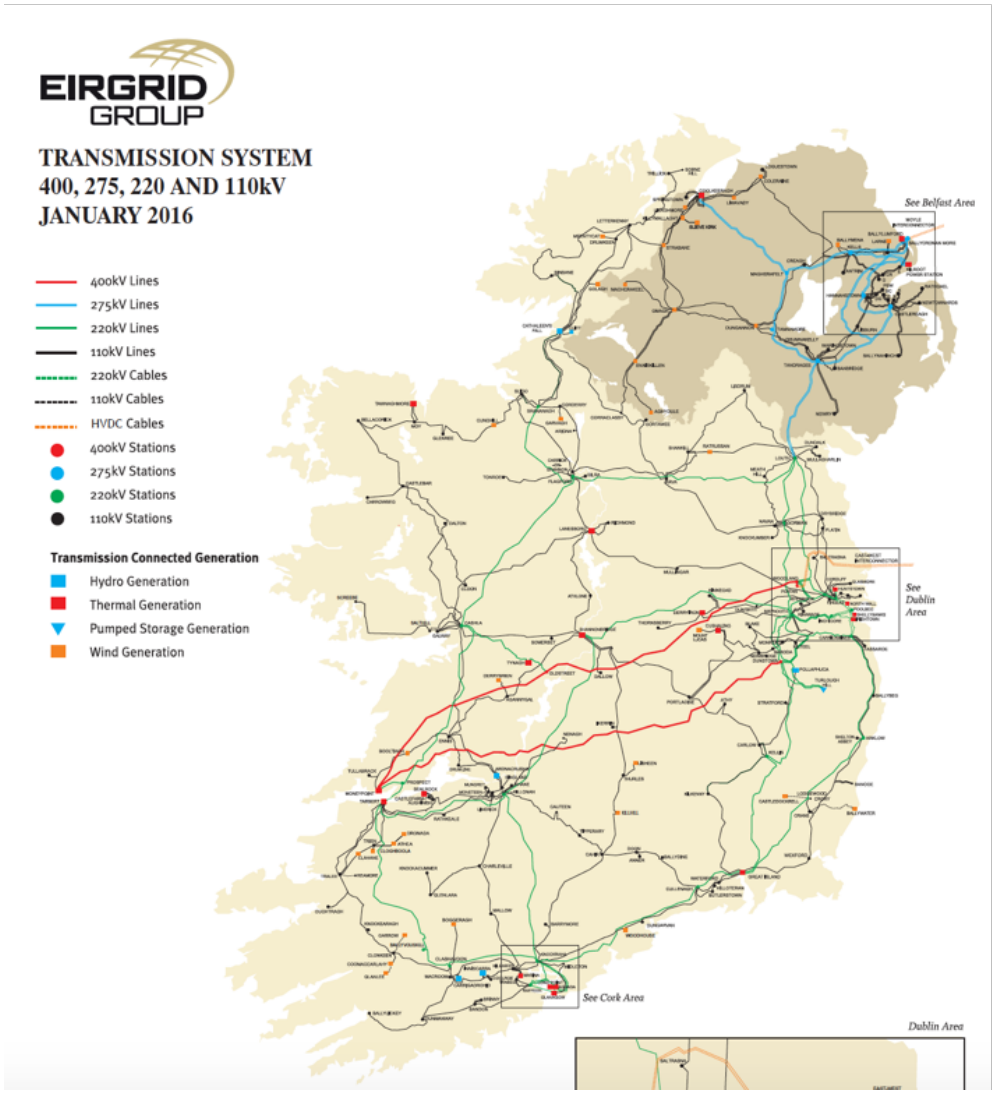
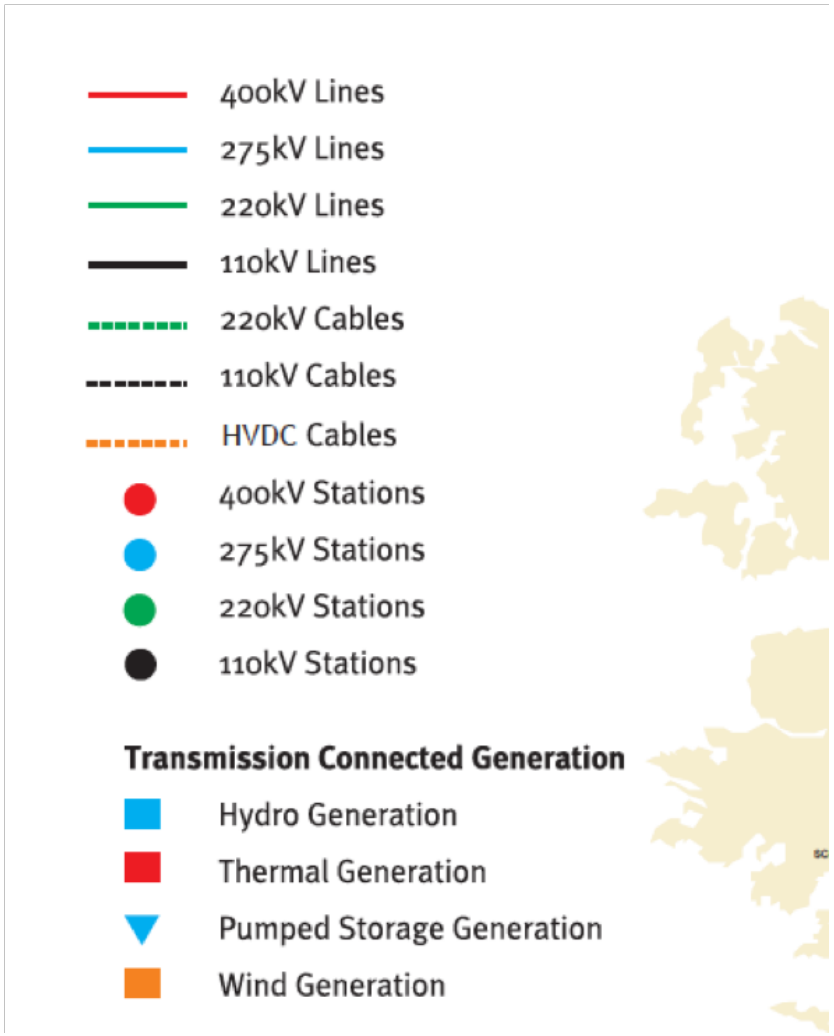
9. An Energy Generation Case Study

