of the Reno-Nord CHP plant
heatproduction	chp	renonordl3	Heat produced by area L3 of the Reno-Nord CHP plant
electricityconsumption	chp	renonordbypass	Electricity consumed by the bypass of the Reno-Nord CHP plant
heatproduction	chp	renonordbypass	Heat produced by the bypass of the Reno-Nord CHP plant
heatproduction	excessheat	aalborgportlandvg1	Excess heat produced by Portland's factory – group 1
heatproduction	excessheat	aalborgportlandvg2	Excess heat produced by Portland's factory – group 2
heatproduction	excessheat	aalborgportlandadditional	Additional excess heat produced in Portland's factory
heatproduction	excessheat	differentheatproducers	Excess heat produced by different small producers
fuel	chp	nordjyllandsvaerketcoalfiredplantminlastcondensation	Fuel used to generate electricity through the condensation turbine at the coal fired CHP plant of Nordjylland, minimum load
electricityproduction	chp	nordjyllandsvaerketcoalfiredplantminlastcondensation	Electricity produced by the condensation turbine at the coal fired CHP plant of Nordjylland, minimum load
electricityconsumption	chp	nordjyllandsvaerketcoalfiredpla	Electricity consumed in the operation of the load counter-pressure turbine at the

Metric's designation	Tags (Value/Key) System	Tags (Value/Key) Installation	Description
		ntminlastcounterpressure	coal fired CHP plant of Nordjylland, minimum load
heatproduction			Heat produced to the operation of the counter-pressure turbine at the coal fired CHP plant of Nordjylland, minimum load
fuel	chp	nordjyllandsvaerketcoalfiredplantbensonbackpressure	Fuel used by the Benson steam generator - backpressure turbine, at the coal fired CHP plant of Nordjylland,
electricityproduction			Electricity produced due to the benson steam generator - backpressure turbine, at the coal fired CHP plant of Nordjylland
heatproduction			Heat produced by the benson steam generator- backpressure turbine at the coal fired CHP plant of Nordjylland
fuel	chp	nordjyllandsvaerketcoalfiredplantfullloadbackpressure	Fuel used to generate electricity through the back pressure turbine at the coal fired CHP plant of Nordjylland, at full load
electricityproduction			Electricity produced by the back pressure turbine at the coal fired CHP plant of Nordjylland, at full load

Appendix 4 – Ispaster data use agreement

AUTORIZACIÓN PARA CONSULTA Y DESCARGA DE DATOS DE CONTADORES ENERGÉTICOS EN LA RED DE CALOR Y ELECTRICIDAD DE ISPASTER

GARBIÑE SAENZ DE BURUAGA.. con DNI 30576738D ________________________ en representación de AYUNTAMIENTO DE ISPASTER, con ClF P4805900J..................................

autoriza el acceso y descarga de los datos registrados en los contadores energéticos de los que es titular y son gestionados desde la entidad BARRIZAR,E.Z.E.

El responsable del tratamiento de los datos facilitados por la persona titular de los contadores es Sistemes Avançats d'Energia Solar Térmica S.C.C.L., con C.I.F. F62787692 y domicilio social en C/ Roger de Llúria, 29, 3r 2a 08009 Barcelona. Como tal, garantiza la seguridad de los mismos y su tratamiento confidencial, conforme a lo dispuesto en el Reglamento General de Protección de Datos (RGPD) y cualquier otra normativa que resulte de aplicación,
Dentro de las plataformas digitales de Sistemes Avançats d'Energia Solar Termica S.C.C.L„ la recogida y tratamiento de los datos personales se realizará, en función de la relación con el usuario, con la siguiente finalidad:

Consultar, descargar y analizar las medidas de los contadores existentes para poder desarrollar el proyecto europeo H2020 CHESTER, con código de proyecto 764042.

Los datos de los terceros a los que es necesario comunicar parte o la totalidad de los datos del titular, de forma que el proyecto pueda ser completado de manera eficaz, son:

TECNALIA ESG48975767

PLANENERGI FOND,DK74038212

ENCONTECHB.V. NL819797170B01

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BE0248015142

UNIVERSITAT POLITECNICA DE VALENCIAESQ4618002B

UNIVERSITY OF

ULSTERGB672390524 PNO

INNOVATION NV

BE0546587872

GOIENERS.COOP ESF75074872

DEUTSCHES ZENTRUM FUER LUFT - UND RAUMFAHRT e.V. CIF: KOELN 51147

IREN SPA IT07129470014

UNIVERSITAET STUTTGART DE147794196

En .lspaster

Firma:

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SISTEMES AVANCATS D'ENERGIA SOLAR TÉRMICA, S.C.C.L. CIF:F62787692 Inscrita al Registre de Cooperatives de Barcelona amb 124911 ª Inscripci6 11 d'Abril de 2002

Appendix 5 – Aalborg data use agreement

AUTHORIZATION TO ACCESS AND DOWNLOAD DATA FROM THE AALBORG DISTRICT HEATING NETWORK

Per Alex Sørensen, Head of Department of the company PlanEnergi, with Company VAT number DK74038212, authorizes to access and download the data recorded in the Aalborg district heating that have been provided to the firm PlanEnergi by the district heating company Aalborg Forsyning.

The company responsible to handle the data provided by PlanEnergi is Sistemes Avançats d'Energia Solar Térmica S.C.C.L., with VAT number ESF62787692 and registered address C/ Roger de Llüria, 29, 3r 2a 08009 Barcelona, which guarantees that data will be securely and confidentially treated, in accordance with the provisions of the General Data Protection Regulation (GDPR) and any other regulations that may apply. In the digital platform of Sistemes Avançats d'Energia Solar Térmica S.C.C.L., the collection and process of data will be carried out with the following purpose:

Check, download and analyse existing district heating data to develop the European Project H2020
CHESTER, project code No. 764042. *

*It is not allowed the partners to use the data in any other project than CHESTER and it is not allowed to give third parties access to the data.

In order to efficiently complete the project, district heating data will be partly or fully shared with the following CHESTER project third parties:

TECNALIA, ESG48975767

PLANENERGI, DK74038212

ENCONTECHBV, NL819797170B01

GHENT UNIVERSITY, BE0248015142

UNIVERSITAT POLITECNICA DE VALENCIA, ESQ4618002B

UNIVERSITY OF ULSTER, GB672390524

PNO INNOVATION NV, BE0546587872

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