Detailed measurements of heat and electricity consumption in Sønderborg households during the herating season 08/09

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Contents

1 Introduction

This report describes measurements of energy consumption from 56 households connected to the district heating system in Sønderborg, Denmark. The data has been logged approximately every 10th minute during the heating season 2008/9 via the district heating measuring unit and hence consist of many variables related to the consumption of district heating. The measuring unit is equipped with 2 sockets for pulse input. For 27 households measurements of the accumulated tap water consumption is performed via socket 1 and measurements of the accumulated electricity consumption is performed via socket 2[1].

The measuring unit consists of a Kamstrup Multical 66C with a module for data logging. Depending on the amount of data logged log time intervals down to 5 minutes are supported, but here the target interval size is 10 minutes. The measuring unit is connected to a GMS/GPRS modem, equipped with a SIM-card which has caused some problems. According to Sønderborg Fjernvarme these cards are now replacced with more reliable cards.

For the first few months of 2008, data on heat load and tap water has previously been considered in the documents ENFOR/03EKS0003A001-A[1] and ENFOR/03EKS0003A002-A[2]. Based on these documents it were concluded that the accumulated measurements of tap water and heat consumption are too coarse for calculation of 10 minute average flows of water or heat. In ENFOR/03EKS0003A001-A[1] it is concluded that it is more adequate to use the direct measurements of heat load in kW (variable `EFFEKT`), for tap water there is no alternative variable. The report ENFOR/03EKS0003A001-A[1] also describes temperature measurements and measurements of district heating water, both as flows and as accumulated measurements. Furthermore, ENFOR/03EKS0003A001-A[1] considers the unit of measurements as reported for the accumulated district heating energy consumption. It is concluded that this seems erroneous and that the unit is actually GJ.

2 Measurements

The data received contain 35 unnamed columns with names / order:

`SERIENR, DATOTID, TYPE_, ENERGI, ENHEDENERGI, VAND, ENHEDVAND, TIMETAELLER, TEMPFREM, TEMPRETUR, FEJLKODE, MAALERNR, TEMPDIFF, EFFEKT, FLOW, EFFEKTMAX, FLOWMAX, BEREGNENERGI, BEREGNVAND, AARSAGRING, INTERNEFEJL, DATOTIDFA5, MTYPE, TIMEONLINE, TAR2, TL2, TAR3, TL3, EPEAKDATE, FPEAKDATE, M3TF, M3TR, PEAKYEAR, P1, P2`

[1]Except for the unit with serial number 5168264 for which the inputs are swapped. In the data presented here this swap of inputs has been reversed.

Of these `EPEAKDATE, FPEAKDATE, PEAKYEAR` does not contain any data.

Here we focus on the following variables:

- `SERIENR`: Identification (serial number) of the district heating measurement unit.
- `DATOTID`: Time and date of measurement.

- `ENERGI`: Accumulated district heating consumption in GJ (see remarks in Section 1).
- `EFFEKT`: Heat load in kW measured directly by the district heating measurement unit.

- `TEMPFREM`: Temperature in ^oC of the district heating water entering the house.
- `TEMPRETUR`: Temperature in ^oC of the district heating water leaving the house.
- `TEMPDIFF`: Difference of the above in ^oC.
- `VAND`: Accumulated amount of district heating water in m^3 which has passed through the house.
- `FLOW`: Flow of district heating water in ℓ/h

- `P2`: Accumulated amount of electricity consumption in kWh

However, the report only contains plots related to `EFFEKT` and `P2`. Furthermore, we mention that `P1` is the accumulated amount of tap water consumption in m^3, see also Section 1.

This report is concerned with data covering the the period starting mid September, 2008 and ending primo December, 2009. However, the data collection continued after that point.

Electricity consumption (`P2`) is only measured for the 27 cases listed below:

```
4218598, 4218600, 4381449, 4711160, 4711176, 4836681, 4836722, 4986050, 5069878,
5069913, 5107720, 5127760, 5127784, 5159799, 5164474, 5164485, 5164523, 5168264,
5183206, 5183228, 5183232, 5191179, 5194940, 5194965, 5197381, 5223030, 5223036
```

Also, for `P2` a few non-positive values occur. According to Anders Bak, DFF-EDB (email: `aba@dff-edb.dk`) these values should be treated as missing since the corresponding log-data were corrupted. Furthermore, some log-data on `P2` are empty.

Measurements of the variable `EFFEKT` is shown in Figure 1 on page 9. A few extreme (high) measurements occur and 0.1% of the data are not shown on the plot. Table 1 on page 17 show the largest values for each ID. It is evident that these are outliers and they can relatively easily be excluded.

The top panels in Figures 5 and 6 on pages 13 and 14 show the lengths of the five longest periods in days where the maximum time difference between measurements are 11 and 20 minutes, respectively.

3 Derived data

Based on the measurements described in Section 2 the following data are derived:

- `deltaTsec`: The time span in seconds since last log time point.
- `deltaENERGI`: Difference in accumulated heat consumption in GJ, measured with two digits precision.
- `diffP2`: Difference in accumulated electricity consumption in kWh, measured with maximal two digits precision.
- `avgP2 = diffP2/(deltaTsec/3600)`: Average power in kW since last log time point.