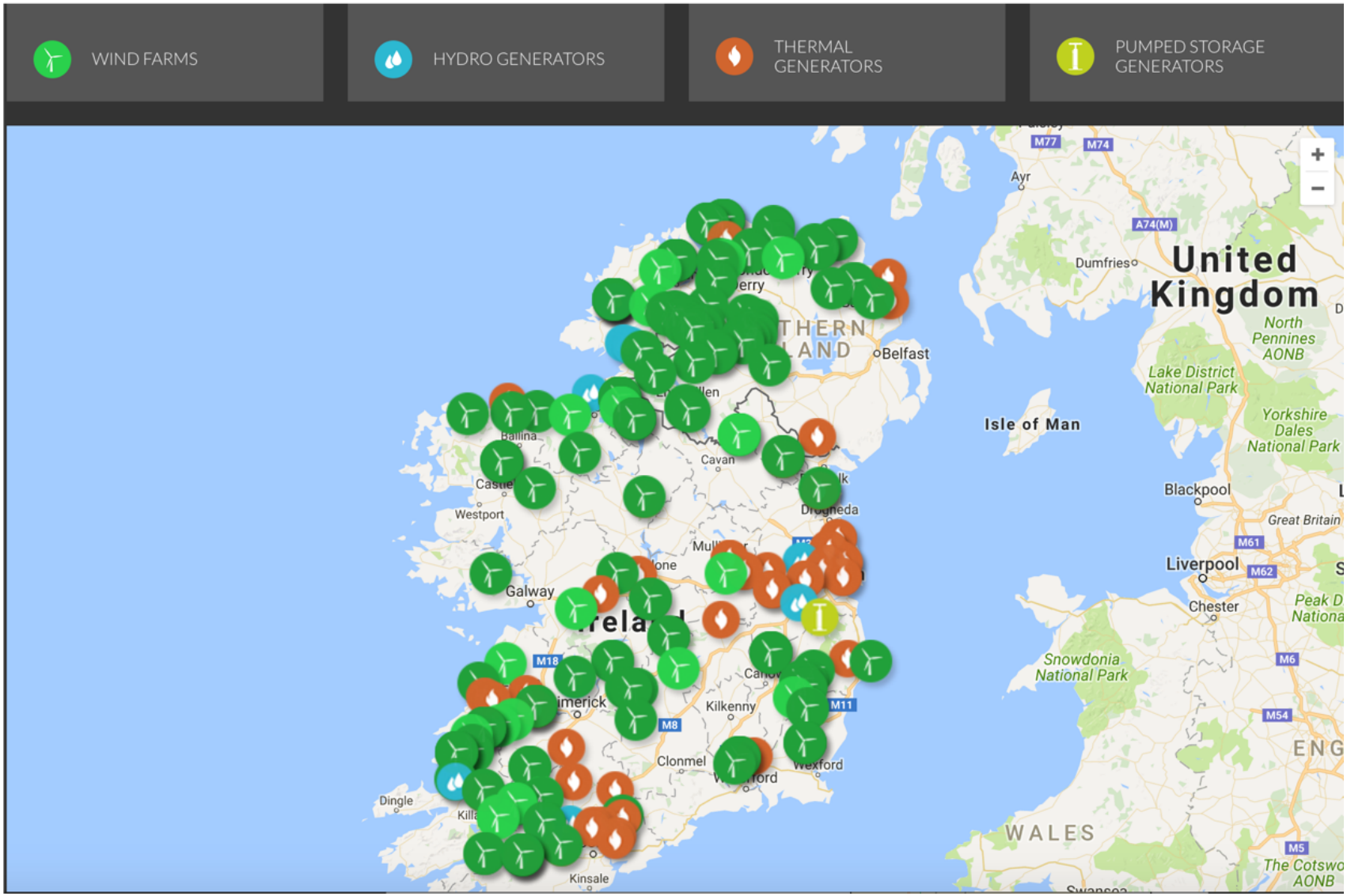
Data Science for OR - J. Duggan

Transmission System (2017)





Generation Information



Sample Data

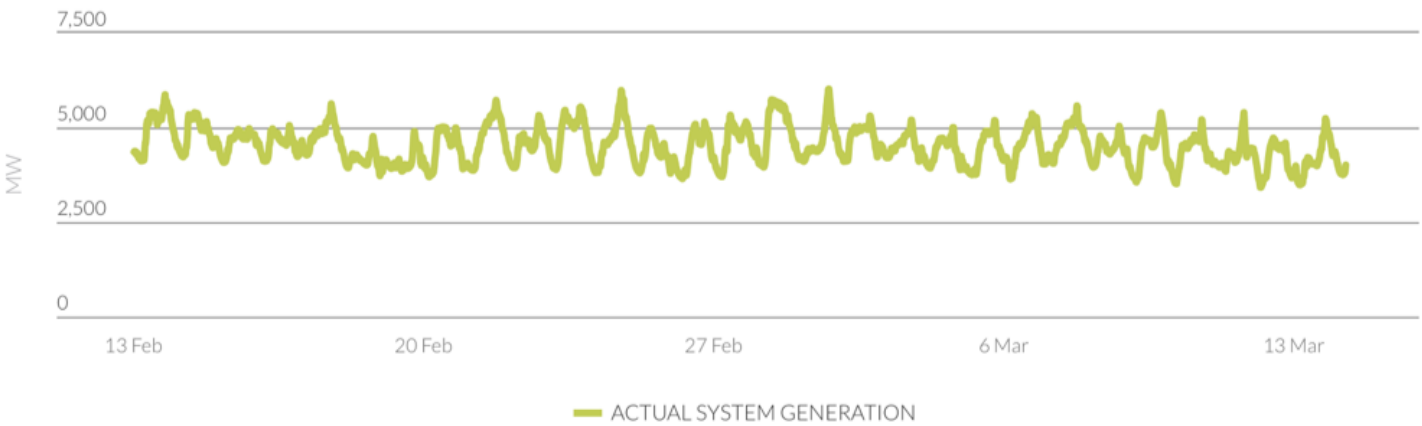
Actual System Generation

System Generation represents the total electricity production on the system, including system losses, but net of generators' requirements. System Generation is shown in 15 minute intervals.

