NZ GREEN Grid Household Power Demand Profiles: Heat Pump

Data extraction and preliminary plots

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Last run at: 2018-06-08 15:50:29

Contents

1 Status

Full run using all data from /Volumes/hum-csafe/Research Projects/GREEN Grid/_RAW DATA/GridSpyData/

2 Citation

If you wish to use any of the material from this report please cite as:

- Anderson, B. (2018) GREEN Grid Heat Pump Profiles, University of Otago: Dunedin, NZ.

3 Introduction

Report circulation:

- Restricted to: NZ GREEN Grid project partners and contractors.

3.1 Purpose

This report is intended to:

- load and clean the project electricity power data (Grid Spy)
- select the Heat Pump circuits (via their labels)
- build exploratory demand profiles

3.2 Requirements:

- cleaned and safe grid spy 1 minute data processed via https://git.soton.ac.uk/ba1e12/nzGREENGrid/blob/master/dataProcessing/processNZGGElecCons1minData.Rmd

3.3 History

Generally tracked via our git.soton repo:

- history
- issues

3.4 Support

This work was supported by:

- The University of Otago
- The New Zealand Ministry of Business, Innovation and Employment (MBIE)
- SPATIALEC - a Marie Skłodowska-Curie Global Fellowship based at the University of Otago's Centre for Sustainability (2017-2019) & the University of Southampton's Sustainable Energy Research Group (2019-202).

We do not 'support' the code but if you have a problem check the issues on our repo and if it doesn't already exist, open one. We might be able to fix it :-)

4 Load data files

4.1 Grid Spy metadata

In this section we load metadata from /Users/ben/Syncplicity Folders/Green Grid Project Management Folder/Gridspy/Master list of Gridspy units.xlsx to link to the power data.

sample	hhID	Adults	Teenagers	Children	removed	nAdults
Powerco	rf_06	2	NA	NA	NA	2
Powerco	rf_07	2	NA	2	NA	2

sample	hhID	Adults	Teenagers	Children	removed	nAdults
Powerco	rf_08	2	NA	NA	NA	2
Powerco	rf_09	2	NA	1	42171	2
Powerco	rf_10	2	NA	1(3yo)	NA	3
Powerco	rf_11	NA	NA	NA	NA	1

4.2 Grid Spy data

In this section we load the cleaned data files from /Volumes/hum-csafe/Research Projects/GREEN Grid/Clean_data/safe/gridSpy/1min/data/. If we loaded all the data at once and then filtered out what we want we might run out of memory so we filter as we load. Set the filters here:

```
circuitPattern <- params$circuitPattern
dateFrom <- params$dateFrom
dateTo <- params$dateTo

plotCaption <- paste0("Source: ", fpath,
                      "\nCircuits: ", circuitPattern, " from ", dateFrom, " to ", dateTo)
```

So we are looking for Heat Pump circuits between 2015-04-01 and 2016-03-31. We do this by checking to see if the extract file has already been created. If so we load it. If not, we create it.

The file we are looking for is: Heat Pump_2015-04-01_2016-03-31_observations.csv

```
## [1] "/Volumes/hum-csafe/Research Projects/GREEN Grid/Clean_data/safe/gridSpy/1min/dataExtracts/Heat
## [1] "# Loaded 14,252,439 rows of data"
```

The following table summarises the Heat Pump data we have found.

	hhID	r_dateTime	circuit	powerW	obsHourMin
	Length:14252439	Length:14252439	Length:14252439	Min. : -655.00	Length:14252439
	Class :character	Class :character	Class :character	1st Qu.: 0.00	Class :character
	Mode :character	Mode :character	Mode :character	Median : 0.00	Mode :character
	NA	NA	NA	Mean : 147.90	NA
	NA	NA	NA	3rd Qu.: 61.23	NA
	NA	NA	NA	Max. :27759.00	NA

This table will have a large number (14,252,439) of obserations caused by the number of different circuit labels as shown by the following table.

Var1	Freq
Bedroom & Lounge Heat Pumps$2741	526568
Downstairs (inc 1 Heat Pump)$2212	526929
Heat Pump (x2) & Lounge Power$4166	338289
Heat Pump & 2 x Bathroom Heat$4171	525108
Heat Pump & Bedroom 2$2731	152669
Heat Pump & Kitchen Appliances$4186	526780
Heat Pump & Lounge$2590	519185
Heat Pump & Misc$2107	102188
Heat Pump & Washing Machine$2750	505042
Heat Pump$2092	521843
Heat Pump$2148	520028