Values of the variable `avgP2` is shown in Figure 2 on page 10. A few extreme (high) measurements occur and 0.1% of the data are not shown on the plot. Table 2 on page 18 show the largest values for each ID. It is evident that these outliers can relatively easily be excluded.

The middle and bottom panels in Figures 5 and 6 on pages 13 and 14 show the lengths of the five longest periods in days where the maximum time difference between measurements are 11 and 20 minutes, respectively. The bottom panels are most relevant since these considers ID's where the resolution of the power measurements are adequate[2].

4 Climate measurements

The climate variables ambient air temperature in ^oC, wind speed in m/s, wind direction in degrees and light intensity in Lux are measures as 10 minute averages. The measurements are shown in Figure 7 on page 15.

[2]Subjectively judged from Figure 2 on page 10.

5 Availability of data

Data are supplied in csv-format as the files `SoenderborgClimate0809.csv` and `SoenderborgConsumption0809.SERIENR.csv`. Permission to use the data should be obtained from both Project Manager, Poul Erik Pedersen, Elsparefonden (email: `pepe@elsparefonden.dk`) and from Managing Director, Steffen Moe, Sønderborg Fjernvarme (email: `moe@sonderborg-fjernvarme.dk`). Background information regarding the households can be obtained from Professor Henrik Madsen, DTU•Informatics (email: `hm@imm.dtu.dk`).

Specific questions related to the consumption data can be directed to:

Anders Bak, DFF-EDB, (email: `aba@dff-edb.dk`),

Finn Madsen, Sønderborg Fjernvarme (email: `fm@sonderborg-fjernvarme.dk`), or

Henrik Aalborg Nielsen, ENFOR A/S (email: `han@enfor.dk`).

Furthermore questions related to climate measurements can be addressed to Henrik Aalborg Nielsen, ENFOR A/S (email: `han@enfor.dk`) or Bjarne Højriis, BV-Electronic (email: `bh@bve.dk`).