DAY | WEEK | MONTH

COMPARE WITH OTHER DATA

< Last 30 Days (13/02/2017 - 14/03/2017) >



Accessing Data

```
ener <- read_excel("../../datasets/energy/IrelandData January
glimpse(ener)
```

```
## Observations: 2,784
## Variables: 8
## $ DateTime    <dttm> 2017-01-29 00:00:00, 2017-01-29 00:15:0
## $ Demand      <dbl> 3834, 3785, 3708, 3634, 3581, 3552, 3491
## $ Generation <dbl> 4041, 4041, 4130, 4181, 4211, 4278, 4133
## $ Wind        <dbl> 449, 505, 521, 492, 538, 561, 484, 474,
## $ CO2         <dbl> 552, 548, 544, 543, 555, 531, 545, 551,
## $ NetImports <dbl> -145, -200, -294, -419, -503, -598, -516
## $ EWIC        <dbl> -33, -108, -183, -258, -333, -379, -374,
## $ Moyle       <dbl> -112, -92, -111, -161, -170, -219, -142,
```

Processing Dates - lubridate

Date component	Accessor
Year	`year()`
Month	`month()`
Week	`week()`
Day of year	`yday()`
Day of month	`mday()`
Day of week	`wday()`
Hour	`hour()`
Minute	`minute()`
Second	`second()`
Time zone	`tz()`

Extracting information

```
ener$DateTime[1]
```

```
## [1] "2017-01-29 UTC"
```

```
year(ener$DateTime[1])
```

```
## [1] 2017
```

```
wday(ener$DateTime[1])
```

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

Adding New Columns

```
ener <- ener %>% mutate(Date=ymd(DateTime),
                        HourOfDay=hour(DateTime),
                        MinuteOfDay=minute(DateTime),
                        DayOfWeek=wday(DateTime,label=T))
```

```
## Warning: All formats failed to parse. No formats found.
```

```
glimpse(ener)
```

```
## Observations: 2,784
## Variables: 12
## $ DateTime    <dttm> 2017-01-29 00:00:00, 2017-01-29 00:15:
## $ Demand      <dbl> 3834, 3785, 3708, 3634, 3581, 3552, 349
## $ Generation  <dbl> 4041, 4041, 4130, 4181, 4211, 4278, 413
## $ Wind        <dbl> 449, 505, 521, 492, 538, 561, 484, 474,
## $ CO2         <dbl> 552, 548, 544, 543, 555, 531, 545, 551,
## $ NetImports  <dbl> -145, -200, -294, -419, -503, -598, -51
```

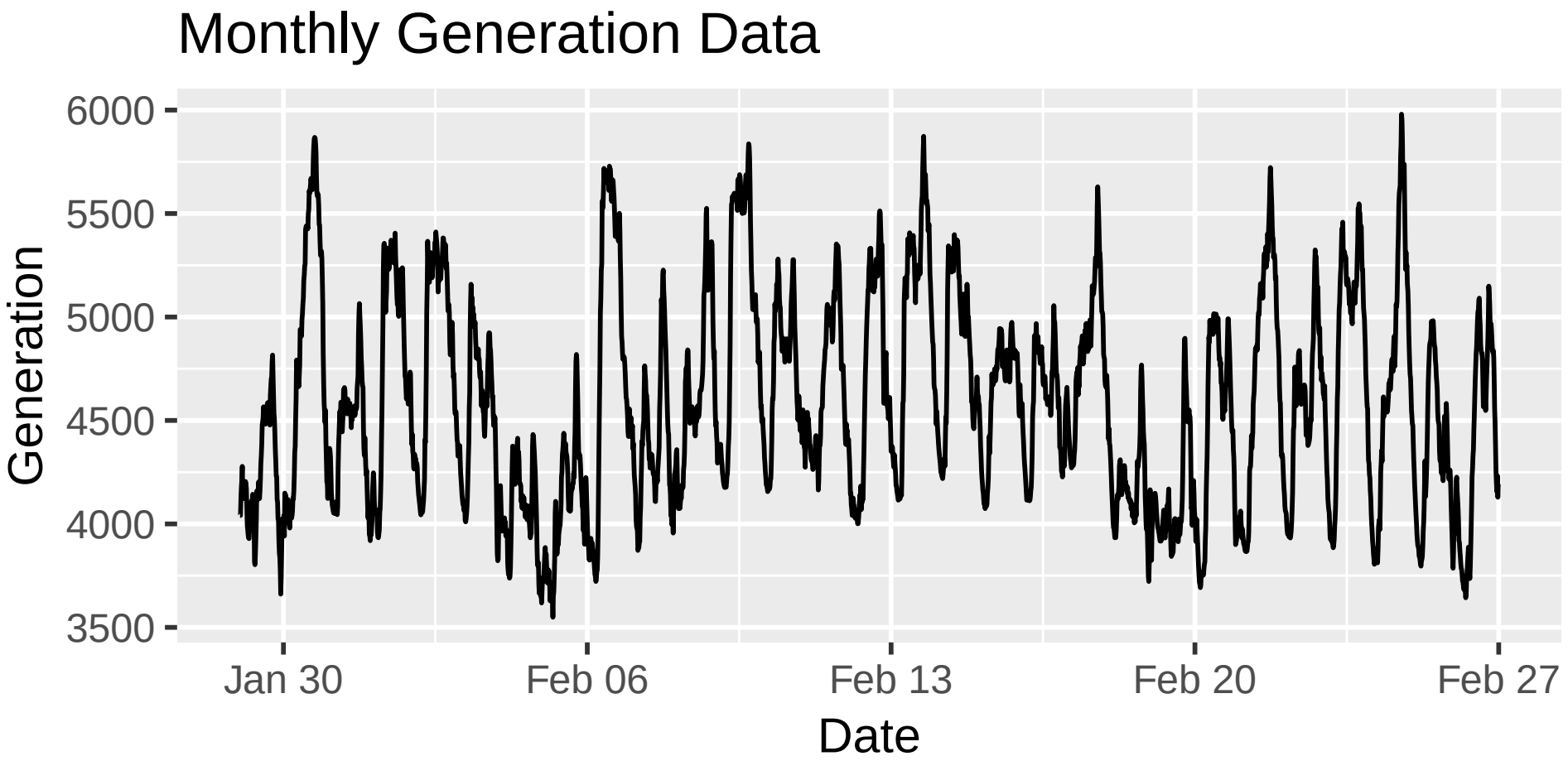
Split out date and time (need for join later)

```
ener <- ener %>% separate(DateTime,c("Date","Time"),
                          sep=" ", remove=F) %>%
        mutate(Date=ymd(Date))
glimpse(ener)
```

```
## Observations: 2,784
## Variables: 13
## $ DateTime    <dttm> 2017-01-29 00:00:00, 2017-01-29 00:15:
## $ Date        <date> 2017-01-29, 2017-01-29, 2017-01-29, 20
## $ Time        <chr> "00:00:00", "00:15:00", "00:30:00", "00
## $ Demand      <dbl> 3834, 3785, 3708, 3634, 3581, 3552, 349
## $ Generation  <dbl> 4041, 4041, 4130, 4181, 4211, 4278, 413
## $ Wind        <dbl> 449, 505, 521, 492, 538, 561, 484, 474,
## $ CO2         <dbl> 552, 548, 544, 543, 555, 531, 545, 551,
## $ NetImports  <dbl> -145, -200, -294, -419, -503, -598, -51
## $ EWIC        <dbl> -33, -108, -183, -258, -333, -379, -374
```

