NZ Electricity Generation Trends 1998-2017

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Contents

Citation

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

- Anderson, B. (2018) *NZ Electricity Generation Trends 1998-2017*, Centre for Sustainability, University of Otago: Dunedin.

About

Circulation

Report circulation:

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

Purpose

This report is intended to:

- load and test NZ electricity generation data from https://www.emi.ea.govt.nz/Wholesale/Datasets/Generation/Generation_MD/ from 1998 to 2017.

Requirements:

- pre-downloaded NZ wholesale generation datasets

History

Generally tracked via our git.soton repo:

- history
- issues

Specific history of this code:

- https://git.soton.ac.uk/ba1e12/nzGREENGrid/commits/master/analysis/generation/nzGenerationHistory.Rmd

Support

This work was supported by:

- The University of Otago;
- The University of Southampton;
- The New Zealand Ministry of Business, Innovation and Employment (MBIE) through the NZ GREEN Grid project;
- 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 :-)

Introduction

Inspired by Steffel (2018) which analyses trends in the type and timing of generation in the UK over the same time period. Intended to build on Kahn et al's 2018 CO2 intensity of peak demand paper - how have thngs changed over time?

Uses https://www.emi.ea.govt.nz/Wholesale/Datasets/Generation/Generation_MD/ from 1998 to 2017.

Data is kWh - so energy not power.

Load data

Load the generation data from files stored in:

- /Volumes/hum-csafe/Research Projects/GREEN Grid/_RAW DATA/EA_Generation_Data/

These have been pre-downloaded and cleaned but could be pulled on the fly to be refreshed for other dates...

```
## Warning in `[.data.table`(filesToDateDT, , `:=`(c("year", "month",
## "stub"), : Supplied 3 columns to be assigned a list (length 5) of values (2
## unused)
```

```
## [1] "Files loaded"
```

```
## [1] "Loaded 352,250 rows of data"
```

The following table sumamrises the data.

Site_Code	POC_Code	Unit_Code	Gen_Code	Fuel_Code	Tech_Code	Trading_Date	Trading_Period	kWh	Time_Zone	rTime	rDate	rDateTime	month	year
Length:352250	Length:352250	Length:352250	Length:352250	Length:352250	Length:352250	Min. :1998-06-01	Min. : 1.000	Min. : 0	Length:352250	Length:352250	Min. :1998-06-01	Min. :1998-06-01 00:15:00	Min. : 6.000	Min. :1998
Class :character	Class :character	Class :character	Class :character	Class :character	Class :character	1st Qu.:1998-12-10	Class :character	1st Qu.: 6563	Class :character	1st Qu.:1998-12-10	1st Qu.:1998-12-10 09:15:00	1st Qu.: 6.000	1st Qu.:1998	
Mode :character	Mode :character	Mode :character	Mode :character	Mode :character	Mode :character	Median :2017-06-11	Median :20	Mode :character	Median :19715	Class2:difftime	Median :2017-06-11	Median :2017-06-11 15:45:00	Median :12.000	Median :2017
NA	NA	NA	NA	NA	NA	Mean :2010-03-23	Mean :26	NA	Mean : 37186	Mode :numeric	Mean :2010-03-23	Mean :2010-03-23 19:23:45	Mean : 9.087	Mean :2010
NA	NA	NA	NA	NA	NA	3rd Qu.:2017-12-06	3rd Qu.:38	NA	3rd Qu.: 48640	NA	3rd Qu.:2017-12-06	3rd Qu.:2017-12-06 19:15:00	3rd Qu.:12.000	3rd Qu.:2017
NA	NA	NA	NA	NA	NA	Max. :2017-12-31	Max. :50	NA	Max. :493020	NA	Max. :2017-12-31	Max. :2017-12-31 23:45:00	Max. :12.000	Max. :2017
NA	NA	NA	NA	NA	NA	NA	NA	NA's :14090	NA	NA	NA	NA's :14090	NA	NA

Notice that there are missing (NA) values in the kWh column. These are caused by periods 49 and 50 being missing:

> "The data is presented by trading period, TP1, TP2, ... TP48. Trading period 1 starts at midnight, trading period 2 starts at 12:30am, trading period 3 starts at 1:00am, etc. Users

of this data should be aware of daylight saving in New Zealand. On the day daylight saving commences there are only 46 trading periods and on the day it ends, there are 50." (https://www.emi.ea.govt.nz/Wholesale/Datasets/Generation/Generation_MD/)

Daylight saving begins/ends in October and March so we carefully avoid this problem by using June and December. However these TP are still present as NA in the data as the following table and plot of NA observations (only) by Fuel Type and month show.

Time_Period	mean
TP1	32193.95
TP10	28197.44
TP11	29102.29
TP12	30355.92
TP13	32589.18
TP14	35307.47
TP15	38153.58
TP16	40611.99
TP17	41846.03
TP18	42344.12
TP19	42572.59
TP2	31058.35
TP20	42364.31
TP21	41953.33
TP22	41580.21
TP23	41157.60
TP24	40811.56
TP25	40331.06
TP26	39886.99
TP27	39653.17
TP28	39227.72
TP29	38878.22
TP3	30111.71
TP30	38668.61
TP31	38707.44
TP32	39144.56
TP33	39847.08
TP34	41145.00
TP35	42903.35
TP36	44126.06
TP37	43686.30
TP38	43162.35
TP39	42323.73
TP4	29313.75
TP40	41477.26
TP41	40763.28
TP42	40360.00
TP43	39752.14
TP44	38615.70
TP45	36913.02
TP46	35083.01
TP47	34647.09
TP48	33234.67
TP49	NA
TP5	28734.70