A Plots of data

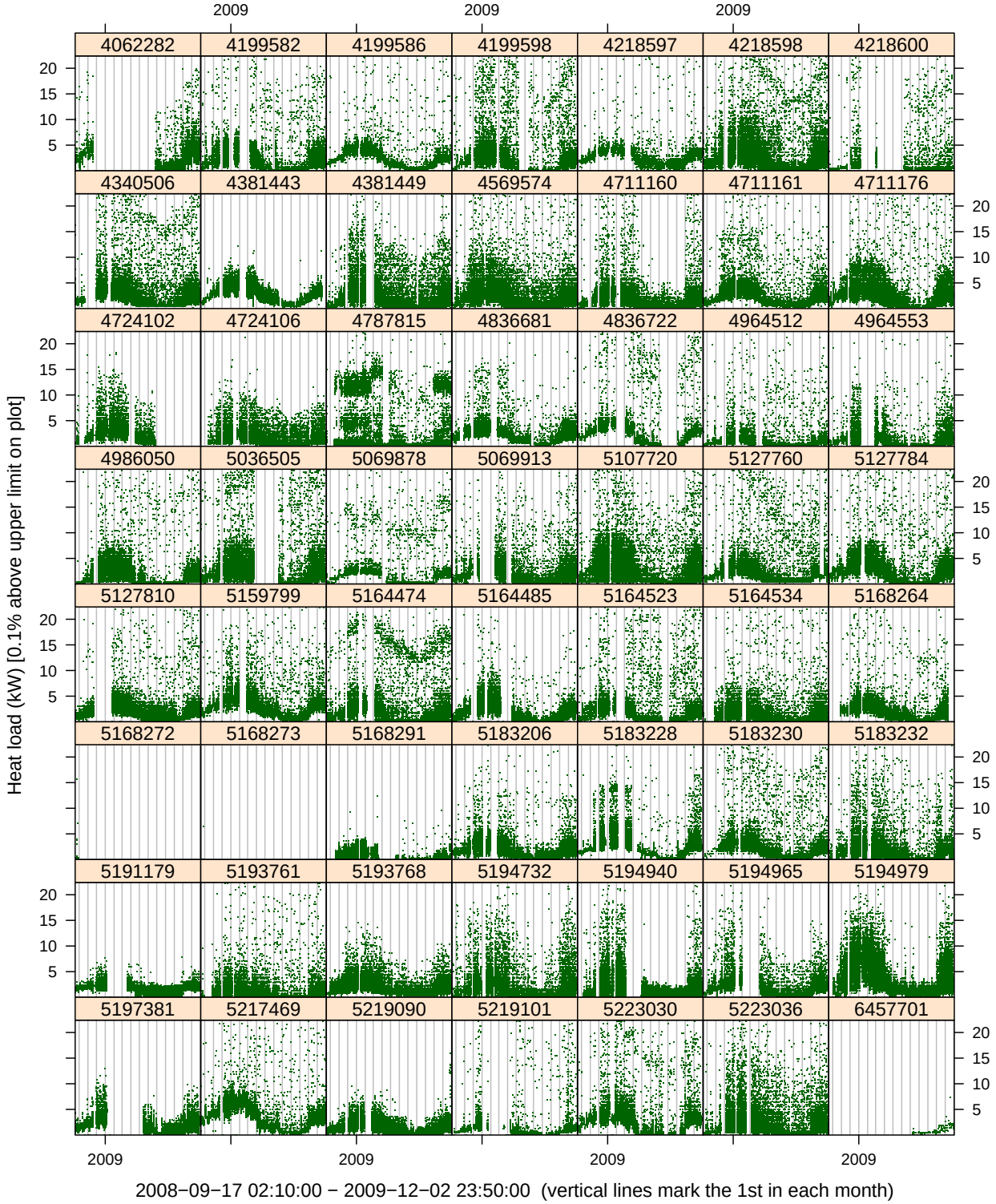

Figure 1: Heat load measurements (kW).

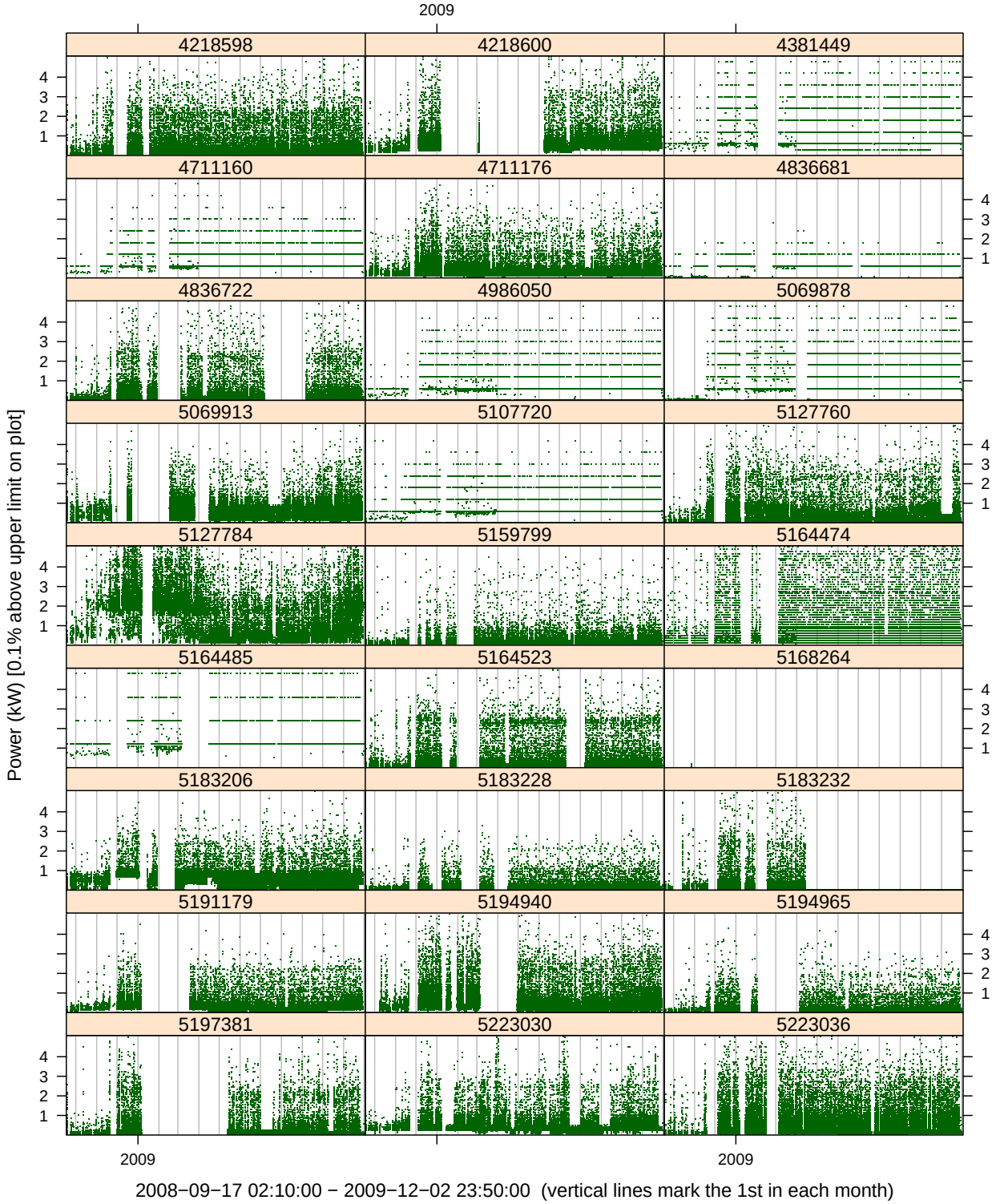

Figure 2: Power measurements (kW).