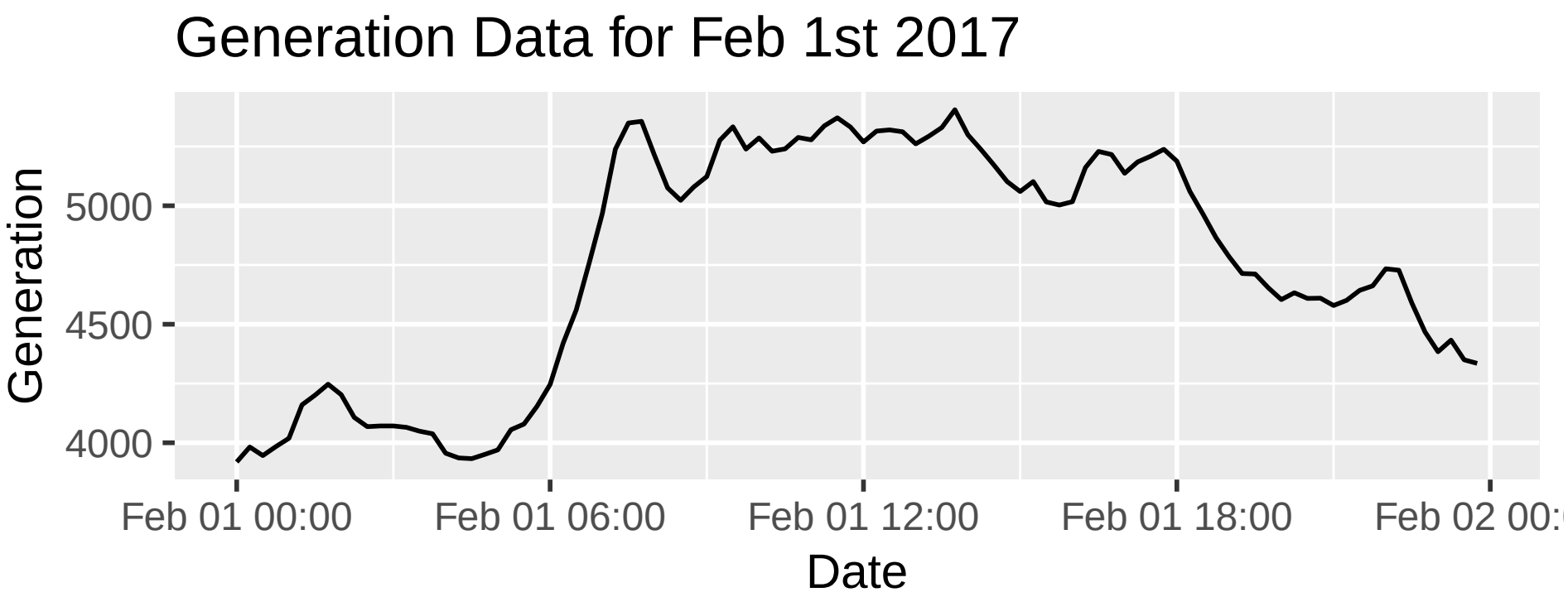
Plot time series

```
ggplot(data = ener,aes(x=DateTime, y=Generation)) +
  geom_line() + xlab("Date") + ylab("Generation") +
  ggtitle("Monthly Generation Data")
```