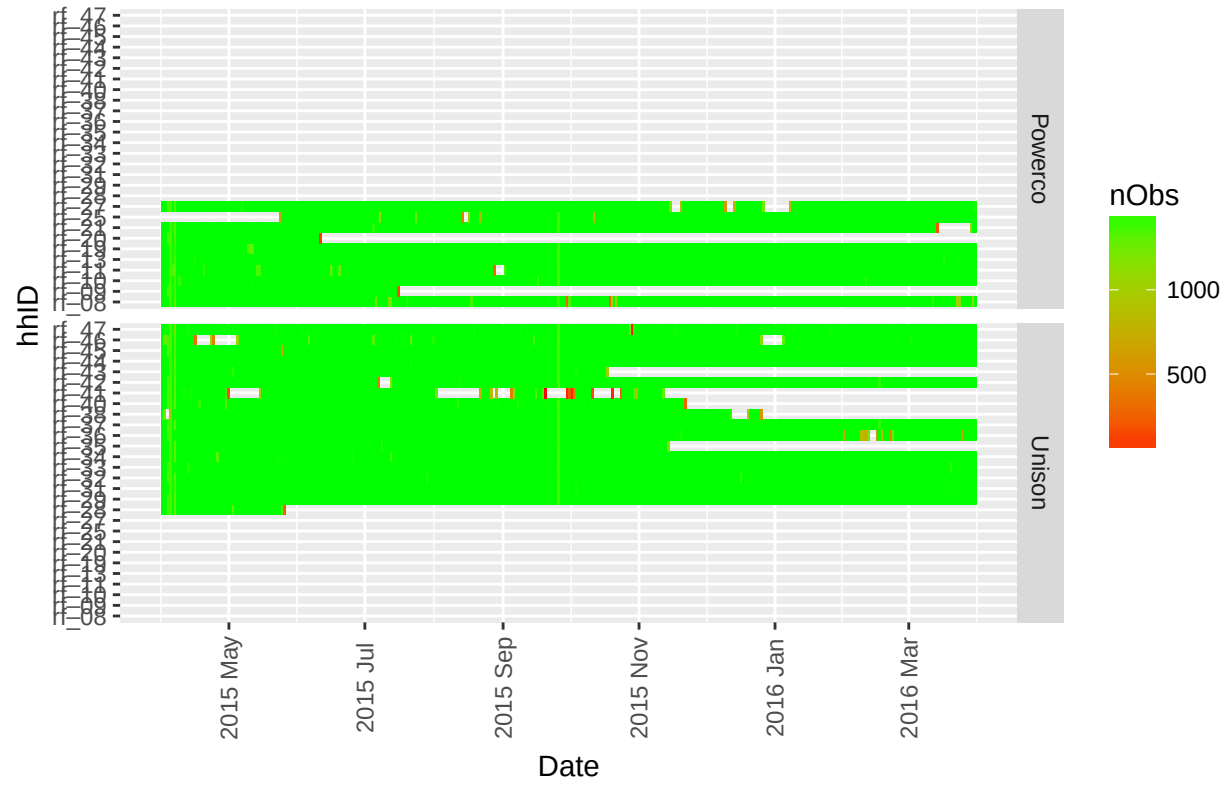
Var1	Freq
Heat Pump$2598	526797
Heat Pump$2758	443936
Heat Pump$2826	497806
Heat Pump$4124	327974
Heat Pump$4130	518179
Heat Pump$4134	526771
Heat Pump$4150	516242
Heat Pump$4154	526850
Heat Pump$4160	526110
Heat Pump$4175	373722
Heat Pump$4190	223824
Heat Pump$4196	526785
Heat Pump$4204	526878
Heat Pump$4211	288838
Heat Pump$4219	79085
Heat Pump$4223	526677
Heat Pumps (2x) & Power$4232	486982
Heat Pumps (2x) & Power$4399	463994
Kitchen Appliances & Heat Pump$4140	526863
Theatre Heat Pump$2740	526568
Upstairs Heat Pumps$2211	526929

Note that some households may have more than one Heat Pump circuit.

4.3 Test Heat Pump data

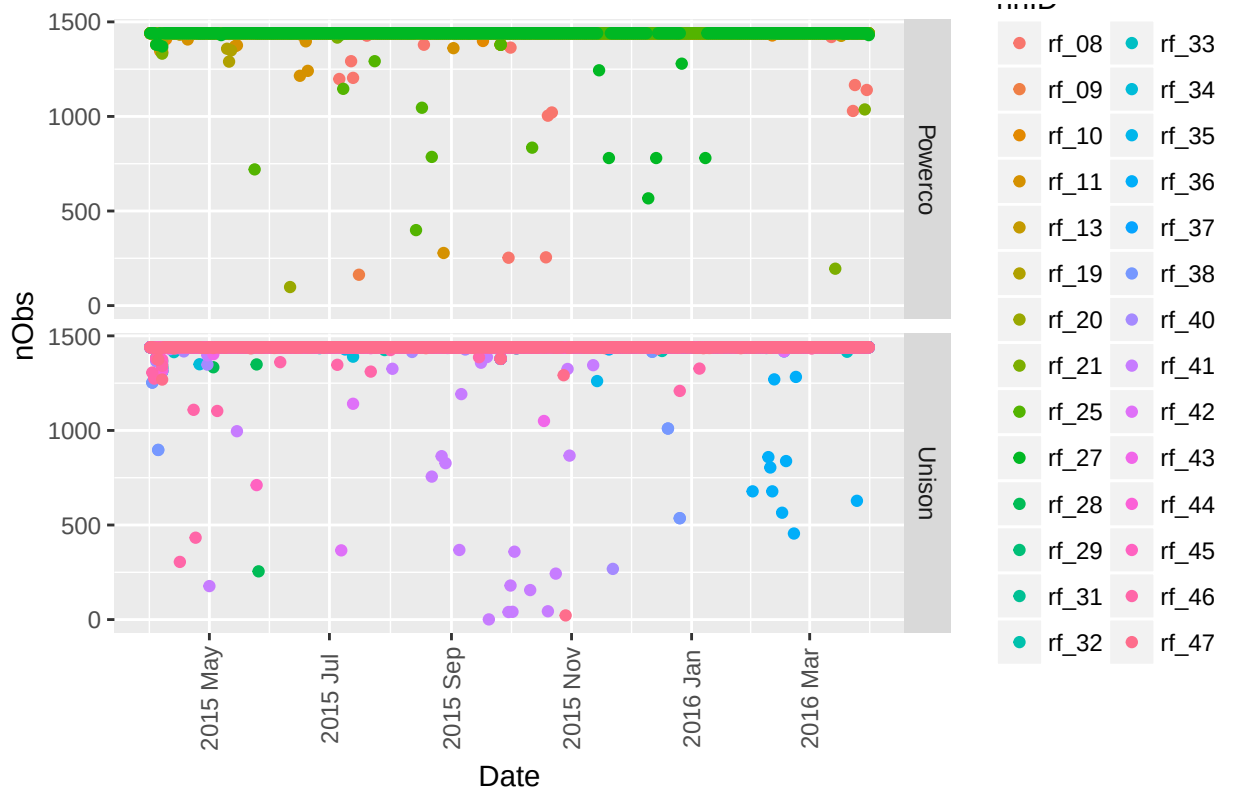
This section tests the availability of Heat Pump data by replicating the standard data quality checks used for the whole gridSpy dataset.