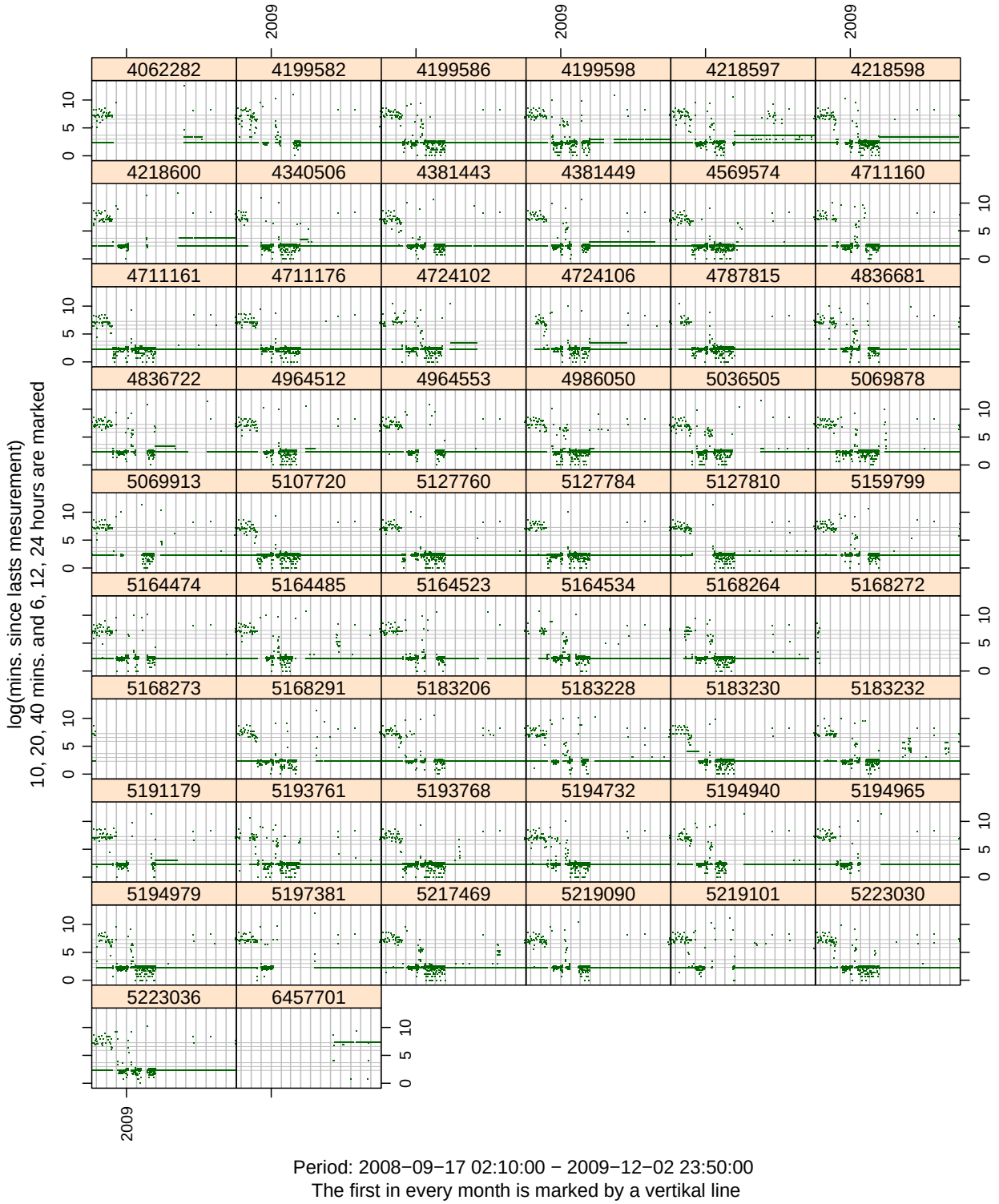

Figure 3: Time span between measurements.