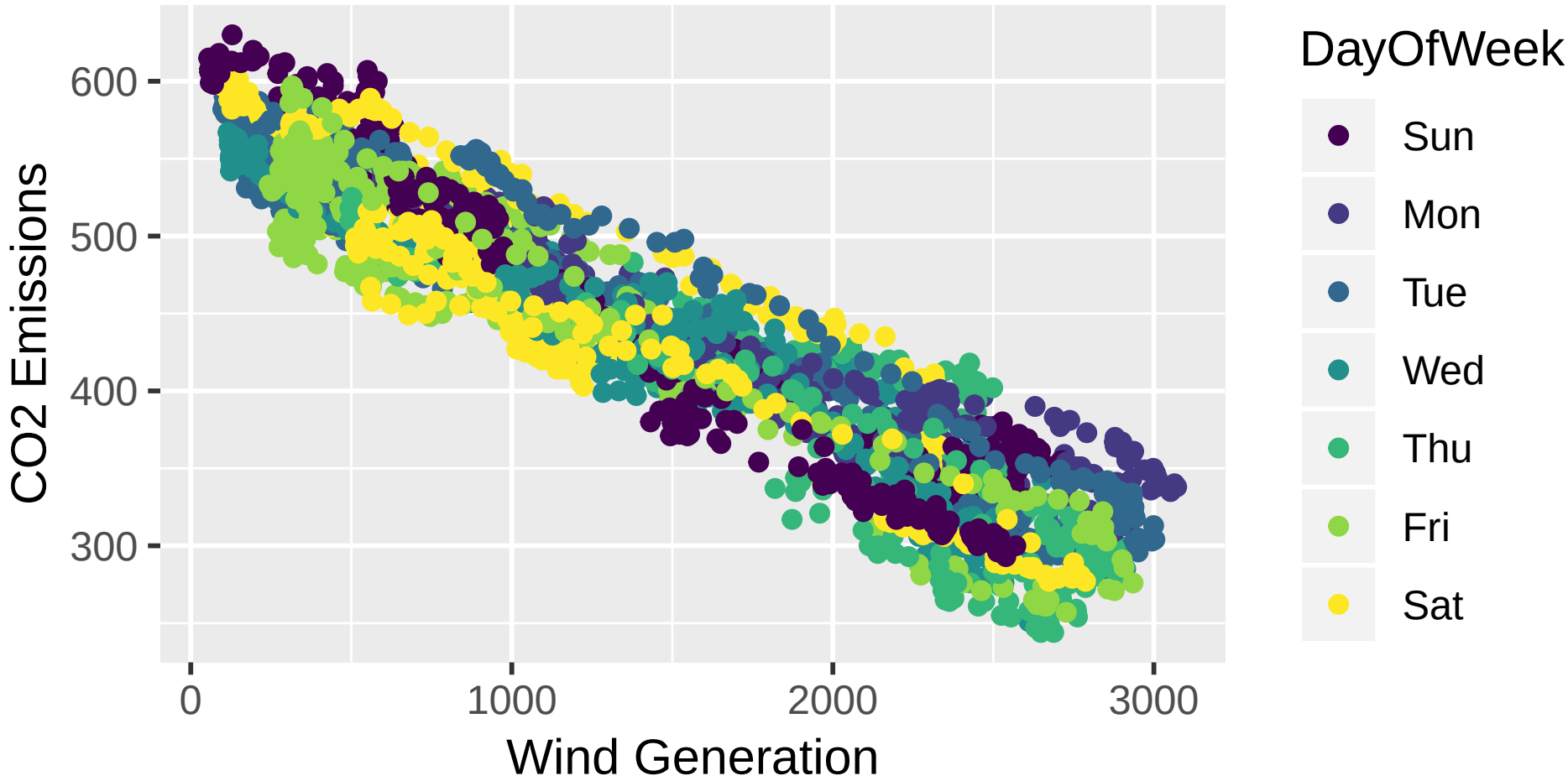
Extract value for 1/2/2017

```
ggplot(data = filter(ener,Date=="2017-02-01"),
       aes(x=DateTime, y=Generation)) +
  geom_line() + xlab("Date") + ylab("Generation") +
  ggtitle("Generation Data for Feb 1st 2017")
```



Wind Generation v CO2 Emissions

```
ggplot(data = ener) +
  geom_point(aes(x=Wind,y=CO2,colour=DayOfWeek))+
  xlab("Wind Generation") + ylab("CO2 Emissions")
```

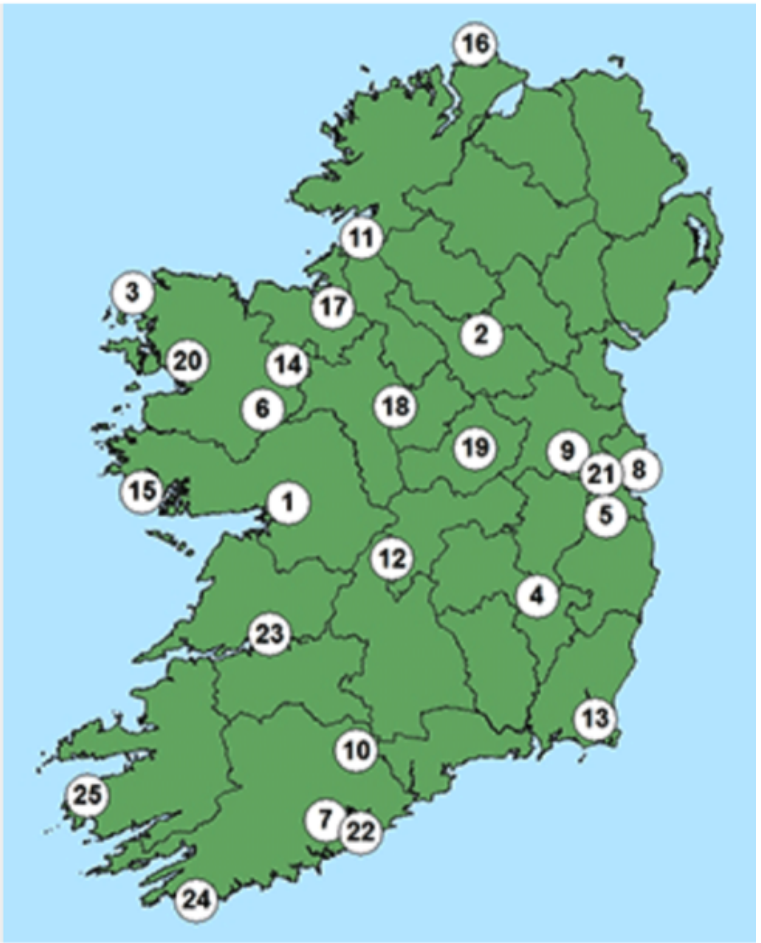


Linking weather to wind generation

Monthly Data

Please choose a monthly data report from any station by clicking one of the links below:

1 Athenry
2 Ballyhaise
3 Belmullet
4 Carlow Oakpark
5 Baldonnel - Casement Aerodrome
6 Claremorris
7 Cork Airport
8 Dublin Airport
9 Dunsany
10 Fermoy Moorepark
11 Finner
12 Gurteen Agri College
13 Johnstown
14 Knock Airport
15 Mace Head
16 Malin Head
17 Markree
18 Mount Dillon
19 Mullingar
20 Newport
21 Phoenix Park
22 Roches Point
23 Shannon Airport
24 Sherkin Island
25 Valentia Observatory



Sample Data

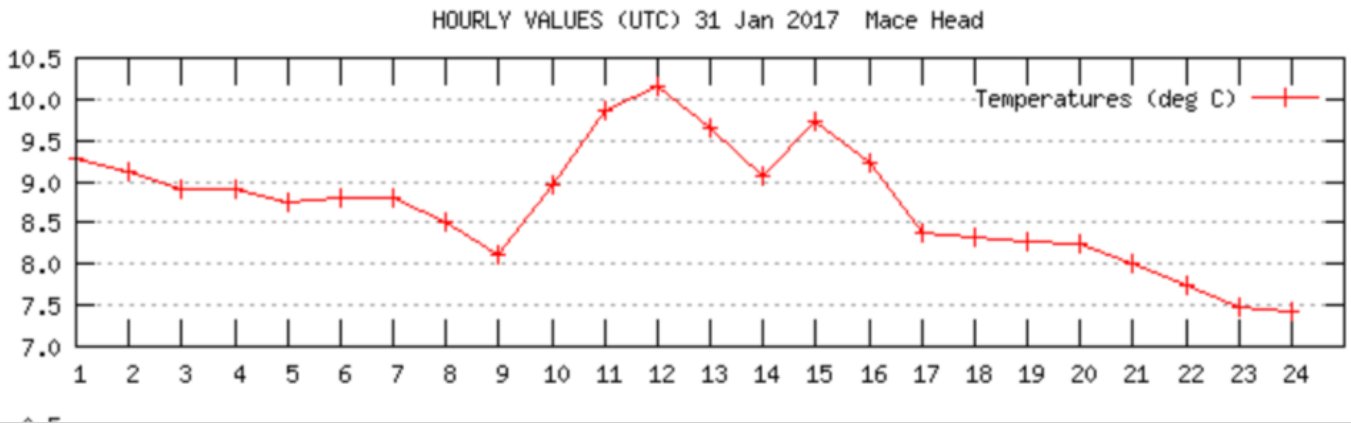
Daily Data

Weather Station Data - From 13/03/2015 to 12/03/2017

Please Select a Station and Date from the menu on the right.

REPORTS FROM MACE HEAD (A)

Date	Rainfall (mm)	Max Temp (°C)	Min Temp (°C)	Grass Min Temp (°C)	Mean Wind Speed (knots)	Maximum Gust (if >= 34 knots)	Sunshine (hours)
31/1/2017	0	10.3	7.3	5.8	10		



Select Station & Date

Station

Mace Head (A)

Date

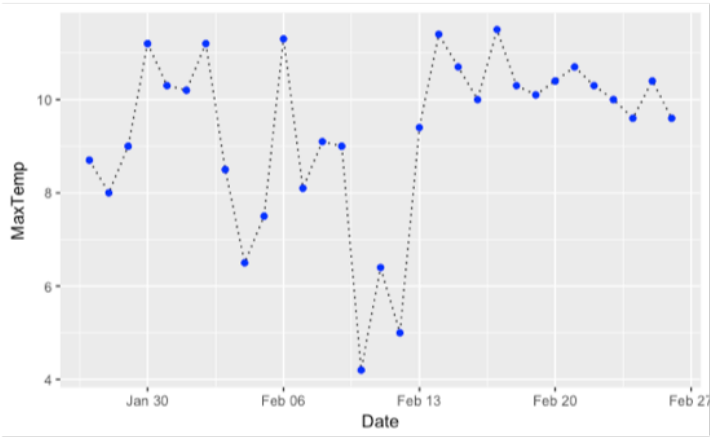
31/01/2017

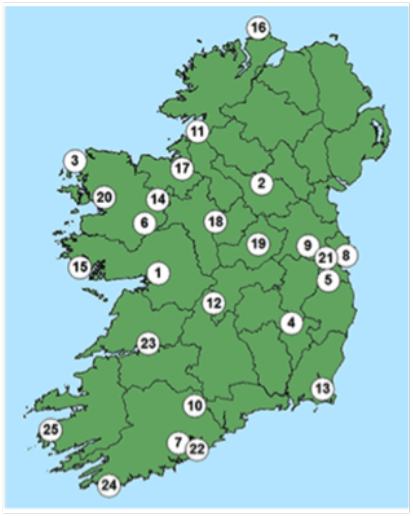
Go ->

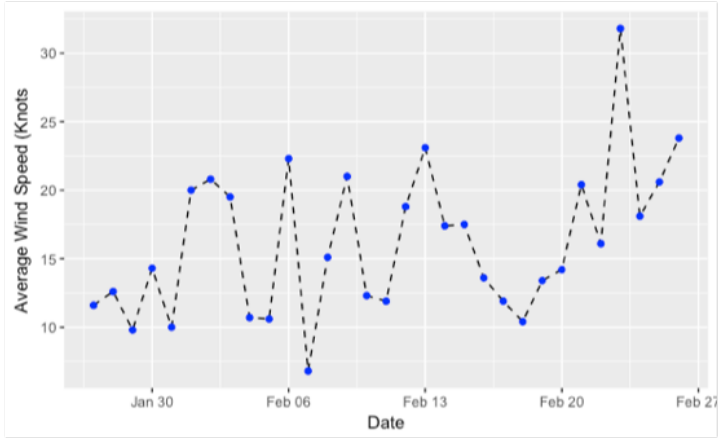
Synoptic Stations 2011

http://www.met.ie

Mace Head Daily Data







Date	Rainfall	MaxTemp	MinTemp	GrassMinTemp	AVRWind	MaxWindGust
27/01/17	7.9	8.7	4.3	-0.7	11.6	
28/01/17	3.5	8	4.5	2.9	12.6	
29/01/17	4.7	9	4.9	3.7	9.8	
30/01/17	7.8	11.2	7.1	5.8	14.3	
31/01/17	0	10.3	7.3	5.8	10	
01/02/17	0.6	10.2	6.1	5.2	20	38
02/02/17	4.9	11.2	7.4	6.4	20.8	45
03/02/17	2.2	8.5	3.6	2.1	19.5	46
04/02/17	5.3	6.5	1.8	-1.3	10.7	