The following plot shows loaded data observation plots - just to confirm what Heat Pump data we have.



ɹrce: /Volumes/hum−csafe/Research Projects/GREEN Grid/_RAW DATA/GridSpyData/
Circuits: Heat Pump from 2015−04−01 to 2016−03−31

The next plot shows the same data but as a dot plot to highlight those households and dates where we did not receive 60 * 24 = 1440 observations per day.



umes/hum−csafe/Research Projects/GREEN Grid/_RAW DATA/GridSpyData/
Circuits: Heat Pump from 2015−04−01 to 2016−03−31

The following table shows the min/max observations per day and min/max dates for each household. As above, we should not see:

- dates before 2014 or in to the future (indicates date conversion errors)
- more than 1440 observations per day (indicates potentially duplicate observations)
- non-integer counts of circuits as it suggests some column errors

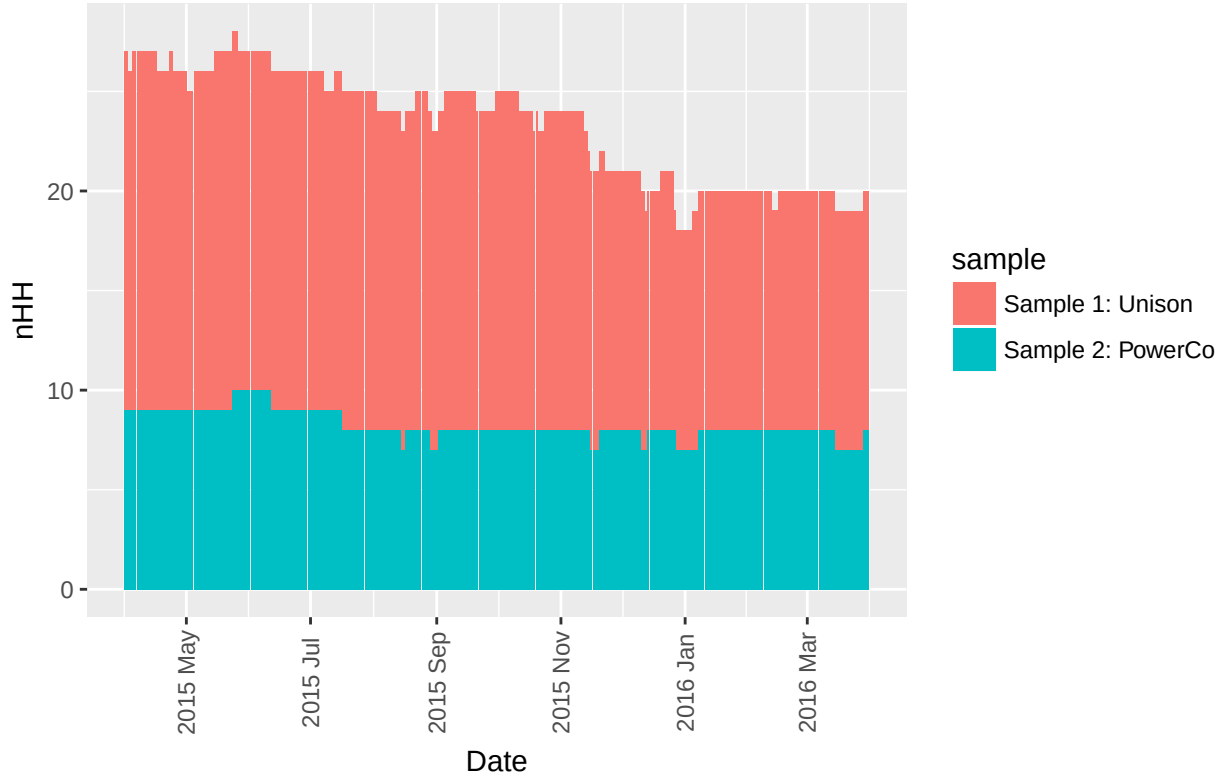
We should also not see NA in any row (indicates date conversion errors).

If we do see any of these then we still have data cleaning work to do!

hhID	sample	nObs	minDate	maxDate
rf_28	Unison	79085	2015-04-01T00:00:00Z	2015-05-26T04:56:00Z
rf_20	Powerco	102188	2015-04-01T00:00:00Z	2015-06-11T01:37:00Z
rf_09	Powerco	152669	2015-04-01T00:00:00Z	2015-07-16T02:42:00Z
rf_43	Unison	288838	2015-04-01T00:00:00Z	2015-10-18T17:29:00Z
rf_41	Unison	223824	2015-04-01T00:00:00Z	2015-11-12T22:24:00Z
rf_35	Unison	327974	2015-04-01T00:00:00Z	2015-11-14T21:00:00Z
rf_40	Unison	338289	2015-04-01T00:00:00Z	2015-11-22T04:27:00Z
rf_38	Unison	747444	2015-04-01T00:00:00Z	2015-12-26T08:55:00Z
rf_08	Powerco	521843	2015-04-01T00:00:00Z	2016-03-31T23:59:00Z
rf_10	Powerco	526797	2015-04-01T00:00:00Z	2016-03-31T23:59:00Z
rf_11	Powerco	519185	2015-04-01T00:00:00Z	2016-03-31T23:59:00Z
rf_13	Powerco	1053858	2015-04-01T00:00:00Z	2016-03-31T23:59:00Z
rf_19	Powerco	1053136	2015-04-01T00:00:00Z	2016-03-31T23:59:00Z
rf_21	Powerco	505042	2015-04-01T00:00:00Z	2016-03-31T23:59:00Z
rf_25	Powerco	443936	2015-05-24T12:00:00Z	2016-03-31T23:59:00Z
rf_27	Powerco	497806	2015-04-01T00:00:00Z	2016-03-31T23:59:00Z

