NZ GREEN Grid Household Power Demand Profiles: Lighting

Data extraction and preliminary plots

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Last run at: 2018-06-08 16:13:12

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 Lighting 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: Lighting_2015-04-01_2016-03-31_observations.csv

```
## [1] "/Volumes/hum-csafe/Research Projects/GREEN Grid/Clean_data/safe/gridSpy/1min/dataExtracts/Light
## [1] "# Loaded 10,378,657 rows of data"
```

The following table summarises the Lighting data we have found.

	hhID	r_dateTime	circuit	powerW	obsHourMin
	Length:10378657	Length:10378657	Length:10378657	Min. :-133.8	Length:10378657
	Class :character	Class :character	Class :character	1st Qu.: 0.0	Class :character
	Mode :character	Mode :character	Mode :character	Median : 0.0	Mode :character
	NA	NA	NA	Mean : 111.5	NA
	NA	NA	NA	3rd Qu.: 102.5	NA
	NA	NA	NA	Max. :4087.4	NA

This table will have a large number (10,378,657) of obserations caused by the number of different circuit labels as shown by the following table.

Var1	Freq
Lighting (inc heat lamps)$4129	518179
Lighting & 2 Towel Rail$4245	495806
Lighting$2232	526097
Lighting$2244	523312
Lighting$4123	327974
Lighting$4133	526771
Lighting$4142	526863
Lighting$4149	516242
Lighting$4153	526850
Lighting$4159	526110
Lighting$4165	338289

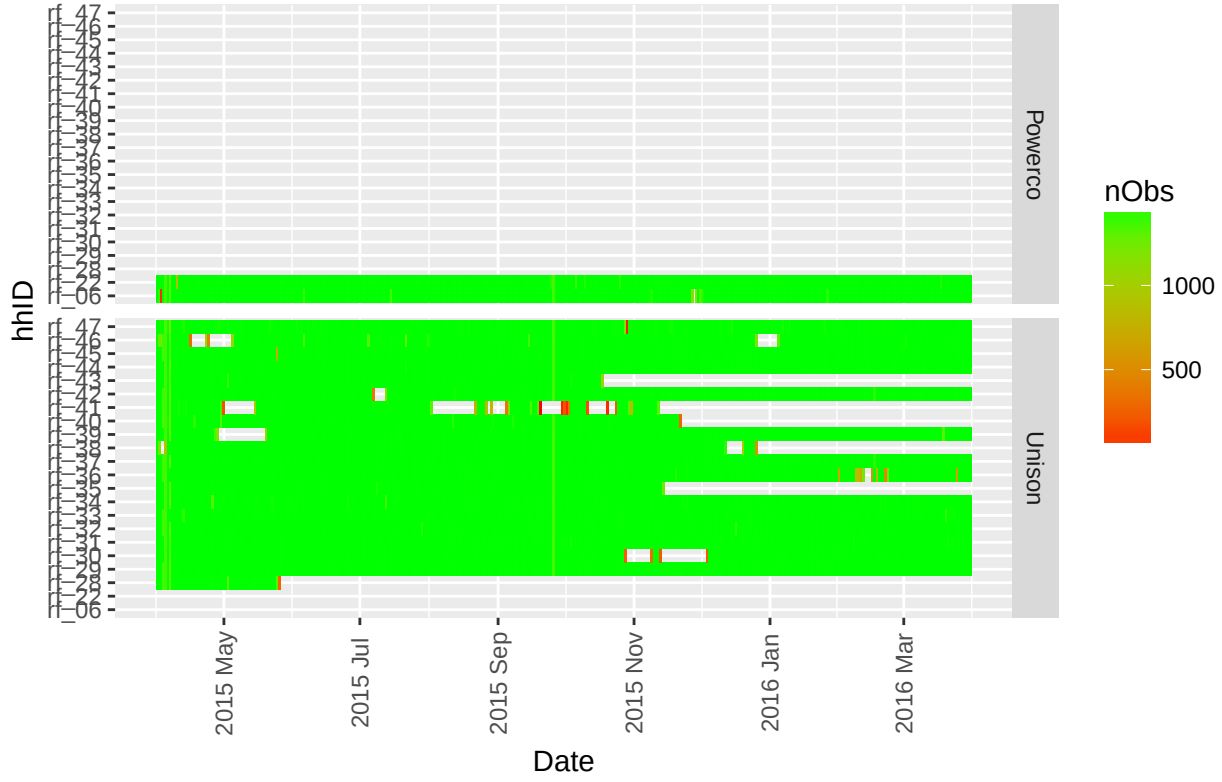
Var1	Freq
Lighting$4172	525108
Lighting$4176	373722
Lighting$4183	526780
Lighting$4189	223824
Lighting$4197	526785
Lighting$4203	526878
Lighting$4212	288838
Lighting$4218	79085
Lighting$4222	526677
Lighting$4233	486982
Lighting$4236	477491
Lighting$4404	463994

Note that some households may have more than one Lighting circuit.