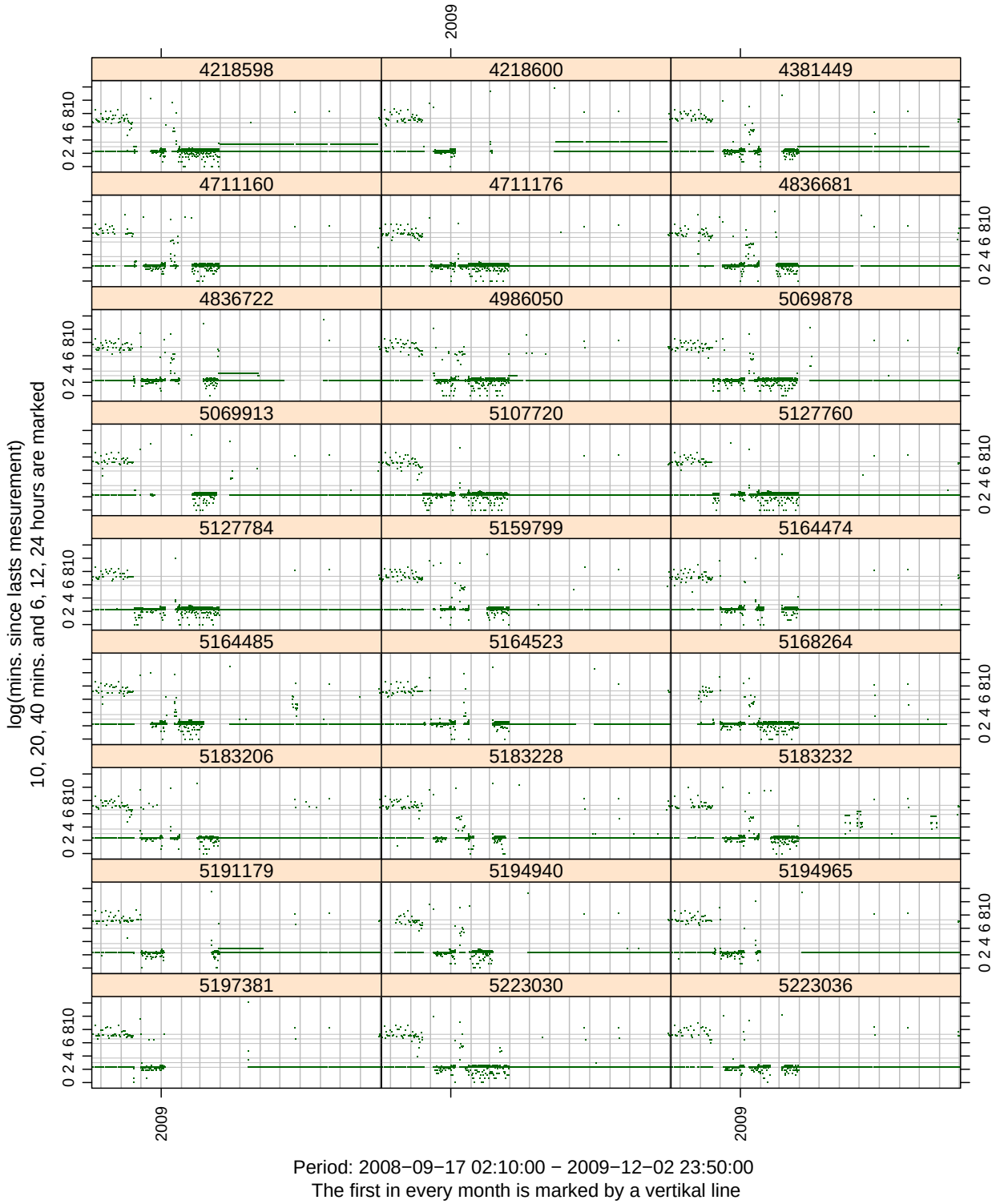

Figure 4: Time span between measurements of accumulated power consumption.