hhID	sample	nObs	minDate	maxDate
rf_29	Unison	526780	2015-04-01T00:00:00Z	2016-03-31T23:59:00Z
rf_31	Unison	526878	2015-04-01T00:00:00Z	2016-03-31T23:59:00Z
rf_32	Unison	526785	2015-04-01T00:00:00Z	2016-03-31T23:59:00Z
rf_33	Unison	526863	2015-04-01T00:00:00Z	2016-03-31T23:59:00Z
rf_34	Unison	526677	2015-04-01T00:00:00Z	2016-03-31T23:59:00Z
rf_36	Unison	516242	2015-04-01T00:00:00Z	2016-03-31T23:59:00Z
rf_37	Unison	526771	2015-04-01T00:00:00Z	2016-03-31T23:59:00Z
rf_42	Unison	518179	2015-04-01T00:00:00Z	2016-03-31T23:59:00Z
rf_44	Unison	526850	2015-04-01T00:00:00Z	2016-03-31T23:59:00Z
rf_45	Unison	526110	2015-04-01T00:00:00Z	2016-03-31T23:59:00Z
rf_46	Unison	950976	2015-04-01T00:00:00Z	2016-03-31T23:59:00Z
rf_47	Unison	525108	2015-04-01T00:00:00Z	2016-03-31T23:59:00Z

Finally we show the total number of households which we think we have Heat Pump data for.



The following table summarises the Heat Pump data. Any surprises?

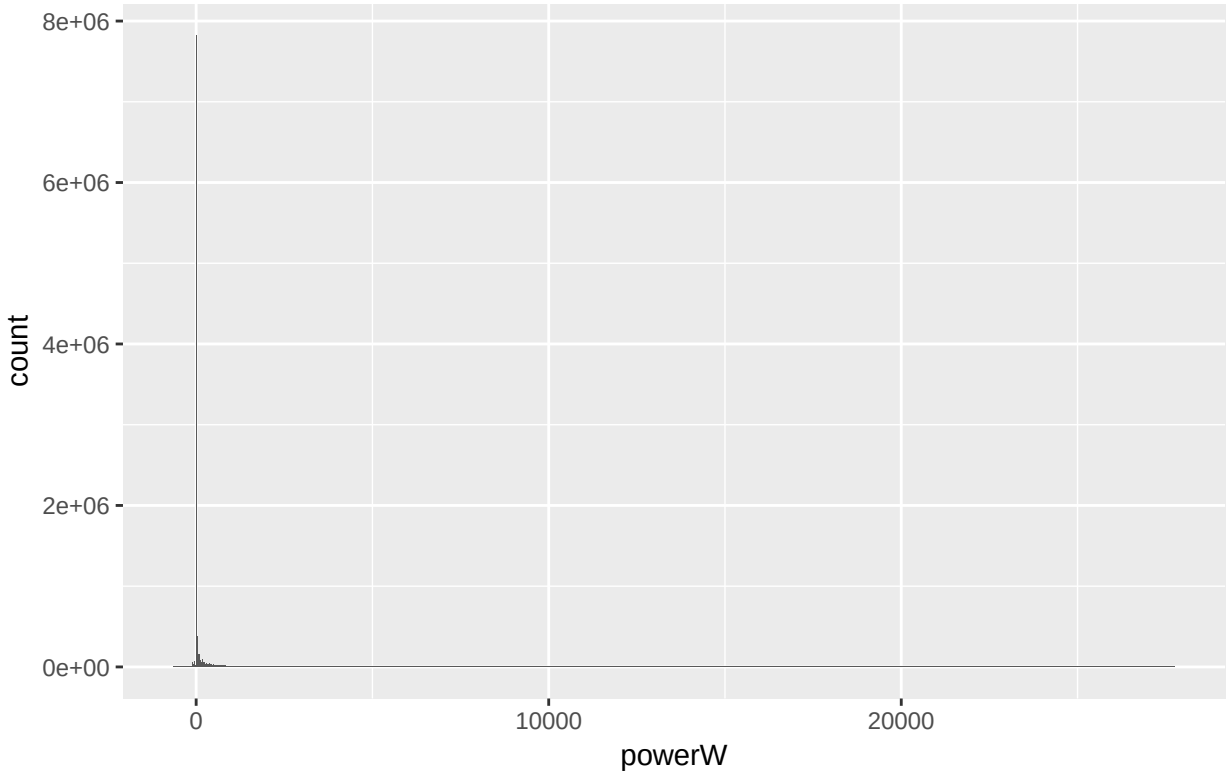
```
t <- summary(gs1MinDT)
knitr::kable(caption = paste0("Summary of ", circuitPattern, " circuits"), t)
```

	hhID	r_dateTime	circuit	powerW	obsHourMin
	Length:14252439	Length:14252439	Length:14252439	Min. : -655.00	Length:14252439
	Class :character	Class :character	Class :character	1st Qu.: 0.00	Class :character
	Mode :character	Mode :character	Mode :character	Median : 0.00	Mode :character
	NA	NA	NA	Mean : 147.90	NA