4.3 Test Lighting data

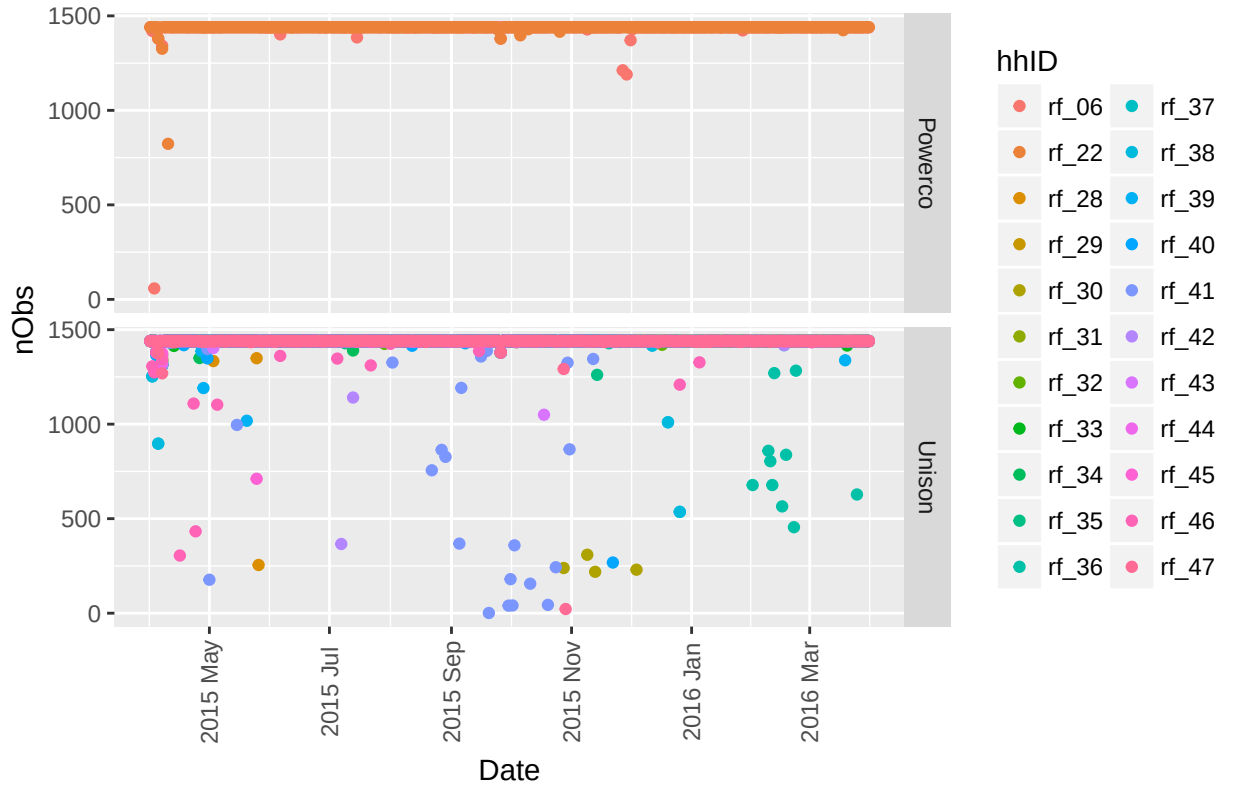
This section tests the availability of Lighting data by replicating the standard data quality checks used for the whole gridSpy dataset.