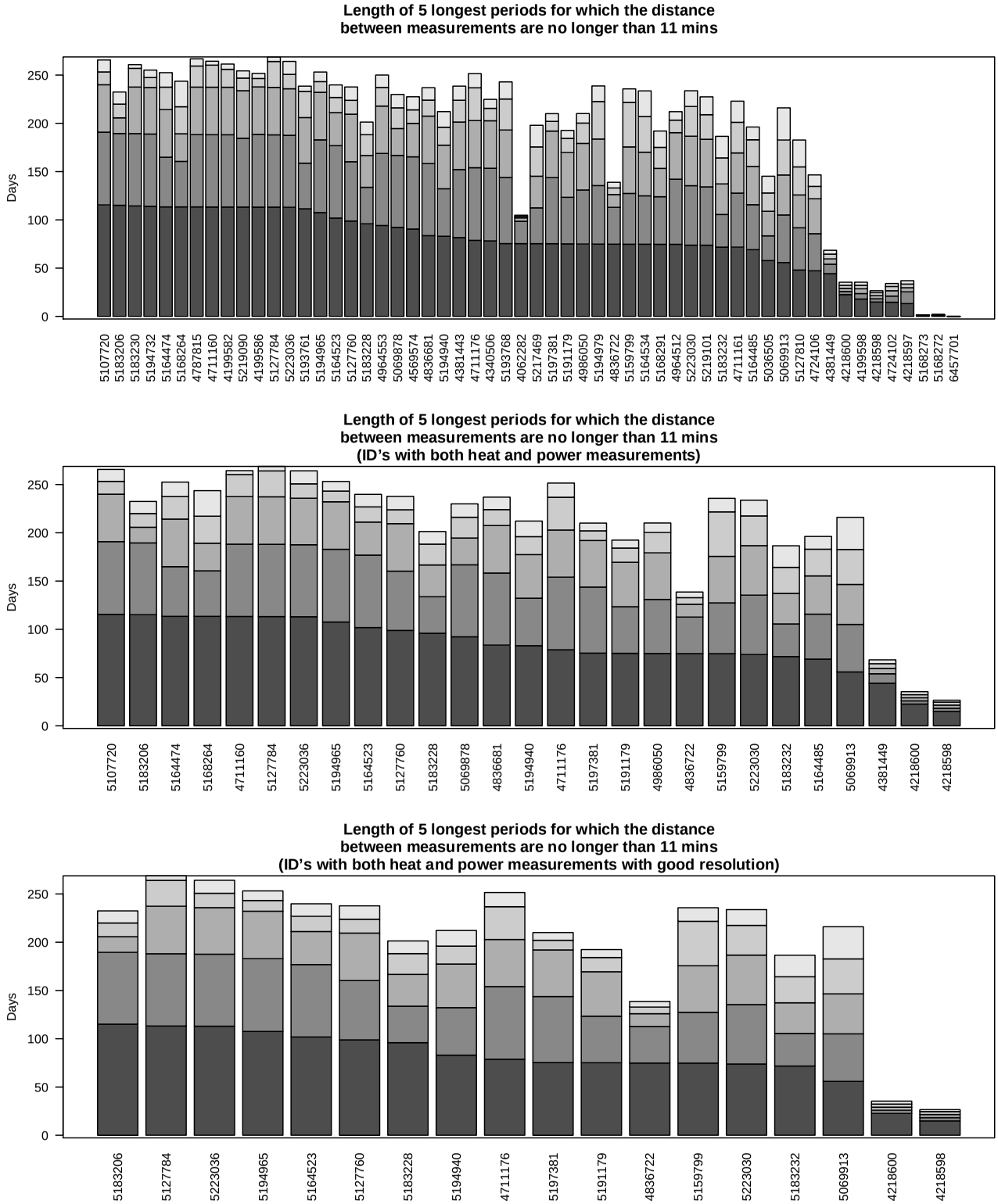

Figure 5: Length of periods where the maximum distance between measurements is 11 minutes.

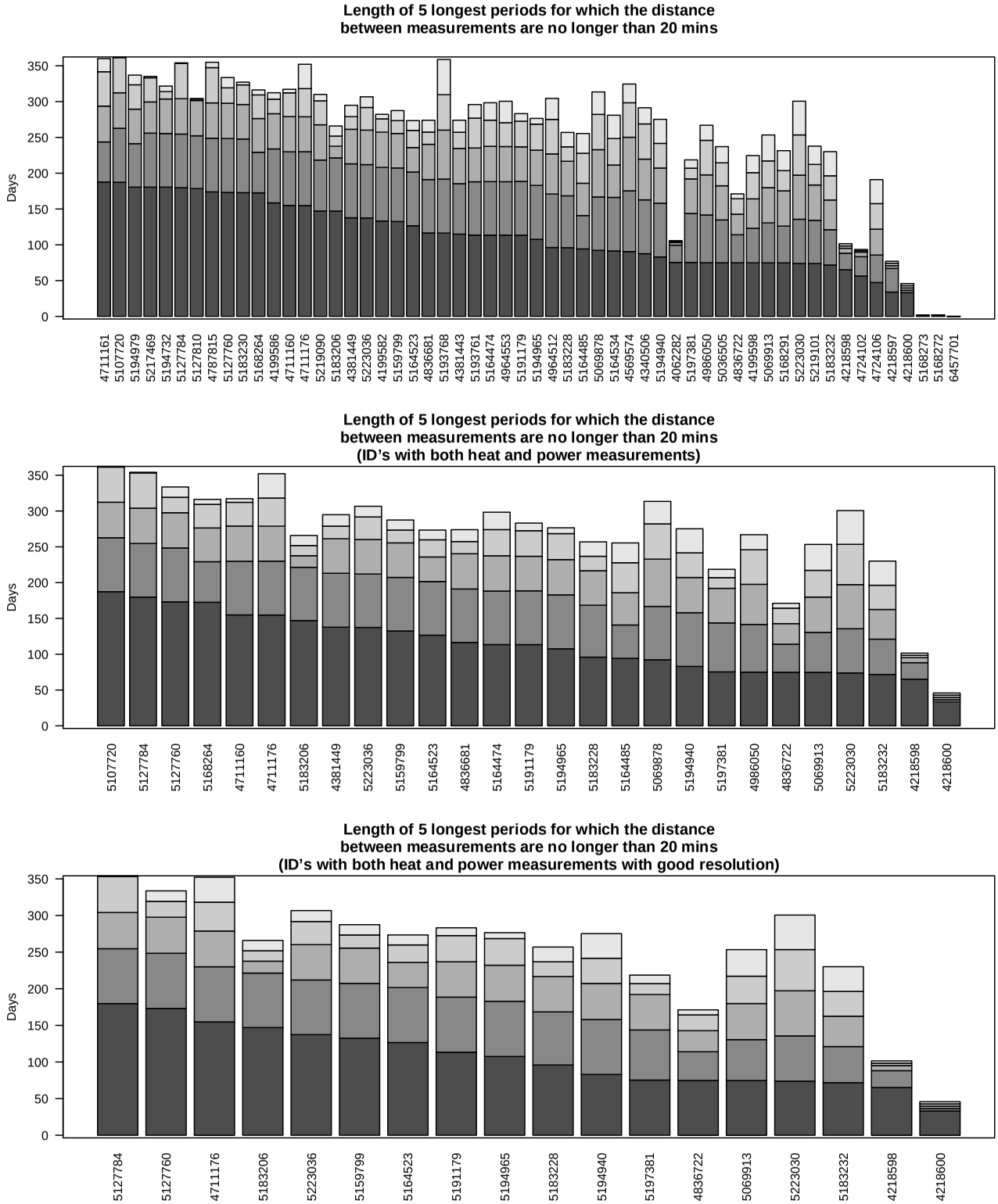

Figure 6: Length of periods where the maximum distance between measurements is 20 minutes.