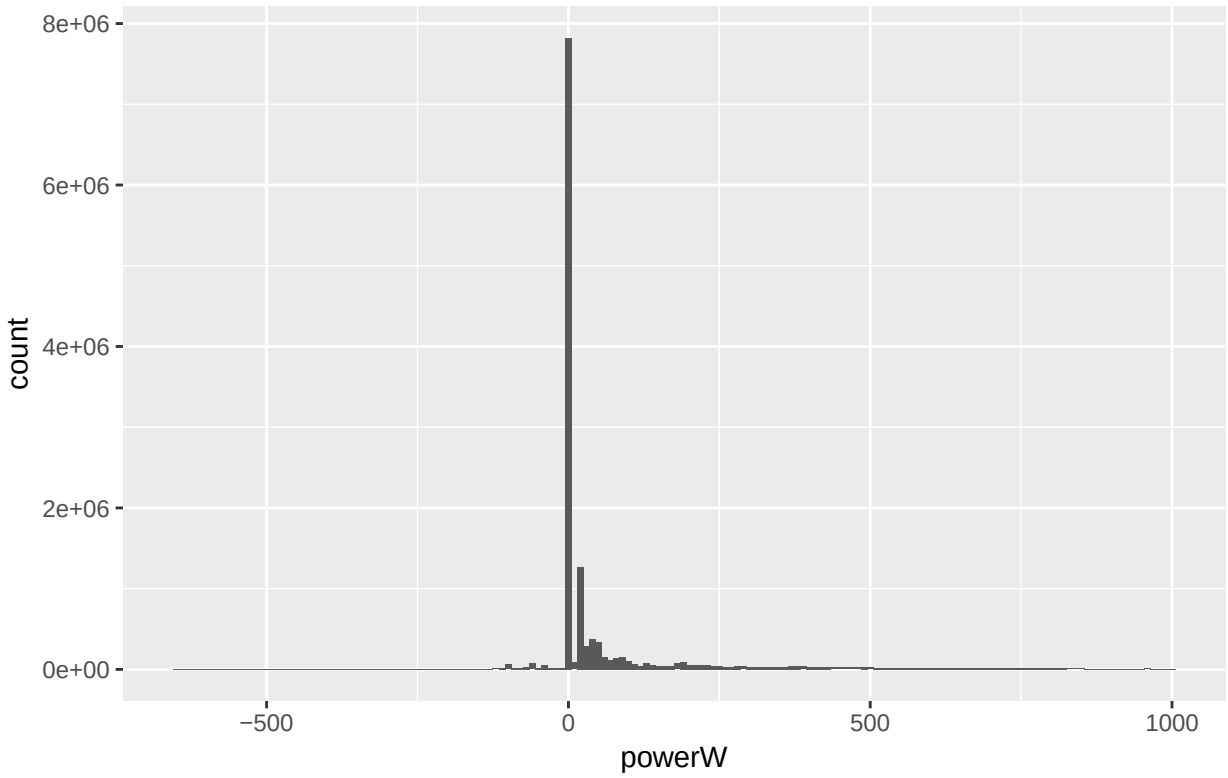
hhID	r_dateTime	circuit	powerW	obsHourMin
NA	NA	NA	3rd Qu.: 61.23	NA
NA	NA	NA	Max. :27759.00	NA

We seem to have some negative powerW values and at least one very large power value.

Nasty surprises often lurk in histograms... The following histogram shows all observations.



The next shows the histogram for powerW < 1000W...



There are a lot of zeros (as we'd expect) but why are there negative values?