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



ırce: /Volumes/hum−csafe/Research Projects/GREEN Grid/_RAW DATA/GridSpyData/
Circuits: Lighting 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: Lighting 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

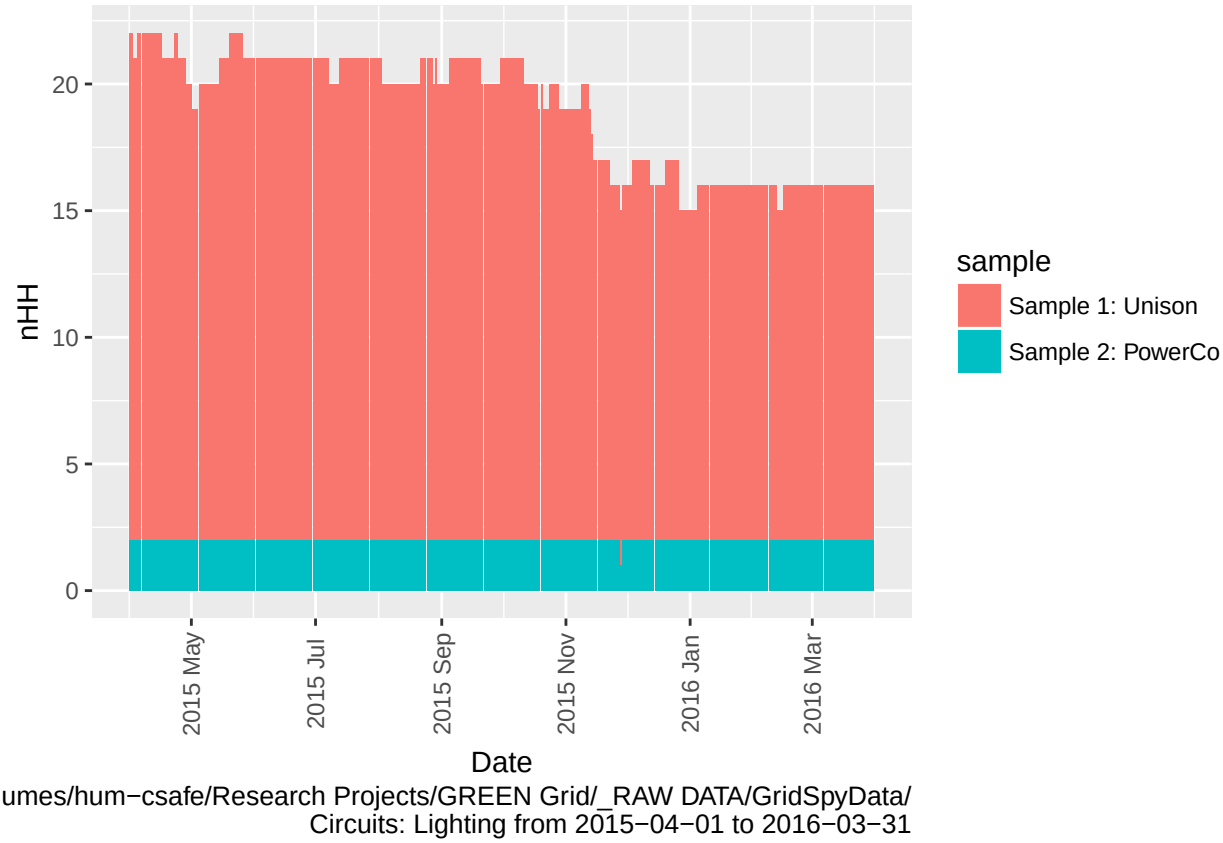
We should also not see NA in any row (indicates date conversion errors).

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_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_06	Powerco	523312	2015-04-01T00:00:00Z	2016-03-31T23:59:00Z
rf_22	Powerco	526097	2015-04-01T00:00:00Z	2016-03-31T23:59:00Z
rf_29	Unison	526780	2015-04-01T00:00:00Z	2016-03-31T23:59:00Z
rf_30	Unison	477491	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

hhID	sample	nObs	minDate	maxDate
rf_39	Unison	495806	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 Lighting data for.