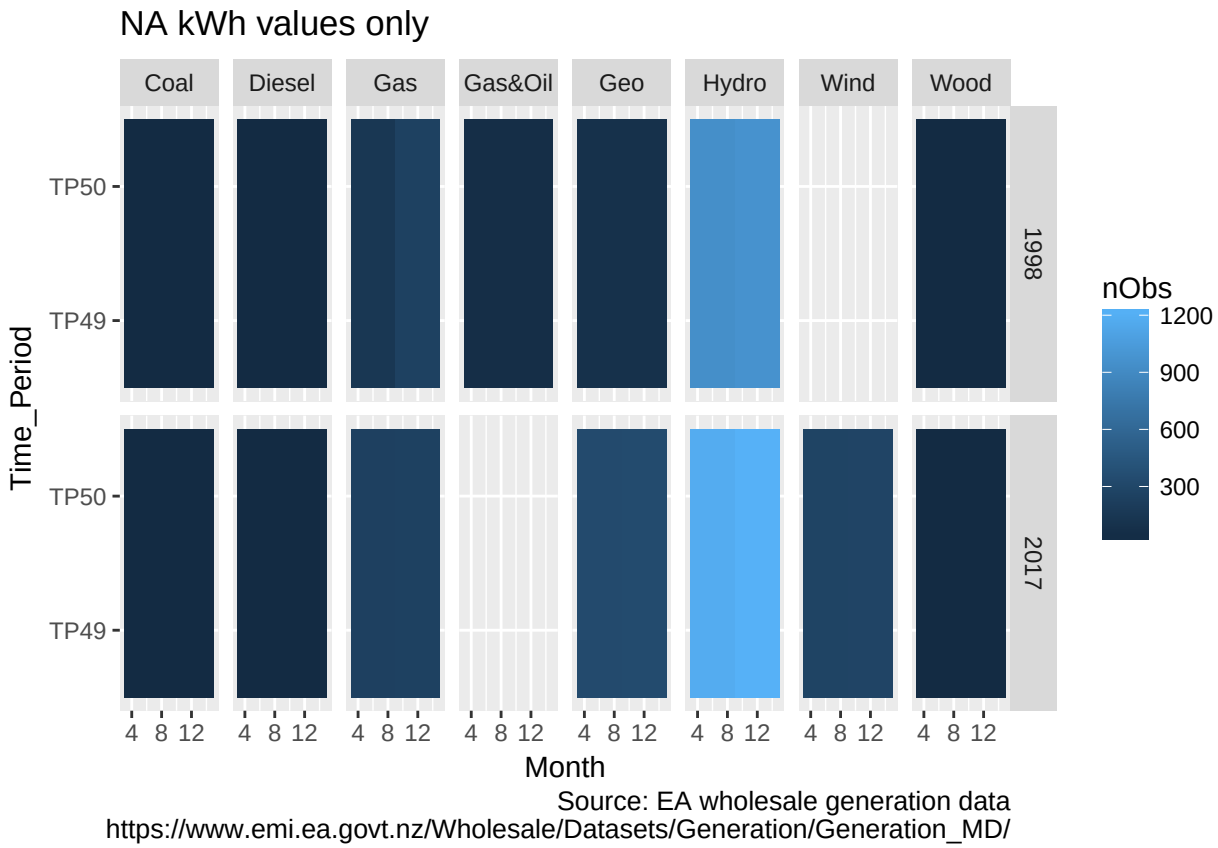


Figure 1: Plot showing presence of NA observations by time period and Fuel Type

Time_Period	mean
TP50	NA
TP6	28278.83
TP7	28020.79
TP8	27830.14
TP9	27905.97

In order to avoid future confusion and to save a lot of error checking we remove NA kWh (i.e. TP49 & TP 50) from the dataset.

```
# N rows before:
nrow(genDT)
```

```
## [1] 352250
```

```
# N time periods before:
uniqueN(genDT$Time_Period)
```

```
## [1] 50
```

```
# remove NA
genDT <- genDT[!is.na(kWh)]
# N rows after
nrow(genDT)
```

```
## [1] 338160
```

```
# N time periods after:
uniqueN(genDT$Time_Period)
```

```
## [1] 48
```

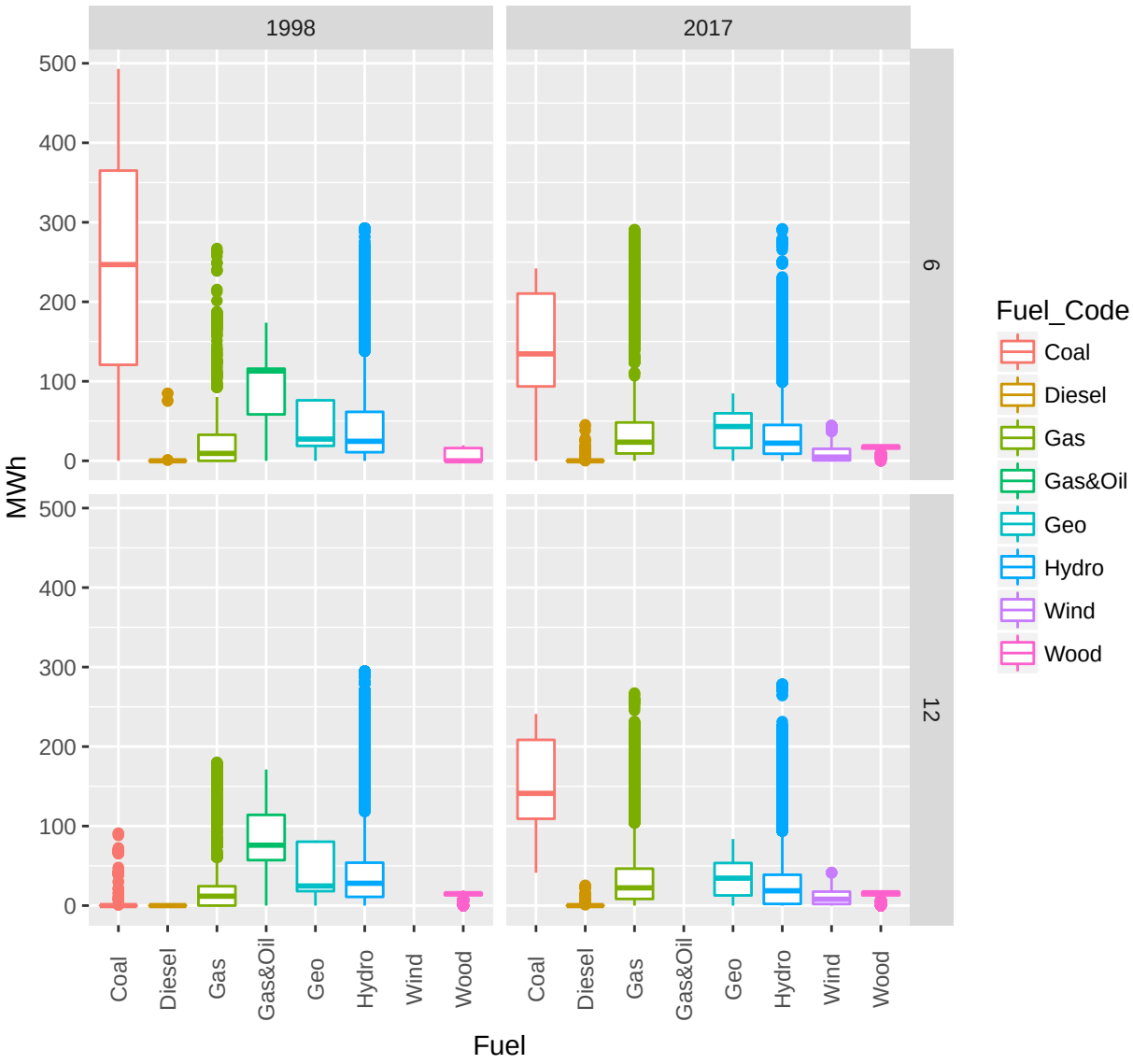
Analysis: 1998 & 2017 Comparison

Distribution tests

The following table shows summary statistics for each fuel source by year. Hydro contributes the majority of energy in each year but coal has the highest half-hourly mean in each year suggesting that is makes large contributions at specific times. Comparing the mean and median for coal shows how skewed this distirbution was in 1998 although far less so in 2017. This is also supported by the maximum values which show coal as the 'peaked' energy producer in 1998 although this has faded by 2017 where it shows similar maxima to gas and hydro. Note that 2 of the 4 the Huntly coal-fired units were mothballed/retired during this period.