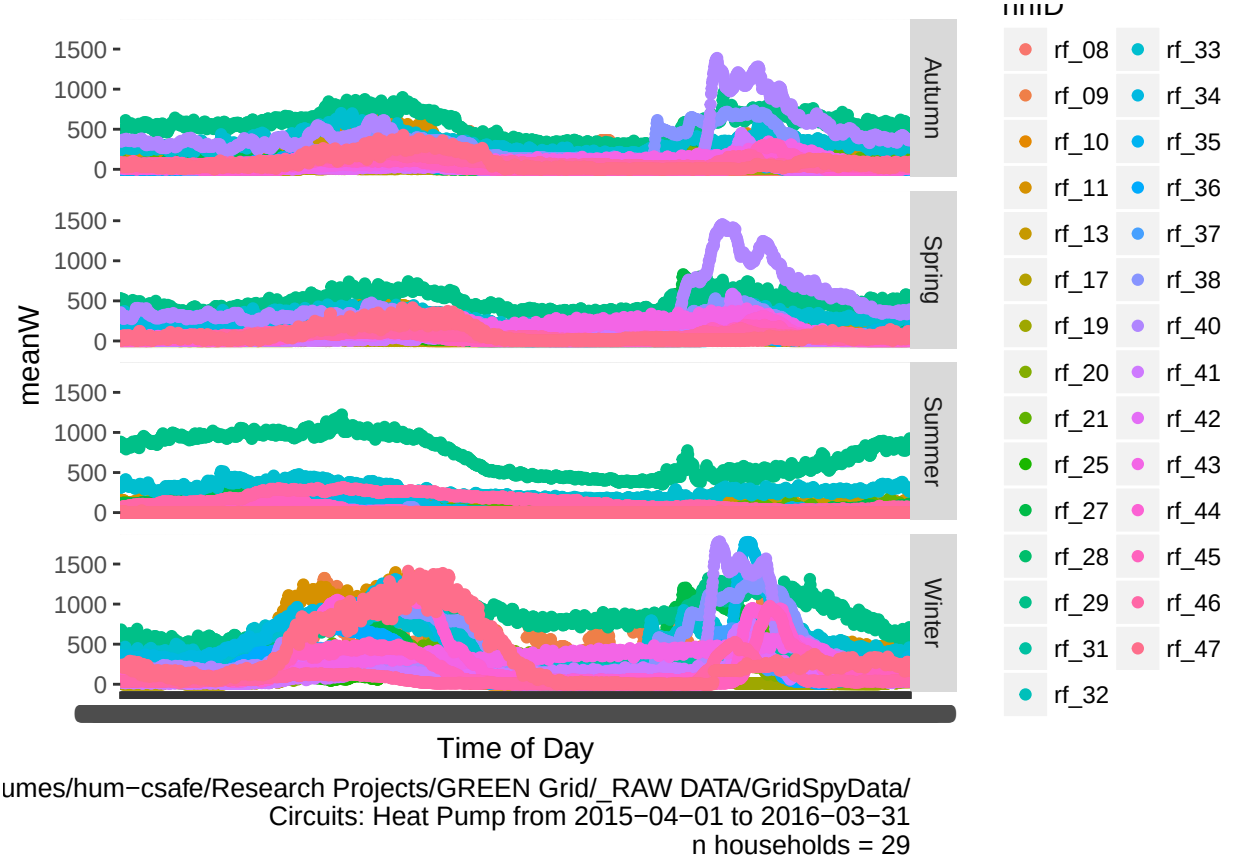
5 Heat Pump profiles

This section produces the profiles as one for each HH but averaged over each season. Data is kept at 1 minute intervals. Note definition of season below...

```
# add season
gs1MinDT <- gs1MinDT[, month := lubridate::month(r_dateTime, label = TRUE)]
gs1MinDT <- gs1MinDT[, season := "Summer"]
gs1MinDT <- gs1MinDT[, season := ifelse(month == "Mar" |
                                        month == "Apr" |
                                        month == "May", "Autumn", season)]
gs1MinDT <- gs1MinDT[, season := ifelse(month == "Jun" |
                                        month == "Jul" |
                                        month == "Aug", "Winter", season)]
gs1MinDT <- gs1MinDT[, season := ifelse(month == "Sep" |
                                        month == "Oct" |
                                        month == "Nov", "Spring", season)]
```

5.1 Profile plots: means per household

This section shows a plot of mean profiles for each household by season.




```
## [1] "Saving plot to /Volumes/hum-csafe/Research Projects/GREEN Grid/Clean_data/safe/gridSpy/1min/pro
```

```
## [1] "Saving profile data used to build this plot to: /Volumes/hum-csafe/Research Projects/GREEN Grid/
```

```
## [1] "Gzipped /Volumes/hum-csafe/Research Projects/GREEN Grid/Clean_data/safe/gridSpy/1min/profiles/H
```

hhID	obsHourMin	season	meanW
Length:151200	Length:151200	Length:151200	Min. : -2.422
Class :character	Class :character	Class :character	1st Qu.: 12.347
Mode :character	Mode :character	Mode :character	Median : 58.538
NA	NA	NA	Mean : 149.354
NA	NA	NA	3rd Qu.: 195.366
NA	NA	NA	Max. :1778.669

As we can see there is considerable variation between households in both the level and timing of heat pump demand.

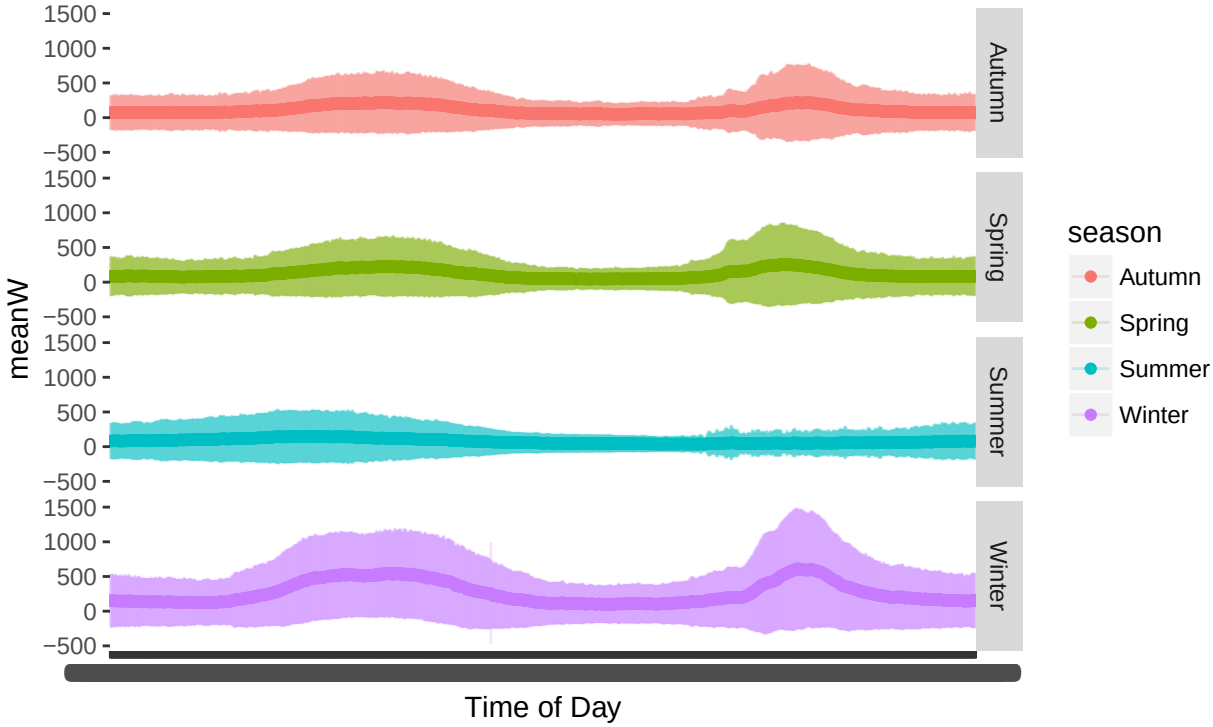
Note that the code saves a high definition version of the plot and the profiles for future re-use.