Weather Data

```
wd <- read_excel("../../datasets/energy/Mac Head Wind Data.xls
wd <- mutate(wd,Date=ymd(Date))
slice(wd,1:7)
```

```
## # A tibble: 7 x 7
##   Date       Rainfall MaxTemp MinTemp GrassMinTemp AVRWind
##   <date>        <dbl>   <dbl>   <dbl>        <dbl>   <dbl>
## 1 2017-01-27      7.9     8.7     4.3         -0.7    11.6
## 2 2017-01-28      3.5     8       4.5          2.9    12.6
## 3 2017-01-29      4.7     9       4.9          3.7     9.8
## 4 2017-01-30      7.8    11.2     7.1          5.8    14.3
## 5 2017-01-31      0      10.3     7.3          5.8    10
## 6 2017-02-01      0.6    10.2     6.1          5.2    20
## 7 2017-02-02      4.9    11.2     7.4          6.4    20.8
```

Select Required Columns - Generation

```
gd <- select(ener,DateTime,Date,Wind) %>%
      arrange(DateTime)
slice(gd,1:7)
```

```
## # A tibble: 7 x 3
##   DateTime            Date        Wind
##   <dttm>              <date>     <dbl>
## 1 2017-01-29 00:00:00 2017-01-29   449
## 2 2017-01-29 00:15:00 2017-01-29   505
## 3 2017-01-29 00:30:00 2017-01-29   521
## 4 2017-01-29 00:45:00 2017-01-29   492
## 5 2017-01-29 01:00:00 2017-01-29   538
## 6 2017-01-29 01:15:00 2017-01-29   561
## 7 2017-01-29 01:30:00 2017-01-29   484
```

Select Required Columns - Weather

```
wd1 <- select(wd,Date,AVRWind) %>%
       arrange(Date)
slice(wd1,1:7)
```

```
## # A tibble: 7 x 2
##   Date       AVRWind
##   <date>       <dbl>
## 1 2017-01-27    11.6
## 2 2017-01-28    12.6
## 3 2017-01-29     9.8
## 4 2017-01-30    14.3
## 5 2017-01-31    10
## 6 2017-02-01    20
## 7 2017-02-02    20.8
```

Approach

Need to find the average generation by wind from grid data

```
avr_wd1 <- gd %>% group_by(Date) %>%
  summarise(AvrWindGeneration=mean(Wind))
slice(avr_wd1,1:7)
```

```
## # A tibble: 7 x 2
##   Date       AvrWindGeneration
##   <date>                 <dbl>
## 1 2017-01-29              431.
## 2 2017-01-30             1726.
## 3 2017-01-31              330.
## 4 2017-02-01             2047.
## 5 2017-02-02             2647
## 6 2017-02-03             1050.
## 7 2017-02-04              591.
```

Join the tables

```
join_t <- left_join(avr_wd1,wd1)
```

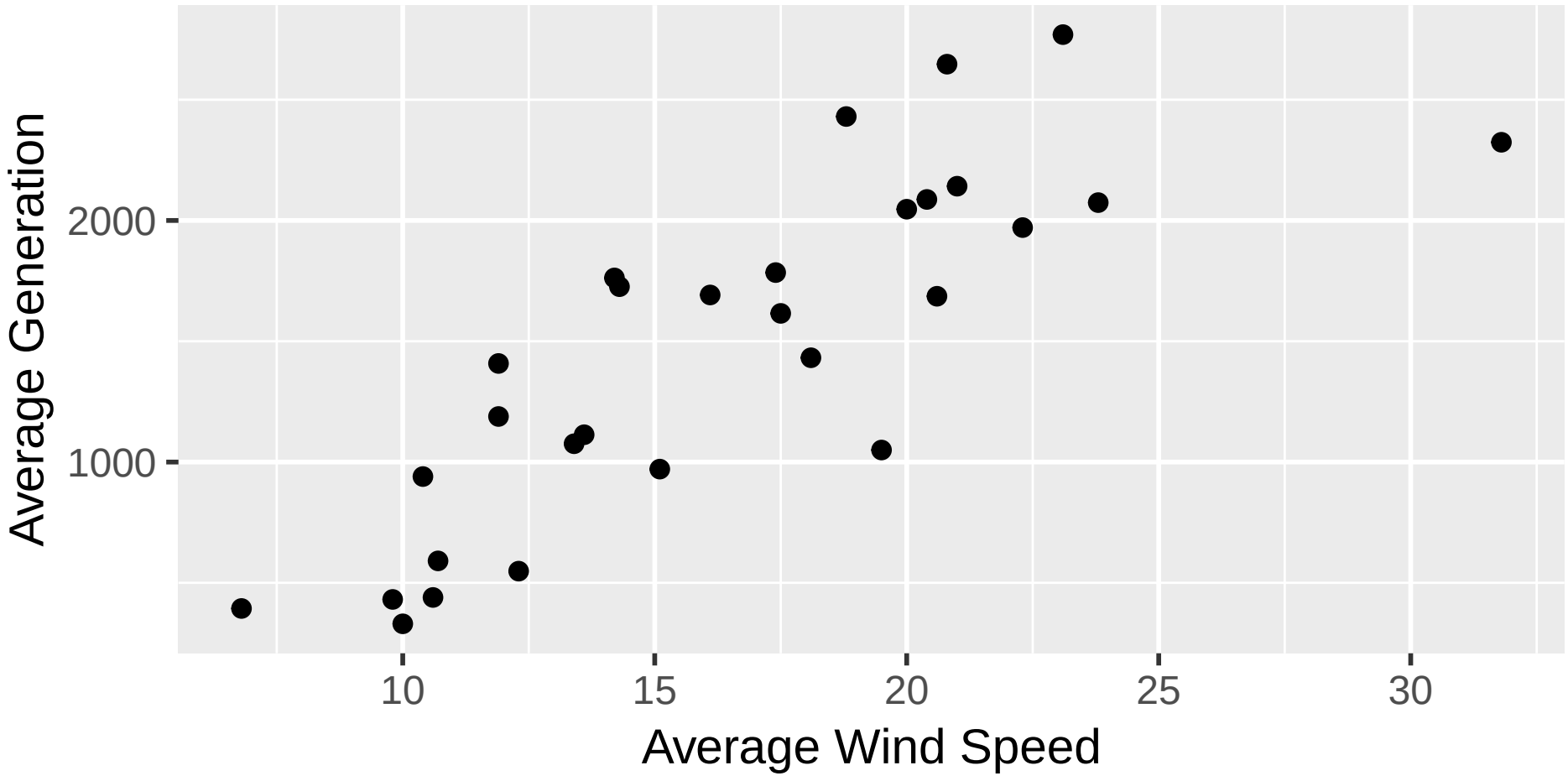
```
## Joining, by = "Date"
```

```
slice(join_t,1:7)
```

```
## # A tibble: 7 x 3
##   Date       AvrWindGeneration AVRWind
##   <date>                 <dbl>   <dbl>
## 1 2017-01-29              431.     9.8
## 2 2017-01-30             1726.    14.3
## 3 2017-01-31              330.    10
## 4 2017-02-01             2047.    20
## 5 2017-02-02             2647     20.8
## 6 2017-02-03             1050.    19.5
## 7 2017-02-04              591.    10.7
```