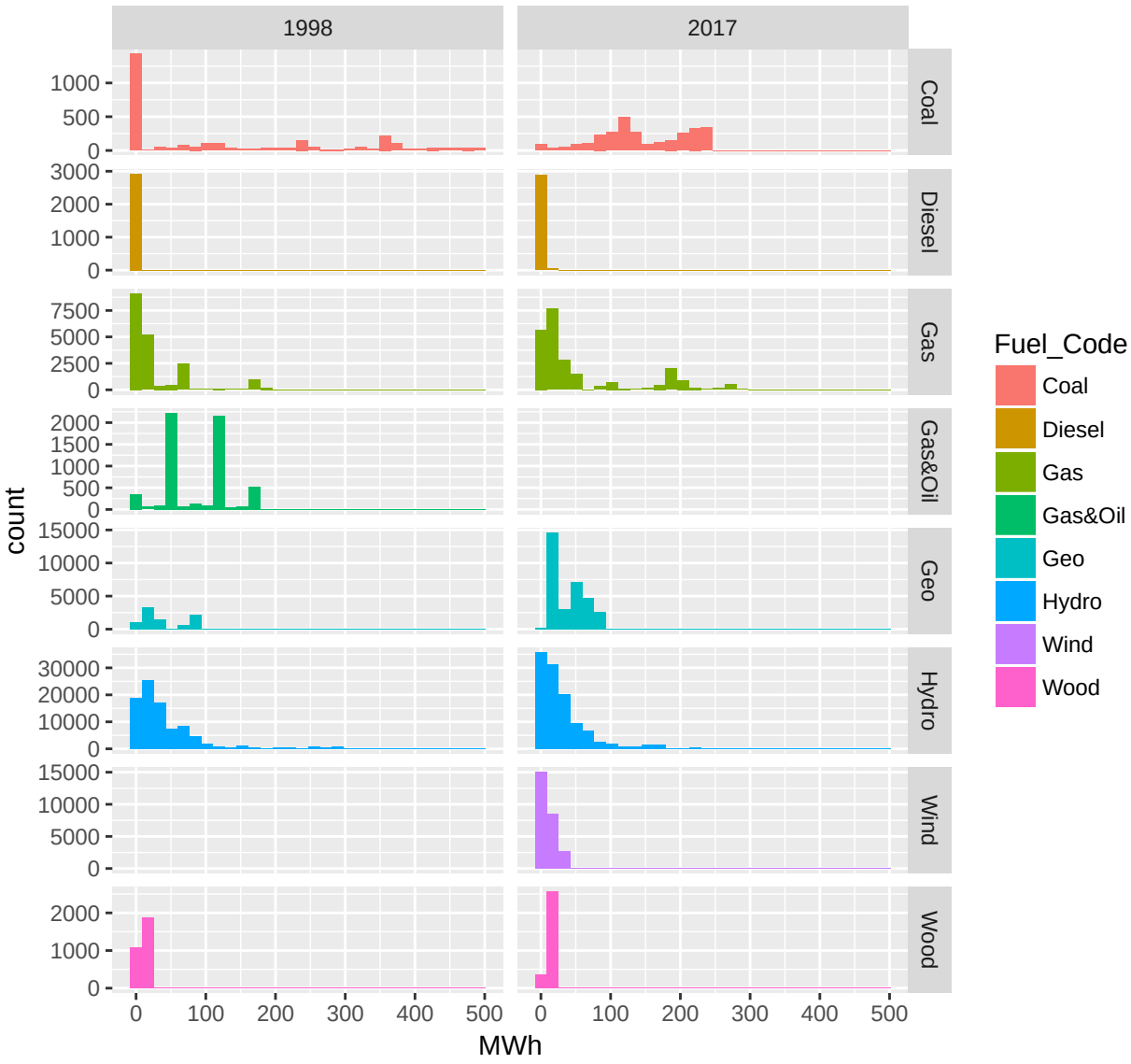
The boxplot shows the distribution of half-hourly observations by month and year. It clearly shows the use of coal in June 1998, non-use in December 1998 but re-use in December 2017 where there appears little differnece between winter & summer use for most fuels. We also see the emergence of wind by 2017.

year	Fuel_Code	sumMWh	meanMWh	medianMWh	minMWh	maxMWh	sdMWh
1998	Coal	379460.72	129.60	40.99	0	493.02	159.50
1998	Diesel	322.77	0.11	0.00	0	84.86	2.97
1998	Gas	537031.60	28.11	10.27	0	267.10	45.45
1998	Gas&Oil	514797.99	87.91	91.95	0	173.73	43.46
1998	Geo	340786.48	38.80	25.60	0	81.87	28.90
1998	Hydro	3870532.38	42.64	26.49	0	294.98	53.53
1998	Wood	29067.50	9.93	14.10	0	19.50	7.41
2017	Coal	426606.86	145.70	140.41	0	241.88	64.98
2017	Diesel	941.40	0.32	0.00	0	45.39	2.49
2017	Gas	1367101.27	58.36	22.78	0	290.87	75.67
2017	Geo	1222782.96	37.97	38.87	0	84.75	23.46
2017	Hydro	3586485.42	31.41	19.57	0	291.82	39.68
2017	Wind	255368.77	9.73	6.30	0	44.27	9.90
2017	Wood	43571.23	14.88	16.64	0	19.51	4.91



The next series of plots use histograms to visualise the distribution of MWh values within fuel sources. Note that the vertical axis has been allowed to vary by fuel source so that smaller counts are visible. The y axis is constant which enables the higher unit output of coal to be clearly visible. The histogram for coal shows the use of multiple units in June 1998 but not 2017 for example. It also shows that coal was almost constantly generating in 2017 (very few zero values). Hydro on the other hand shows a large number of zero or low values as does wind and back-up diesel which is to be expected.