The .csv.gz file can be loaded using the following code:

- `df <- readr::read_csv("/Volumes/hum-csafe/Research Projects/GREEN Grid/Clean_data/safe/gridSpy/1mi Pump_2015-04-01_2016-03-31_byHouseholdSeasonalProfiles.csv.gz")` or
- `dt <- data.table::as.data.table(readr::read_csv("/Volumes/hum-csafe/Research Projects/GREEN Grid/Clean_data/safe/gridSpy/1min/profiles/Heat Pump_2015-04-01_2016-03-31_byHouseholdSeasonalProfi` if you prefer `data.table`

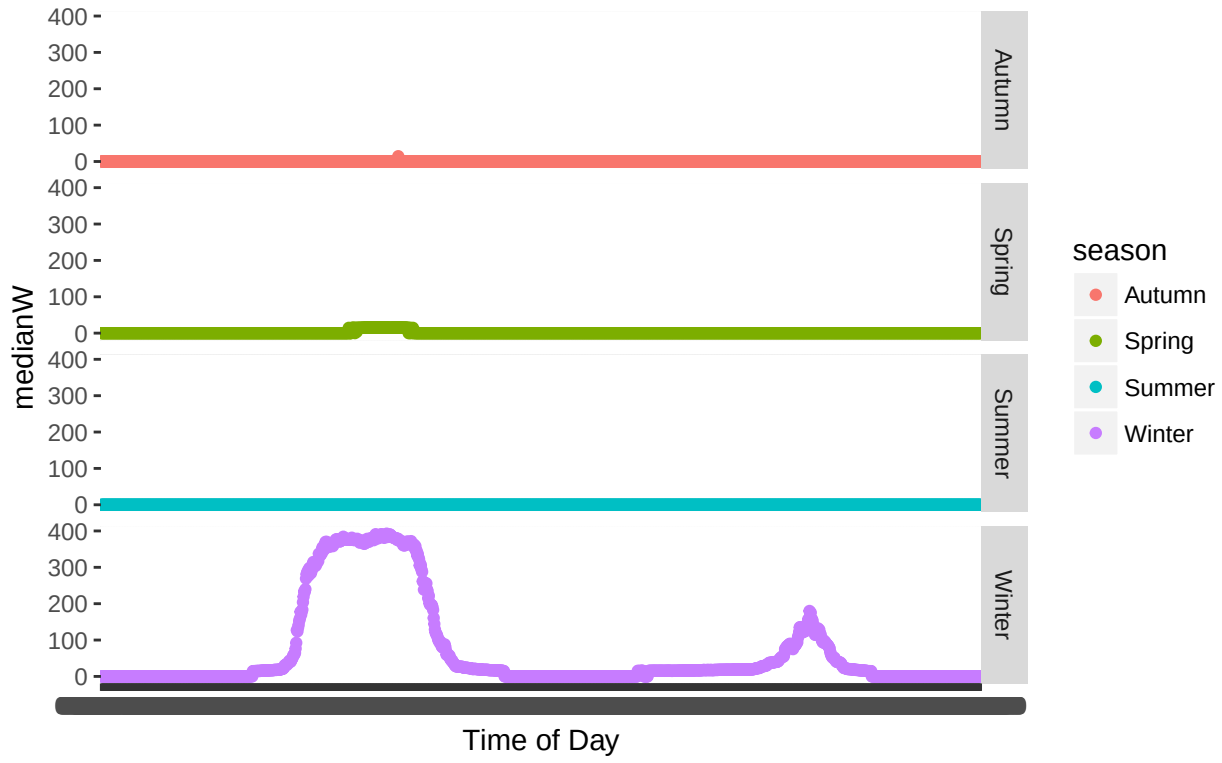
5.2 Profile plots: overall household mean

This section shows a plot of mean and median profiles across all household by season. The mean profile also shows the level of variance by plotting error bars at +/- 1 s.d.



e: /Volumes/hum−csafe/Research Projects/GREEN Grid/_RAW DATA/GridSpyData/
Circuits: Heat Pump from 2015−04−01 to 2016−03−31
n households = 29
Error bars = +/− 1 s.d.

```
## [1] "Saving plot to /Volumes/hum-csafe/Research Projects/GREEN Grid/Clean_data/safe/gridSpy/1min/pro
```



e: /Volumes/hum−csafe/Research Projects/GREEN Grid/_RAW DATA/GridSpyData/
Circuits: Heat Pump from 2015−04−01 to 2016−03−31
n households = 29

```
## [1] "Saving plot to /Volumes/hum-csafe/Research Projects/GREEN Grid/Clean_data/safe/gridSpy/1min/proc
## [1] "Saving profile data used to build this plot to: /Volumes/hum-csafe/Research Projects/GREEN Grid/
## [1] "Gzipped /Volumes/hum-csafe/Research Projects/GREEN Grid/Clean_data/safe/gridSpy/1min/profiles/He
```

	obsHourMin	season	meanW	medianW	nObs	sdW
	Length:5760	Length:5760	Min. : 34.99	Min. : 0.00	Min. :2150	Min. :101.0
	Class :character	Class :character	1st Qu.: 71.88	1st Qu.: 0.00	1st Qu.:2402	1st Qu.:234.3
	Mode :character	Mode :character	Median :104.76	Median : 0.00	Median :2518	Median :298.6
	NA	NA	Mean :143.52	Mean : 17.09	Mean :2474	Mean :329.8
	NA	NA	3rd Qu.:174.71	3rd Qu.: 0.00	3rd Qu.:2599	3rd Qu.:407.1
	NA	NA	Max. :613.89	Max. :392.55	Max. :2688	Max. :879.1

The difference between the mean and median plots is instructive - it suggests that the mean plots for summer are skewed by a few higher heat pump-using households.