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

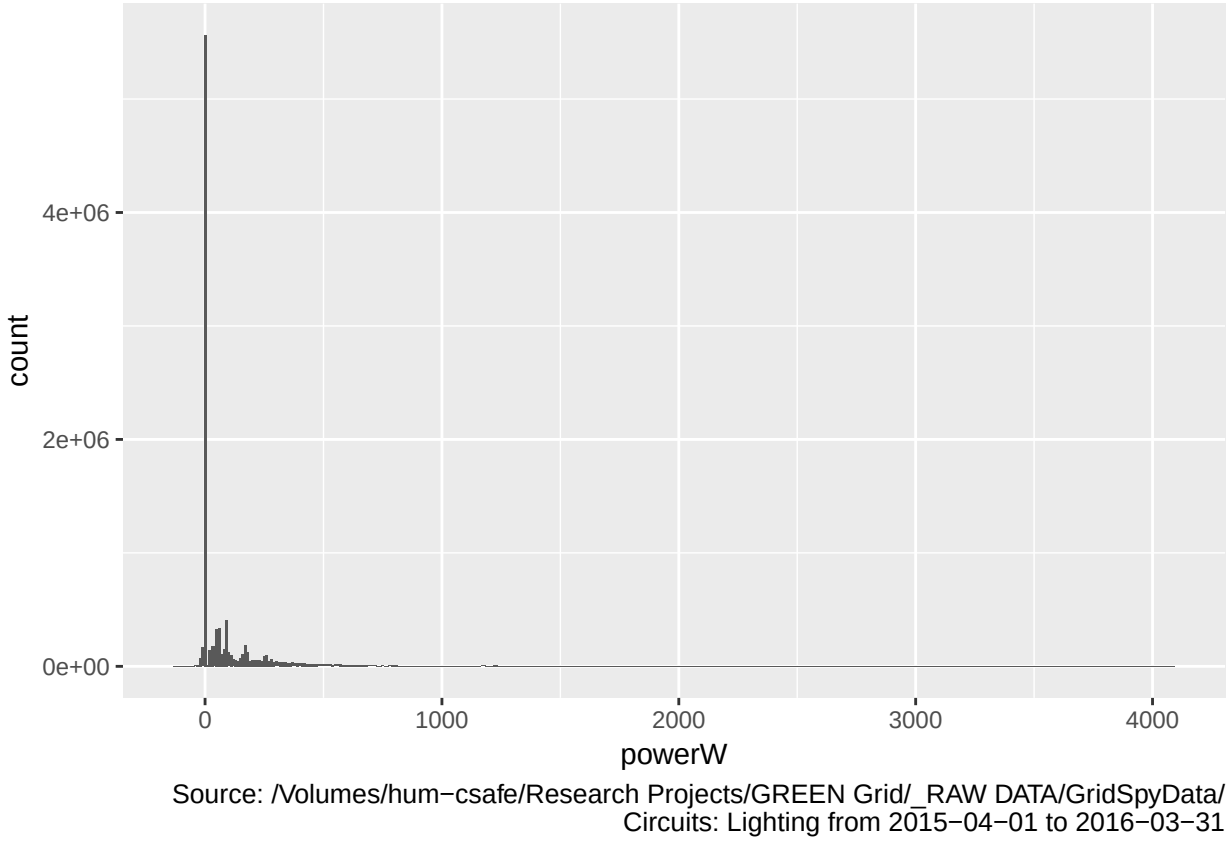
The following table summarises the Lighting data. Any surprises?