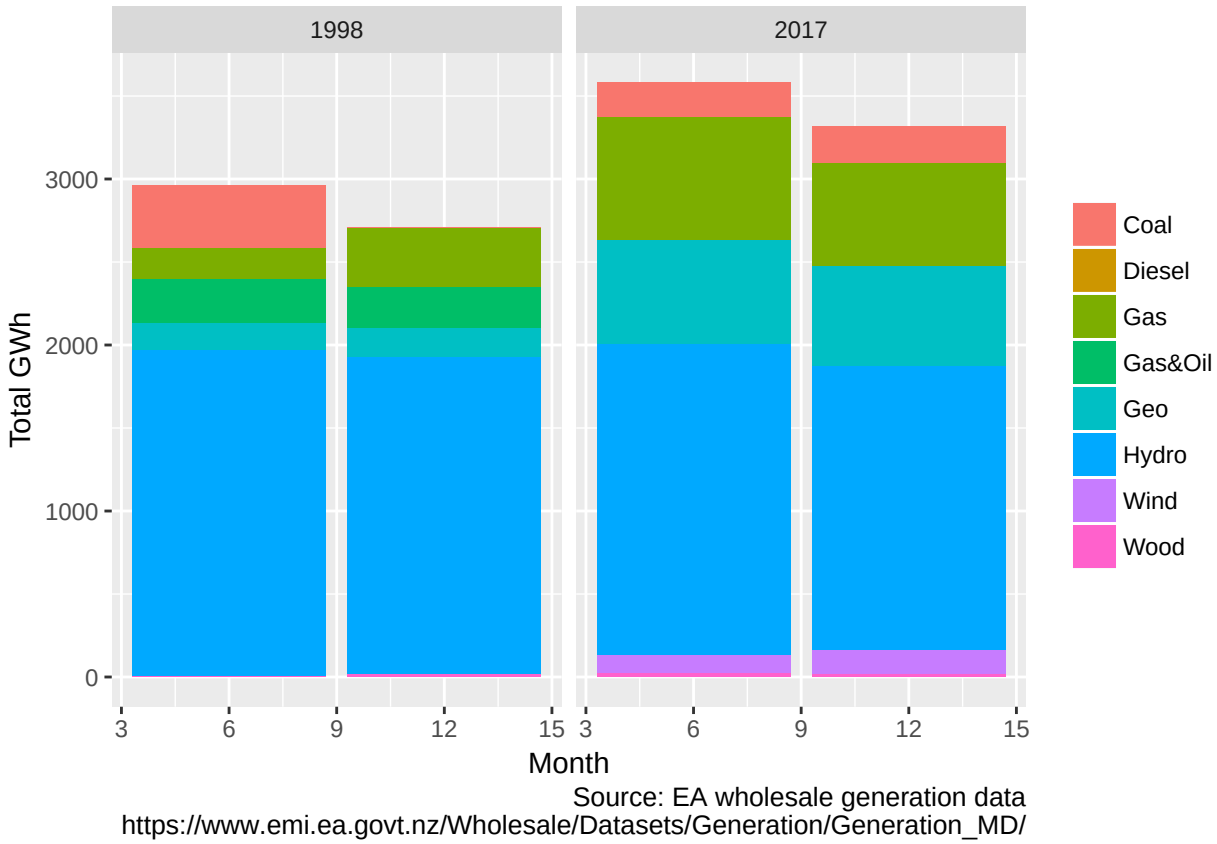
```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```



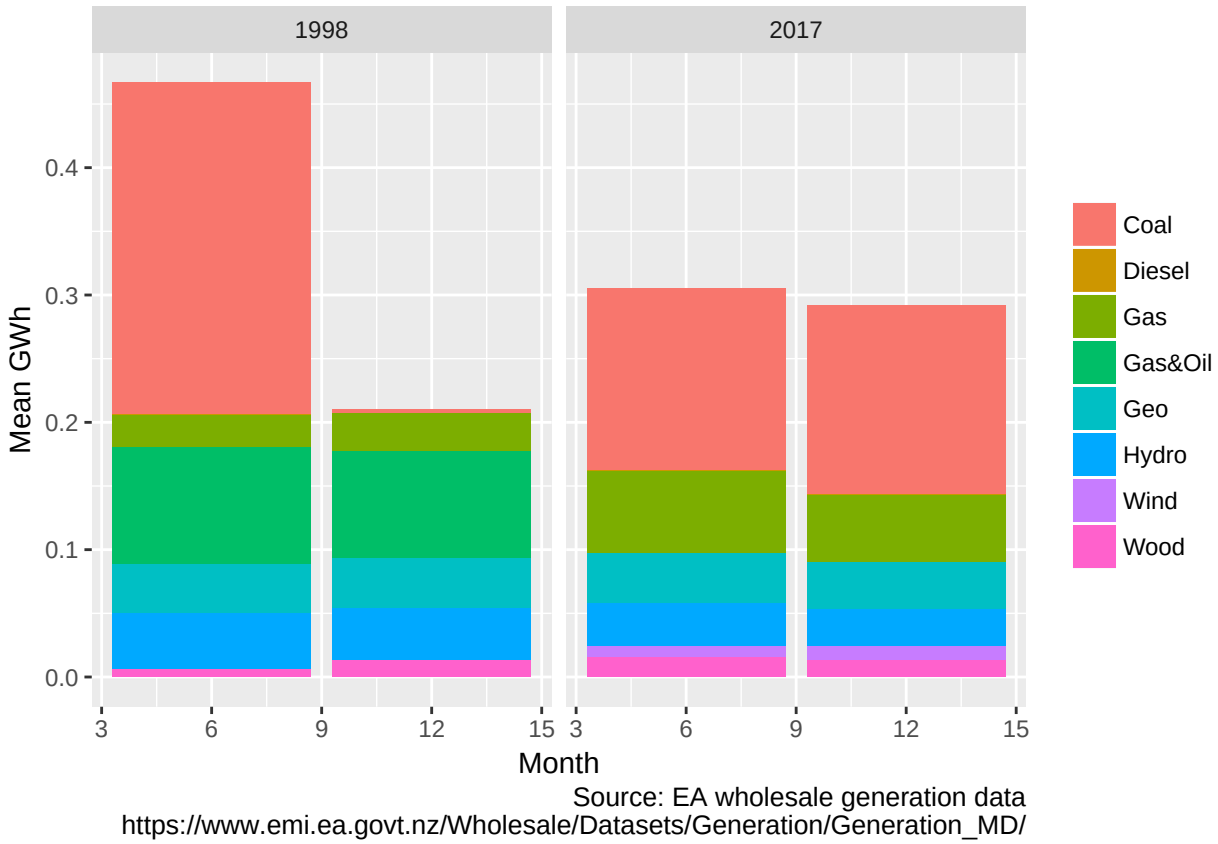
Monthly generation

The following plot shows the total, mean, s.d. and coefficient of variation plots of half-hourly GWh produced by each fuel source each month and to some extent relfects the previous box plots.

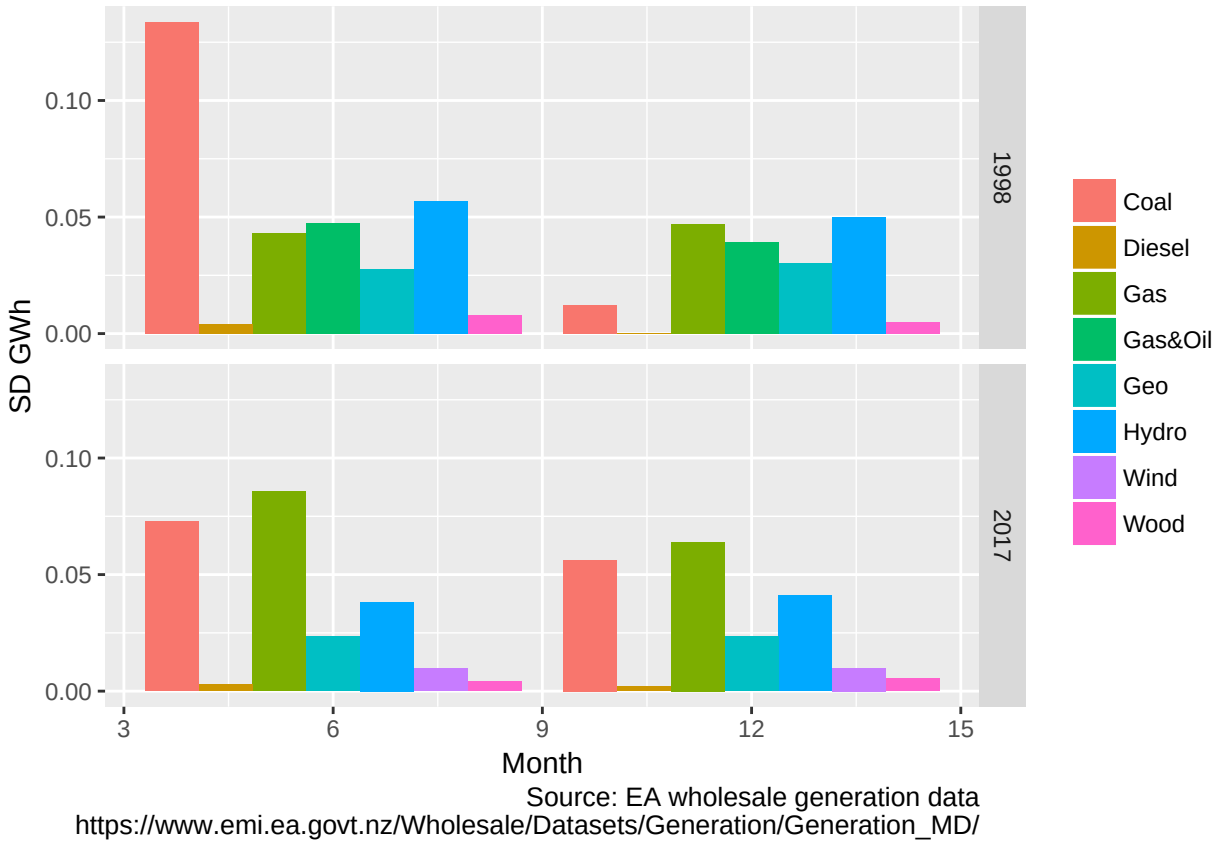
The total is simply the sum of all half-hourly values and it shows the dominance of hydro followed by coal in June 1998; the non-use of coal in December 1998; the growth of gas & geo by 2017 but the relative stasis in at-capacity hydro (?).



The next plot shows the mean of half-hourly values for each month and indicates that the Coal generation may be skewed, especially for June 1998 by a few very large values (ref the histograms above).