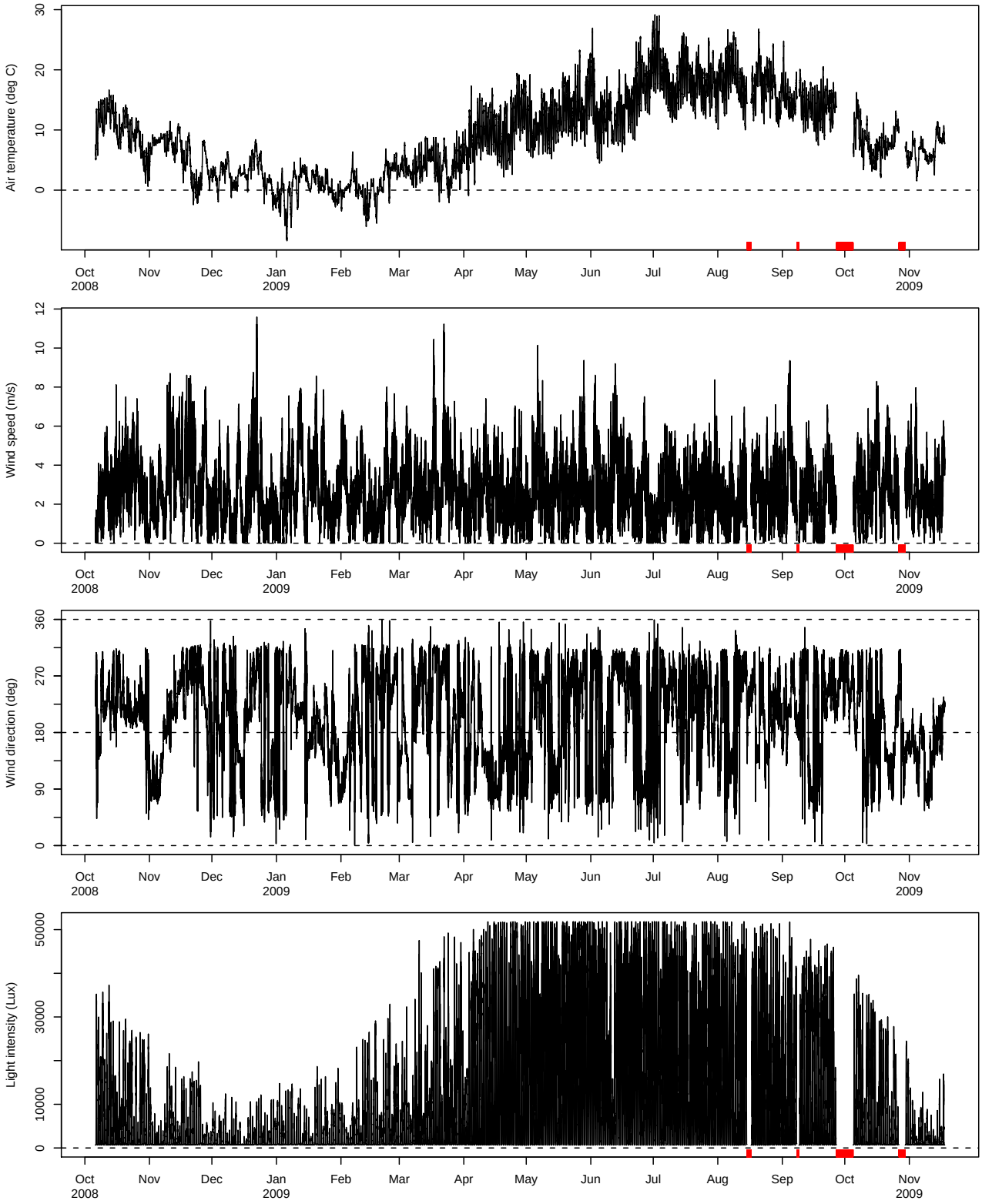

Figure 7: Climate data

B Data listings

B.1 10 largest measurements of EFFEKT

	1	2	3	4	5	6	7	8	9	10
4062282	36	27	20	20	20	20	19	19	19	19
4199582	600000	63	43	37	34	32	31	30	30	30
4199586	47	46	45	44	44	43	43	43	42	41
4199598	989	786	539	491	71	61	60	60	59	55
4218597	42	37	36	35	35	33	33	32	32	32
4218598	40	38	37	36	36	34	34	34	33	33
4218600	36	34	29	26	26	26	25	24	24	24
4340506	4398	48	47	46	38	34	32	30	30	30
4381443	692	638	590	12	11	11	11	10	9	9
4381449	48	39	39	36	36	36	36	36	35	35
4569574	302	44	43	40	38	38	38	38	37	36
4711160	28	27	27	26	26	26	26	26	26	26
4711161	2056	281	33	32	32	29	28	28	28	27
4711176	589	585	39	39	39	37	36	36	34	34
4724102	90003	544	23	18	18	18	18	15	15	15
4724106	35	32	21	17	16	15	15	14	13	13
4787815	1554	1554	1542	1538	1522	36	28	28	28	27
4836681	2385	2016	2014	2014	1712	1676	1675	1613	37	34
4836722	64	58	44	41	40	40	37	36	35	35
4964512	634	601	590	590	581	566	564	502	42	40
4964553	44	38	36	35	32	32	31	30	29	28
4986050	31	26	24	24	23	23	23	23	23	22
5036505	716	66	64	59	59	58	55	54	54	50
5069878	24	23	23	22	22	22	22	21	21	21
5069913	32	28	27	27	25	24	24	24	24	23
5107720	893	884	30	30	30	30	29	29	29	29
5127760	1260	1230	1228	1219	1086	409	40	40	40	39
5127784	2200	1998	1926	1888	996	42	35	34	34	34
5127810	43	43	43	41	40	39	39	38	37	36
5159799	495	450	424	422	33	32	29	29	28	27
5164474	1109	900	736	724	701	42	38	38	34	34
5164485	25	23	22	21	21	20	20	20	20	19
5164523	39	38	38	37	36	34	33	32	32	32
5164534	35	34	34	34	34	33	33	32	32	32
5168264	2448	448	36	27	26	26	25	24	24	23
5168272	700000	300000	16	7	4	4	3	1	0	0
5168273	6	6	0	0	0	0	0	0	0	0
5168291	400000	400000	12	10	9	8	8	7	7	7

5183206	7210	7115	6618	6593	6378	41	38	38	37	35
5183228	871	780	29	28	28	24	24	22	22	22
5183230	55	43	40	34	31	30	30	30	30	29
5183232	33	31	28	26	26	25	25	25	24	24
5191179	609	8	8	7	7	6	6	6	6	6
5193761	3212	37	37	33	31	31	30	30	30	28