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

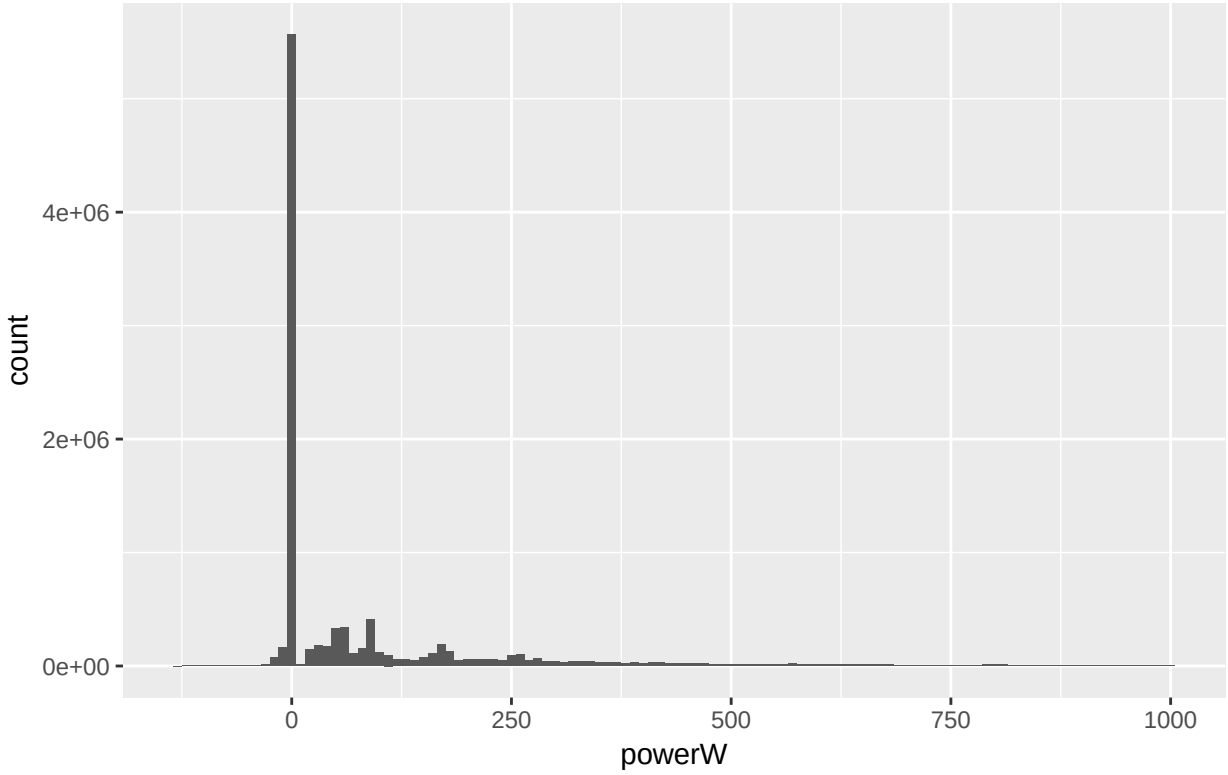
	hhID	r_dateTime	circuit	powerW	obsHourMin
	Length:10378657	Length:10378657	Length:10378657	Min. :-133.8	Length:10378657
	Class :character	Class :character	Class :character	1st Qu.: 0.0	Class :character
	Mode :character	Mode :character	Mode :character	Median : 0.0	Mode :character
	NA	NA	NA	Mean : 111.5	NA
	NA	NA	NA	3rd Qu.: 102.5	NA
	NA	NA	NA	Max. :4087.4	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?