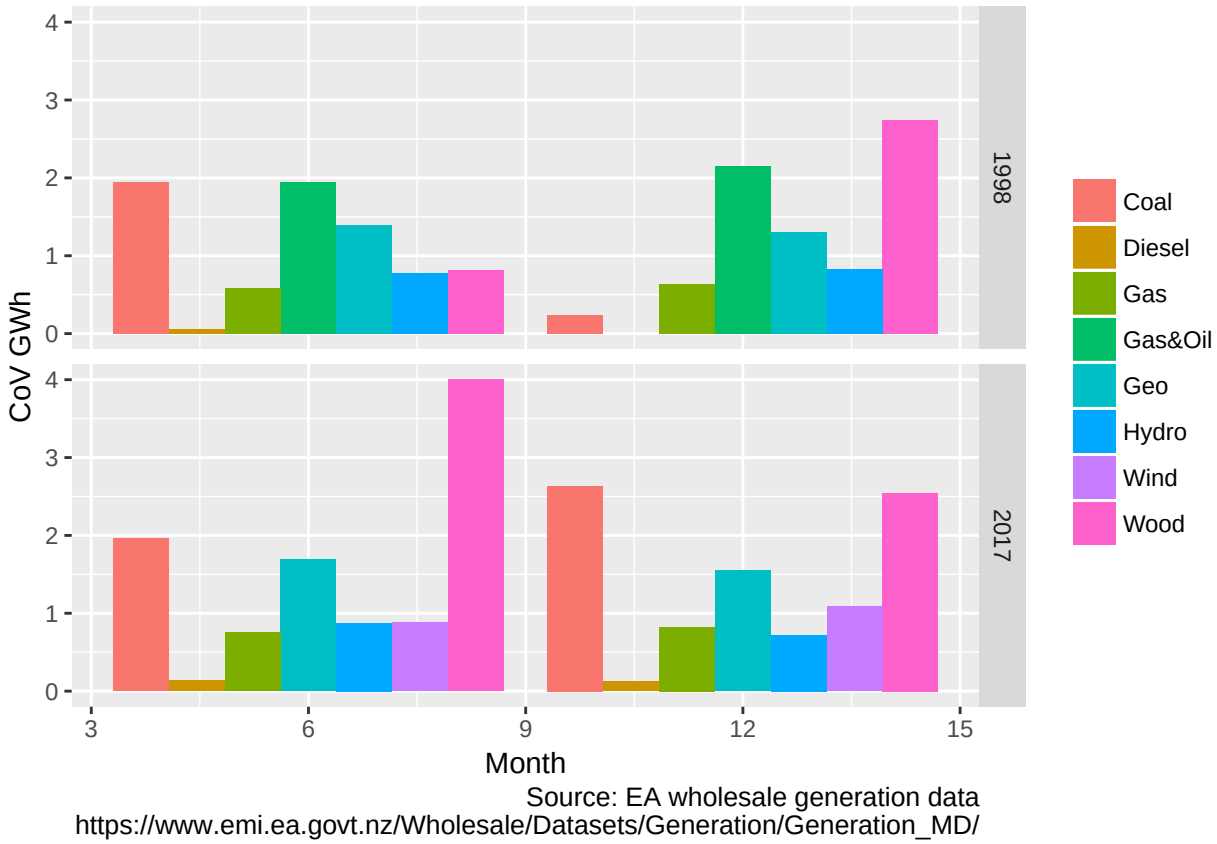
The next plot shows the standard deviation of the half-hourly generation data and suggests that coal has the highest absolute variation in June 1998 which may correspond to a particular spike and/or a period of very heavy use. Coal is less variable in 2017 perhaps due to the increased use of Gas.



Source: EA wholesale generation data
https://www.emi.ea.govt.nz/Wholesale/Datasets/Generation/Generation_MD/

The final plot shows the coefficient of variation across the half-hourly values (mean/s.d). We take the CoV to indicate relative variability in generation load and the plots suggest that coal and wood tend to see greatest relative variability.