The plots could be repeated or re-facted e.g. by household size.

As before, the code saves a high definition version of the plot and the profiles for future re-use.

6 Runtime

Analysis completed in 430.99 seconds (7.18 minutes) using knitr in RStudio with R version 3.5.0 (2018-04-23) running on x86_64-apple-darwin15.6.0.

7 R environment

R packages used:

- base R - for the basics (R Core Team 2016)
- data.table - for fast (big) data handling (Dowle et al. 2015)
- lubridate - date manipulation (Grolemund and Wickham 2011)
- ggplot2 - for slick graphics (Wickham 2009)
- readr - for csv reading/writing (Wickham, Hester, and Francois 2016)
- dplyr - for select and contains (Wickham and Francois 2016)
- progress - for progress bars (Csárdi and FitzJohn 2016)
- knitr - to create this document & neat tables (Xie 2016)
- nzGREENGrid - for local NZ GREEN Grid project utilities

Session info:

```
## R version 3.5.0 (2018-04-23)
## Platform: x86_64-apple-darwin15.6.0 (64-bit)
## Running under: macOS High Sierra 10.13.5
##
## Matrix products: default
## BLAS: /System/Library/Frameworks/Accelerate.framework/Versions/A/Frameworks/vecLib.framework/Versions
## LAPACK: /Library/Frameworks/R.framework/Versions/3.5/Resources/lib/libRlapack.dylib
##
## locale:
## [1] en_GB.UTF-8/en_GB.UTF-8/en_GB.UTF-8/C/en_GB.UTF-8/en_GB.UTF-8
##
## attached base packages:
## [1] stats     graphics  grDevices utils     datasets  methods   base
##
## other attached packages:
## [1] gdtools_0.1.7     rmarkdown_1.9     kableExtra_0.9.0  knitr_1.20
## [5] readr_1.1.1       ggplot2_2.2.1     dplyr_0.7.5       data.table_1.11.2
## [9] nzGREENGrid_0.1.0
##
## loaded via a namespace (and not attached):
##  [1] Rcpp_0.12.17        svglite_1.2.1       lubridate_1.7.4
##  [4] lattice_0.20-35     prettyunits_1.0.2   assertthat_0.2.0
##  [7] rprojroot_1.3-2     digest_0.6.15       R6_2.2.2
## [10] cellranger_1.1.0    plyr_1.8.4          backports_1.1.2
## [13] acepack_1.4.1       evaluate_0.10.1     httr_1.3.1
## [16] highr_0.6           pillar_1.2.2        rlang_0.2.0
## [19] progress_1.1.2      lazyeval_0.2.1      readxl_1.1.0
## [22] rstudioapi_0.7      rpart_4.1-13        Matrix_1.2-14
## [25] checkmate_1.8.5     labeling_0.3        splines_3.5.0
## [28] stringr_1.3.1       foreign_0.8-70      htmlwidgets_1.2
## [31] munsell_0.4.3       tinytex_0.5         compiler_3.5.0
## [34] pkgconfig_2.0.1     base64enc_0.1-3     htmltools_0.3.6
## [37] nnet_7.3-12         tidyselect_0.2.4    tibble_1.4.2
```

```
## [40] gridExtra_2.3       htmlTable_1.11.2    Hmisc_4.1-1
## [43] viridisLite_0.3.0   grid_3.5.0          gtable_0.2.0
## [46] magrittr_1.5        scales_0.5.0        stringi_1.2.2
## [49] reshape2_1.4.3      bindrcpp_0.2.2      latticeExtra_0.6-28
## [52] xml2_1.2.0          Formula_1.2-3       RColorBrewer_1.1-2
## [55] tools_3.5.0         glue_1.2.0          purrr_0.2.4
## [58] hms_0.4.2           survival_2.42-3     yaml_2.1.19
## [61] colorspace_1.3-2    cluster_2.0.7-1     rvest_0.3.2
## [64] bindr_0.1.1
```

References

Csárdi, Gábor, and Rich FitzJohn. 2016. *Progress: Terminal Progress Bars*. https://CRAN.R-project.org/package=progress.

Dowle, M, A Srinivasan, T Short, S Lianoglou with contributions from R Saporta, and E Antonyan. 2015. *Data.table: Extension of Data.frame*. https://CRAN.R-project.org/package=data.table.

Grolemund, Garrett, and Hadley Wickham. 2011. "Dates and Times Made Easy with lubridate." *Journal of Statistical Software* 40 (3): 1–25. http://www.jstatsoft.org/v40/i03/.

R Core Team. 2016. *R: A Language and Environment for Statistical Computing*. Vienna, Austria: R Foundation for Statistical Computing. https://www.R-project.org/.

Wickham, Hadley. 2009. *Ggplot2: Elegant Graphics for Data Analysis*. Springer-Verlag New York. http://ggplot2.org.

Wickham, Hadley, and Romain Francois. 2016. *Dplyr: A Grammar of Data Manipulation*. https://CRAN.R-project.org/package=dplyr.

Wickham, Hadley, Jim Hester, and Romain Francois. 2016. *Readr: Read Tabular Data*. https://CRAN.R-project.org/package=readr.

Xie, Yihui. 2016. *Knitr: A General-Purpose Package for Dynamic Report Generation in R*. https://CRAN.R-project.org/package=knitr.