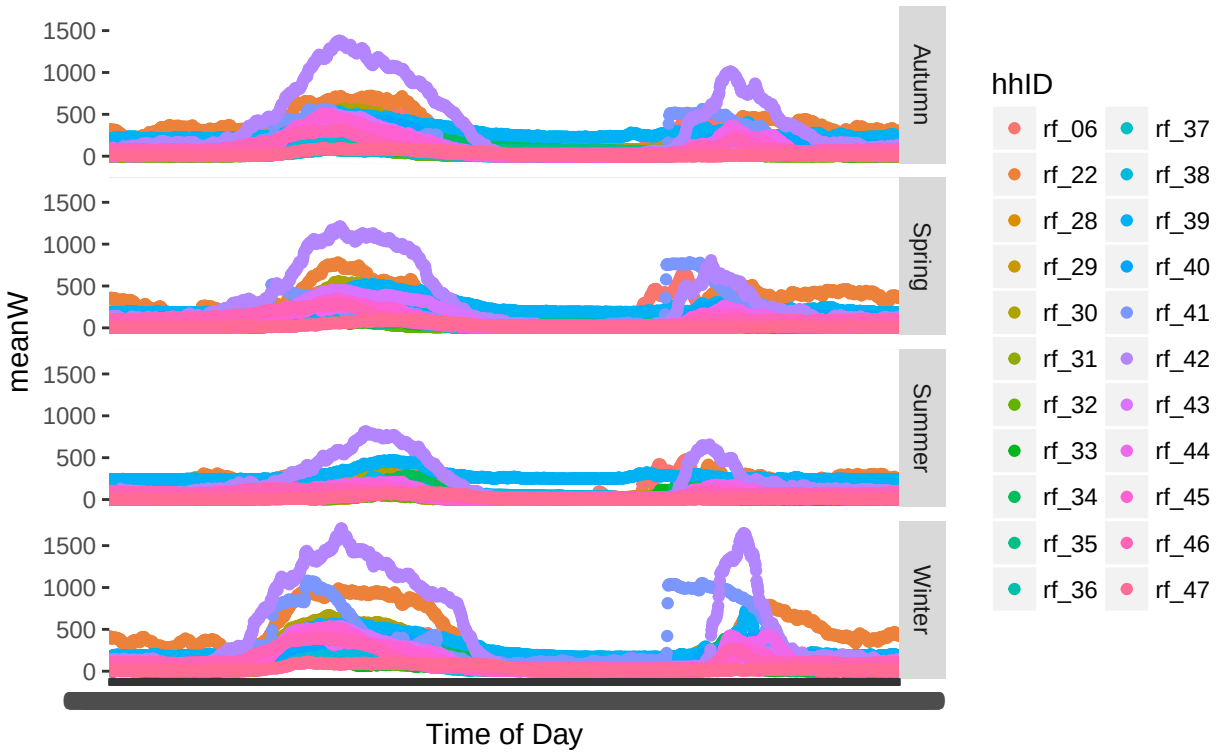
5 Lighting profiles

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.



umes/hum−csafe/Research Projects/GREEN Grid/_RAW DATA/GridSpyData/
Circuits: Lighting from 2015−04−01 to 2016−03−31
n households = 22

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

hhID	obsHourMin	season	meanW
Length:116640	Length:116640	Length:116640	Min. : 0.00
Class :character	Class :character	Class :character	1st Qu.: 10.87
Mode :character	Mode :character	Mode :character	Median : 46.08
NA	NA	NA	Mean : 112.24
NA	NA	NA	3rd Qu.: 140.39
NA	NA	NA	Max. :1705.55

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

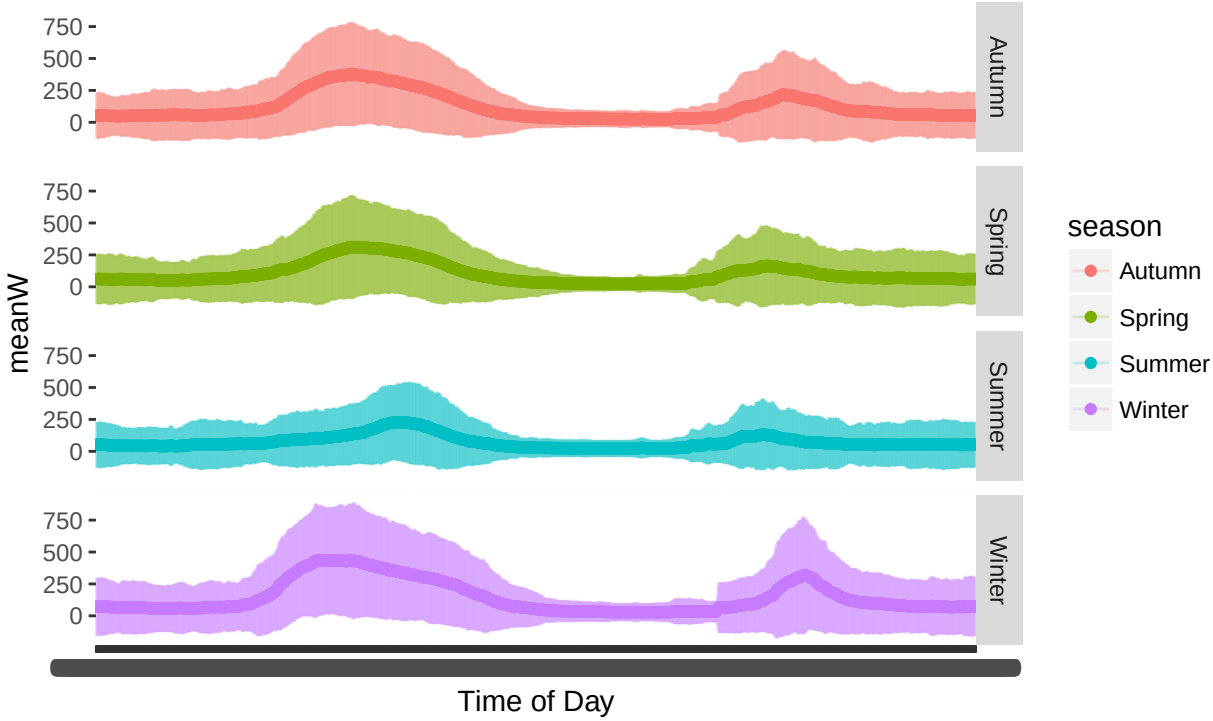
Note that the code saves a high definition version of the plot and the profiles for future re-use.