```
## Warning: Removed 1 rows containing missing values (geom_col).
```

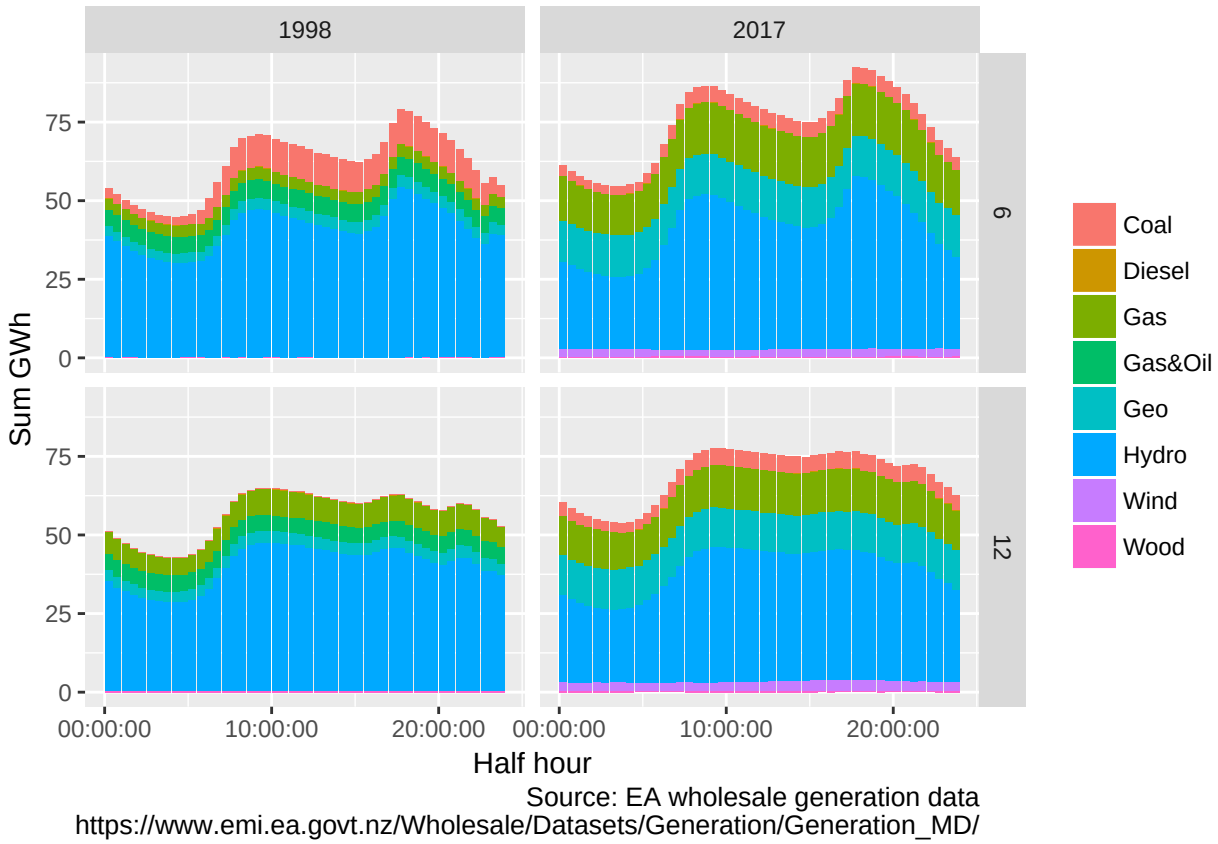


Source: EA wholesale generation data
https://www.emi.ea.govt.nz/Wholesale/Datasets/Generation/Generation_MD/

Half hourly profiles by month

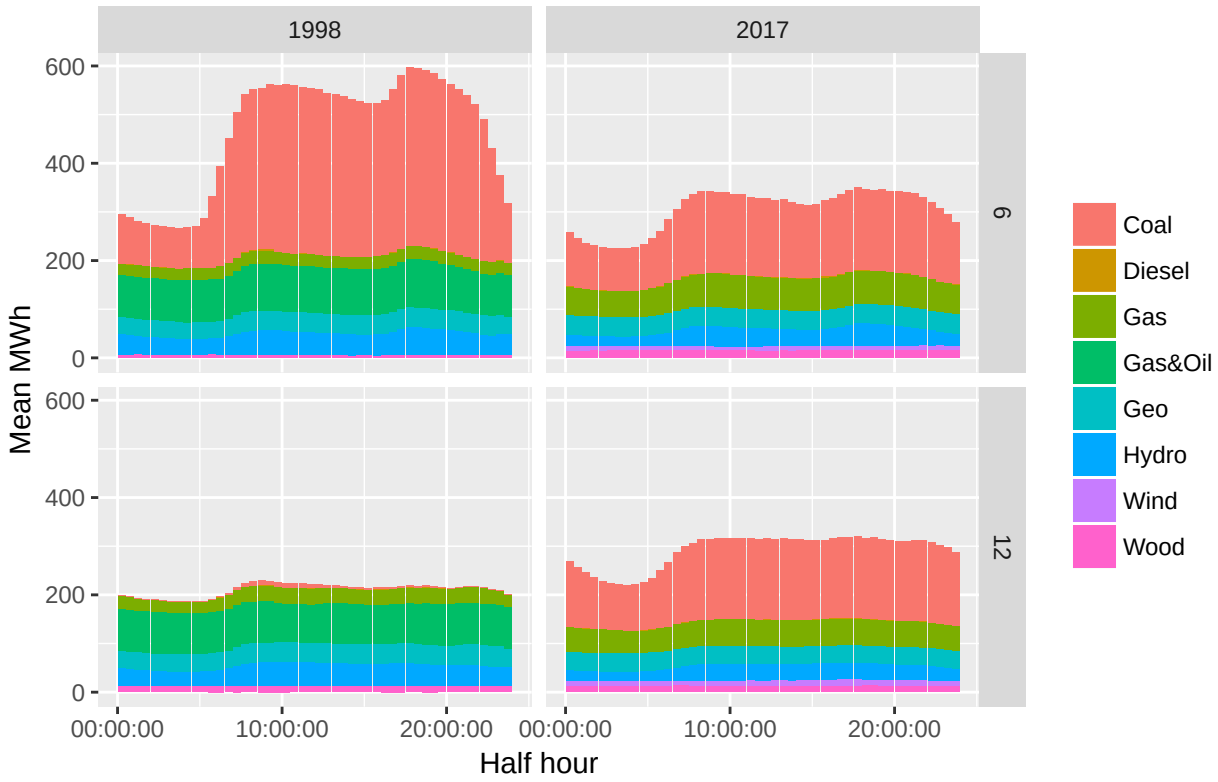
However the monthly plots do not tell us about the use of different generation sources by time of day which has clear implications for how peaks in demand are met.

To do this, the following plot replicates one of those found in Staffel, 2018 for the UK to show how the different components of generation have changed over time. It shows the total half-hourly generation for each month summed over all days. Note that the half-hours are plotted at mid-points (00:15, 00:45, 01:15 etc. . .).



Source: EA wholesale generation data
https://www.emi.ea.govt.nz/Wholesale/Datasets/Generation/Generation_MD/