5193768	1208	1203	1176	212	15	14	14	14	14	13
5194732	31	28	27	27	25	25	25	24	24	23
5194940	25	23	23	23	22	22	22	22	21	21
5194965	22	20	20	20	19	19	19	18	18	18
5194979	724	40	25	24	24	24	22	22	22	21
5197381	13	12	12	11	10	10	10	10	10	10
5217469	50	44	42	40	39	38	38	38	38	38
5219090	27	16	14	14	14	13	13	12	12	12
5219101	46	34	33	31	30	27	27	25	25	24
5223030	613	542	58	52	43	43	42	41	40	39
5223036	1042	1004	41	34	31	28	28	27	27	27
6457701	7	4	3	3	2	2	2	2	2	2

Table 1: 10 largest measurements of `EFFEKT` (kW) rounded to neareast integer for each ID.

B.2 10 largest values of `avgP2`

	1	2	3	4	5	6	7	8	9	10
5183228	10	3	3	3	3	3	3	3	3	3
4218598	16231	13863	16	16	6	6	6	6	6	5
4711160	2669	5	5	5	5	4	4	4	4	4
4218600	8544	35	11	8	7	7	7	7	7	7
5183232	20131	20131	20131	20131	20131	20131	20131	20131	20131	20131
5127784	17411	16	16	10	10	9	8	8	8	8
5069913	6	5	5	5	5	4	4	4	4	4
5223030	1309	13	13	13	13	13	13	13	13	13
5223036	26804	24674	191	7	6	6	6	6	6	6
4381449	1398	9	8	7	7	7	6	6	6	6
5191179	4174	122	4	4	4	4	4	4	4	4
5069878	14480	8804	5884	618	101	64	7	6	6	6
5107720	5728	2288	5	4	4	4	4	4	4	4
5127760	4888	134	106	13	12	12	12	11	6	6
4711176	2822	8	6	6	6	6	6	6	6	5
5194940	1485	30	16	16	8	7	7	7	7	6
5164474	4878	101	11	11	10	10	10	10	10	9
5197381	2593	141	11	5	5	5	5	5	5	5
5164523	3450	712	97	5	5	5	5	5	5	5
5183206	3962	6	5	5	5	5	4	4	4	4
5159799	528	12	5	4	4	4	4	4	4	4
5164485	49676	49669	49655	49638	49630	49625	49619	49613	49608	49603
4836681	7	3	2	2	2	2	2	2	2	2
4836722	3473	77	6	6	6	6	6	6	5	5
5194965	1469	49	4	4	4	4	4	4	4	4
4986050	123756	122034	120480	118860	59133	5663	172	35	6	6
5168264	82	16	10	0	0	0	0	0	0	0

Table 2: 10 largest values of `avgP2` (kW) rounded to neareast integer for each ID.

References

[1] ENFOR/03EKS0003A001-A. Validation of Data on Heat Load for Households Connected to Sønderborg District Heating System, 2008.

[2] ENFOR/03EKS0003A002-A. Validation of Data on Tap Water Consumption for Households in Sønderborg, 2008.