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`
  or
- `dt <- data.table::as.data.table(readr::read_csv("/Volumes/hum-csafe/Research Projects/GREEN Grid/Clean_data/safe/gridSpy/1min/profiles/Lighting_2015-04-01_2016-03-31_byHouseholdSeasonalProfil`
  if you prefer `data.table`

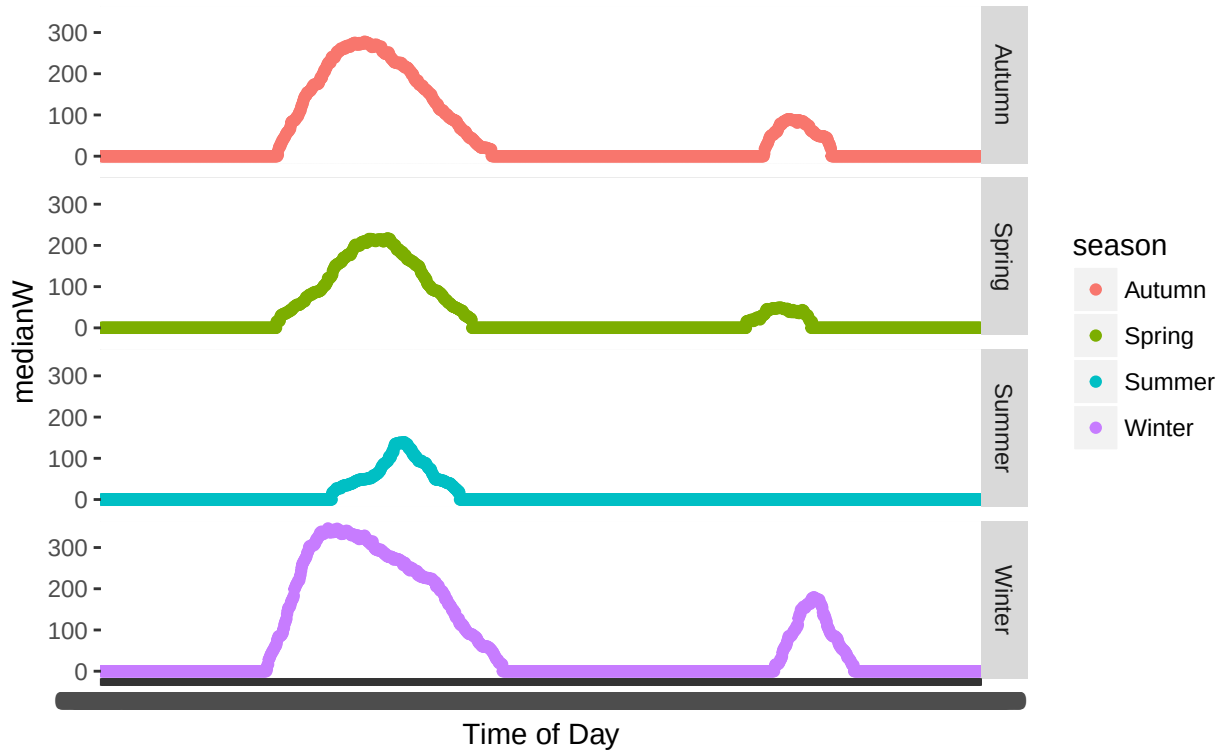
5.2 Profile plots: overall household mean

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: Lighting from 2015−04−01 to 2016−03−31
n households = 22
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: Lighting from 2015−04−01 to 2016−03−31
n households = 22

```
## [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/Li
```

obsHourMin	season	meanW	medianW	nObs	sdW
Length:5760	Length:5760	Min. : 21.72	Min. : 0.00	Min. :1525	Min. : 53.32
Class :character	Class :character	1st Qu.: 49.81	1st Qu.: 0.00	1st Qu.:1734	1st Qu.:147.01
Mode :character	Mode :character	Median : 67.50	Median : 0.00	Median :1836	Median :199.94
NA	NA	Mean :109.21	Mean : 37.48	Mean :1802	Mean :207.87
NA	NA	3rd Qu.:135.72	3rd Qu.: 32.30	3rd Qu.:1900	3rd Qu.:268.93
NA	NA	Max. :437.12	Max. :346.33	Max. :1996	Max. :460.51

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 332.64 seconds (5.54 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/.

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

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