The next plot repeats this analysis but shows the mean, again suggesting that the values for coal are skewed by some extremely large values in December 1998 and by high generation values when used in 2017.



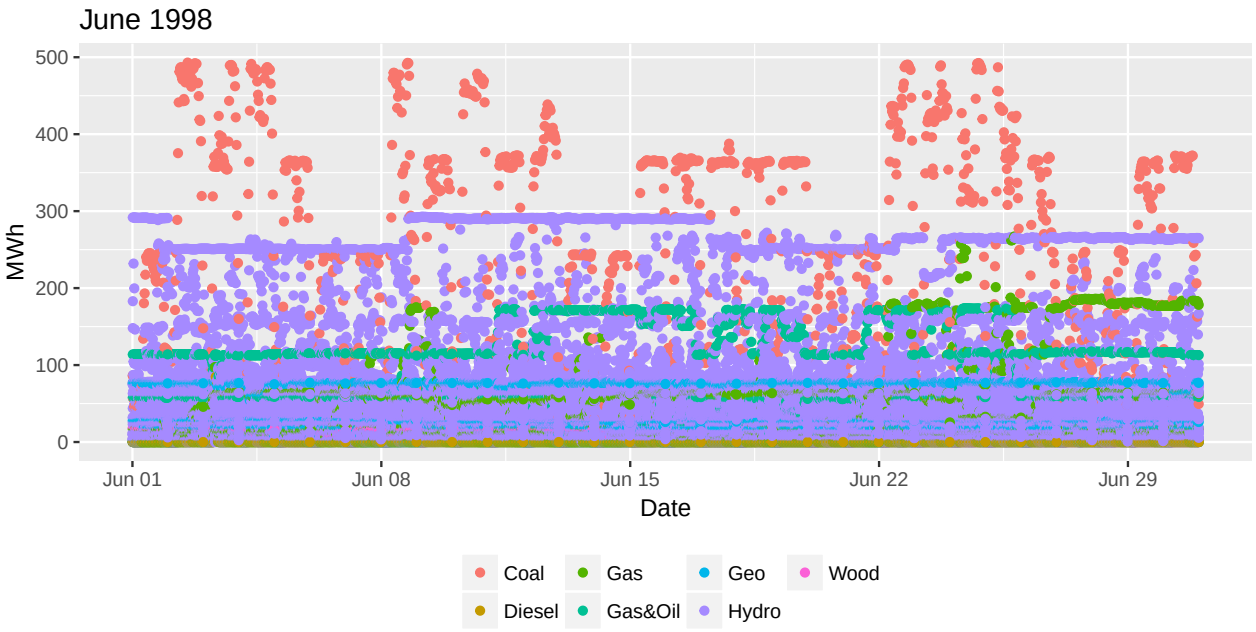
Source: EA wholesale generation data
https://www.emi.ea.govt.nz/Wholesale/Datasets/Generation/Generation_MD/

Half hourly profiles by day of the month

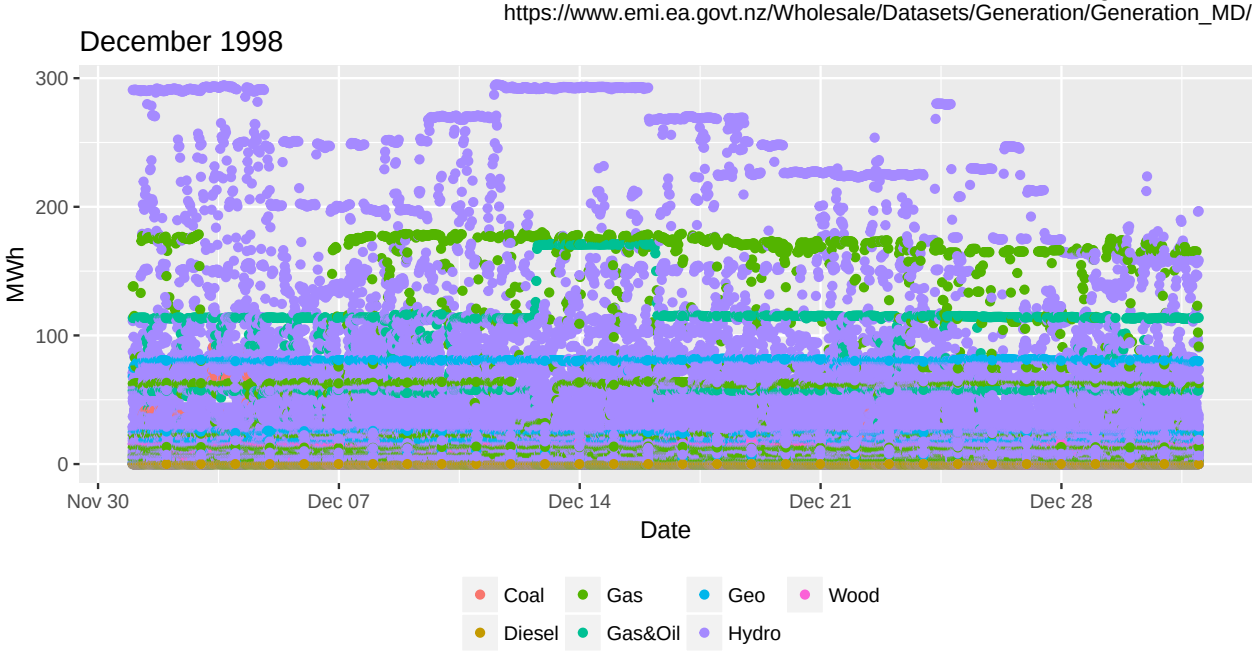
The following plots show the profiles for each day of the month. Unfortunately due to the lack of wind generation in 1998 the colour scheme changes from 1998 to 2017.

To be fixed

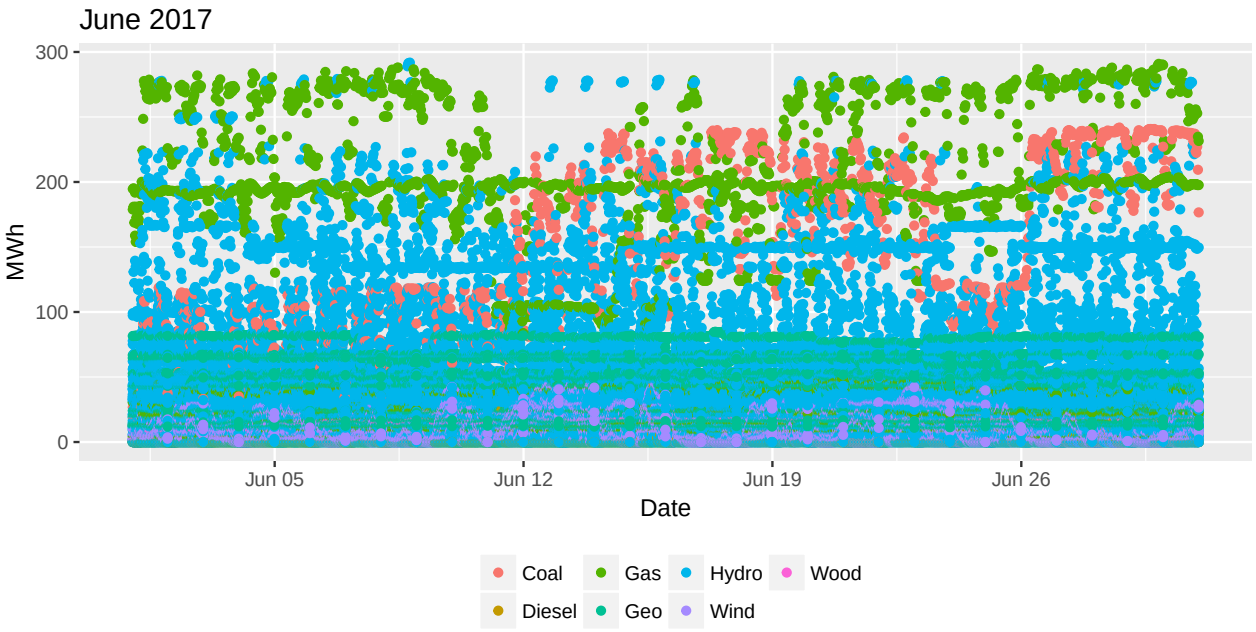
Nevertheless the differences between the compositions of each half-hour can be seen.



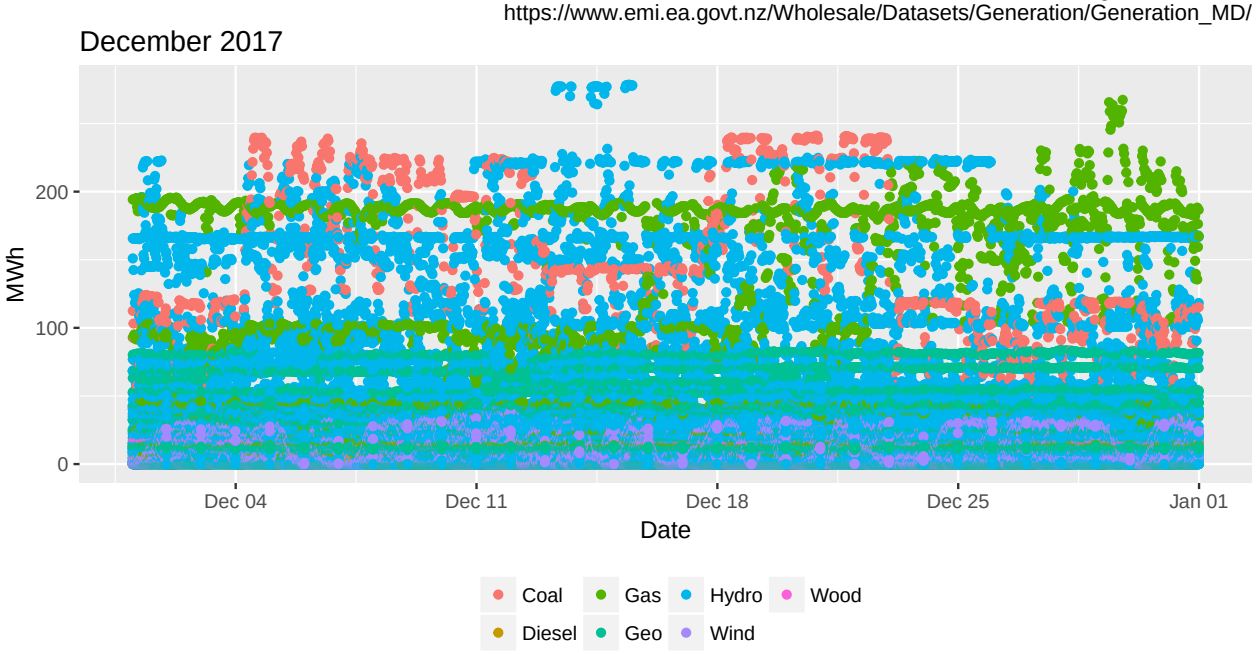
Source: EA wholesale generation data
https://www.emi.ea.govt.nz/Wholesale/Datasets/Generation/Generation_MD/



Source: EA wholesale generation data
https://www.emi.ea.govt.nz/Wholesale/Datasets/Generation/Generation_MD/

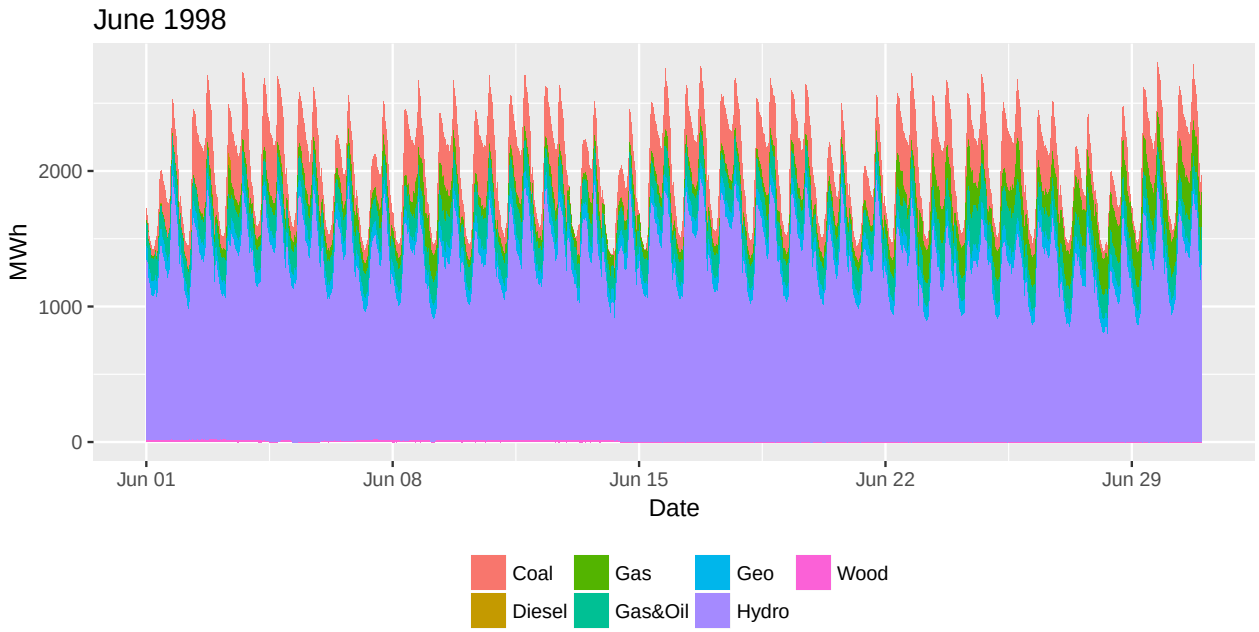


Source: EA wholesale generation data
https://www.emi.ea.govt.nz/Wholesale/Datasets/Generation/Generation_MD/

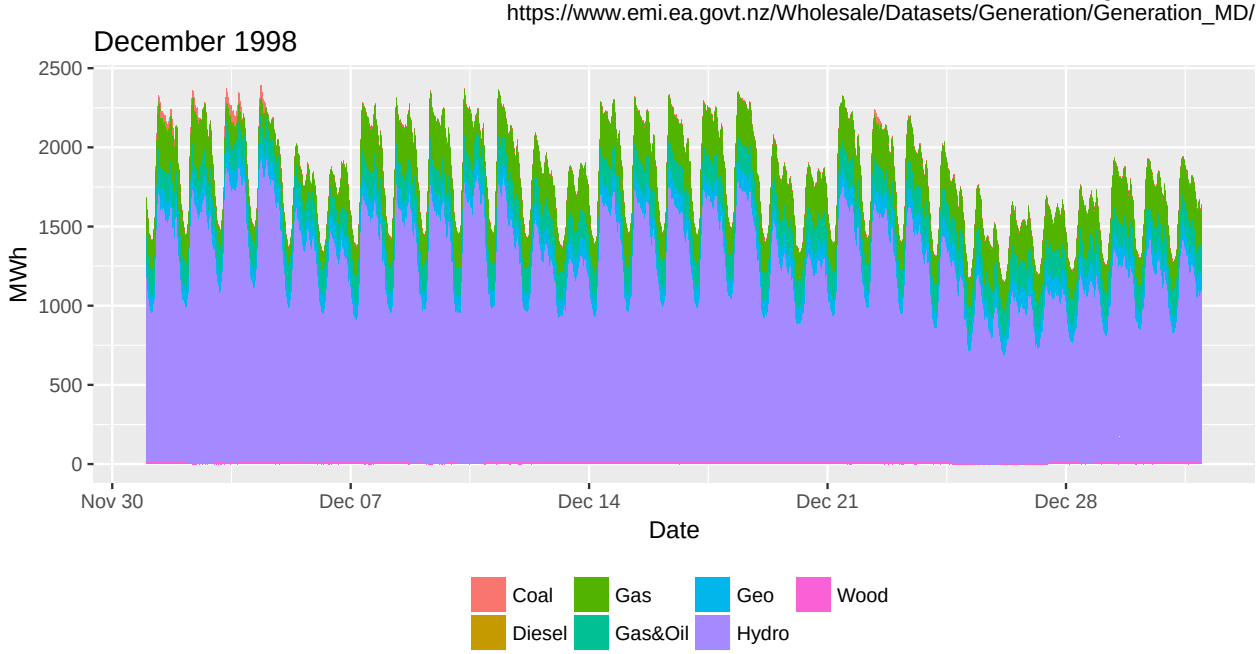


Source: EA wholesale generation data
https://www.emi.ea.govt.nz/Wholesale/Datasets/Generation/Generation_MD/

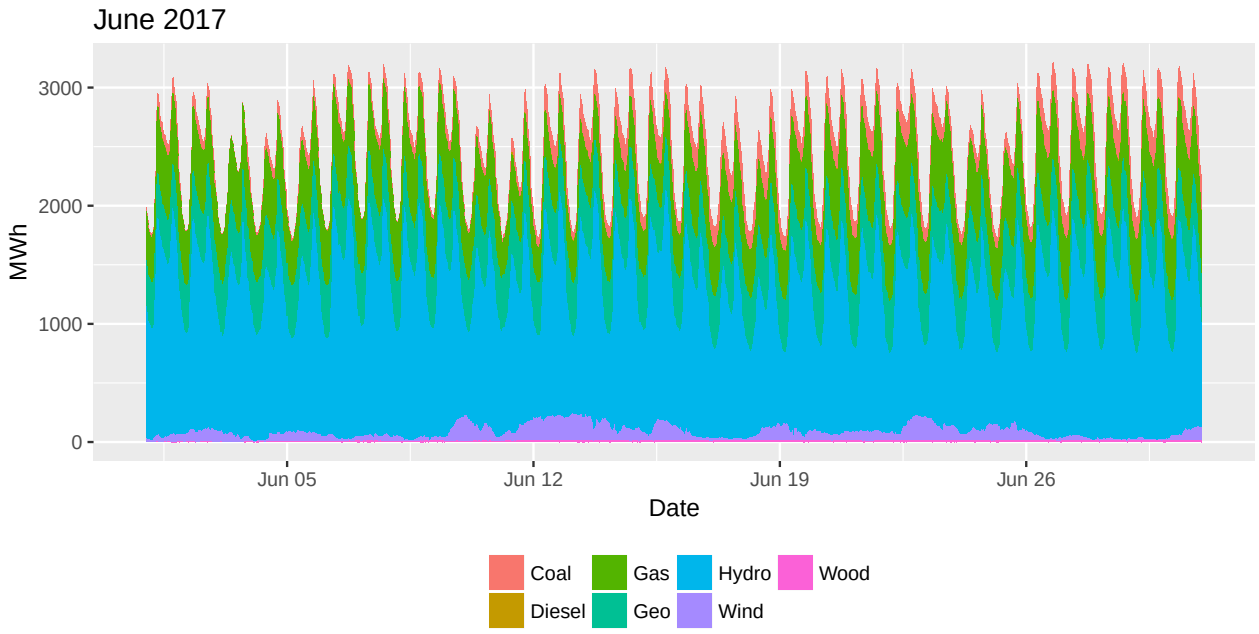
The following plots repeat this but use stacked column plots to show the proportion of energy generation produced by each fuel.



Source: EA wholesale generation data
https://www.emi.ea.govt.nz/Wholesale/Datasets/Generation/Generation_MD/



Source: EA wholesale generation data
https://www.emi.ea.govt.nz/Wholesale/Datasets/Generation/Generation_MD/



Source: EA wholesale generation data
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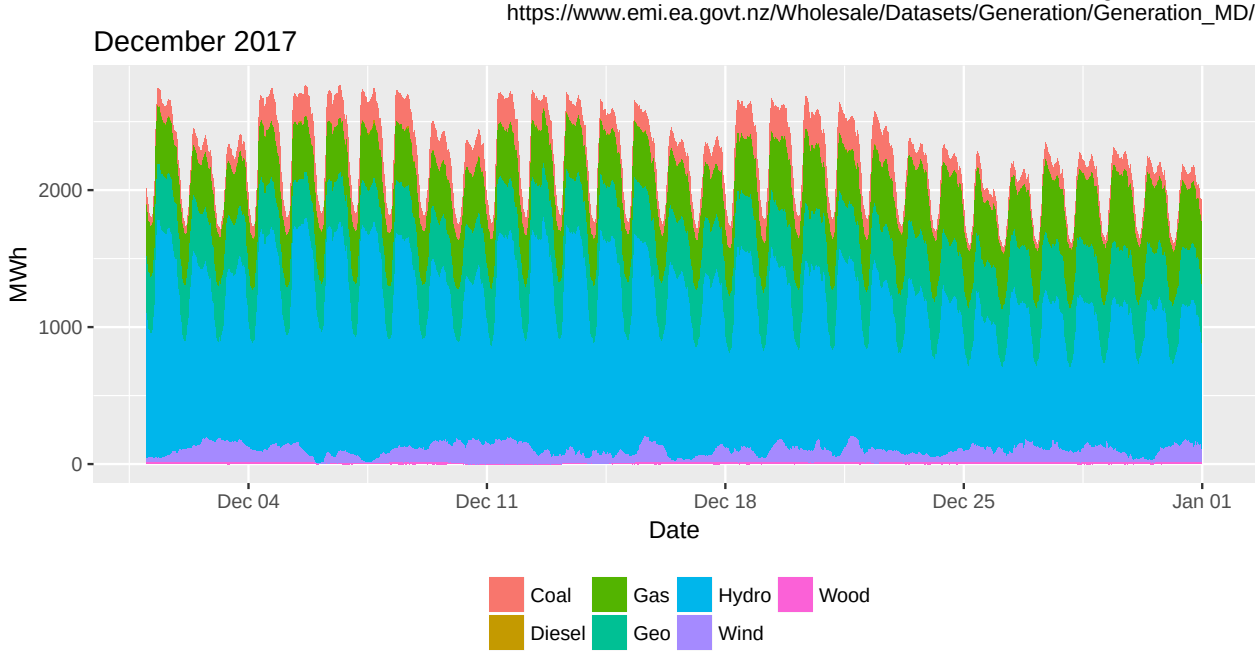

Source: EA wholesale generation data
https://www.emi.ea.govt.nz/Wholesale/Datasets/Generation/Generation_MD/

Analysis: Trends 1998 - 2017

Using full dataset for each month & year. To Do.

Discussion

here

Conclusions

go here

References