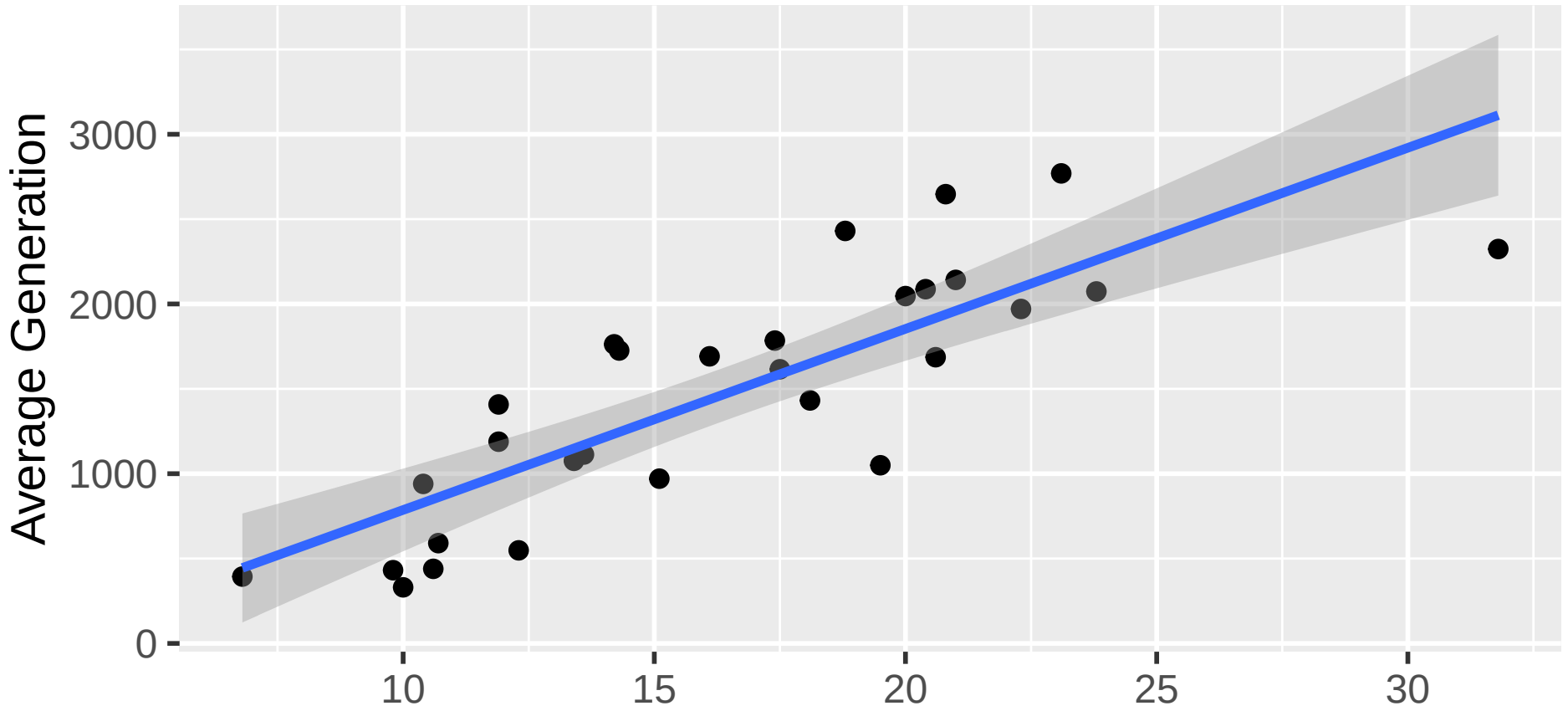
Plot Avr Wind Speed v Avr Wind Generation

```
ggplot(data = join_t) +
  geom_point(aes(x=AVRWind,y=AvrWindGeneration))+
  xlab("Average Wind Speed") + ylab("Average Generation")
```



Visualise Linear Model

```
ggplot(data = join_t,
       aes(x=AVRWind,y=AvrWindGeneration)) +
  geom_point()+xlab("Average Wind Speed") + ylab("Average Gene
  geom_smooth(method="lm")
```



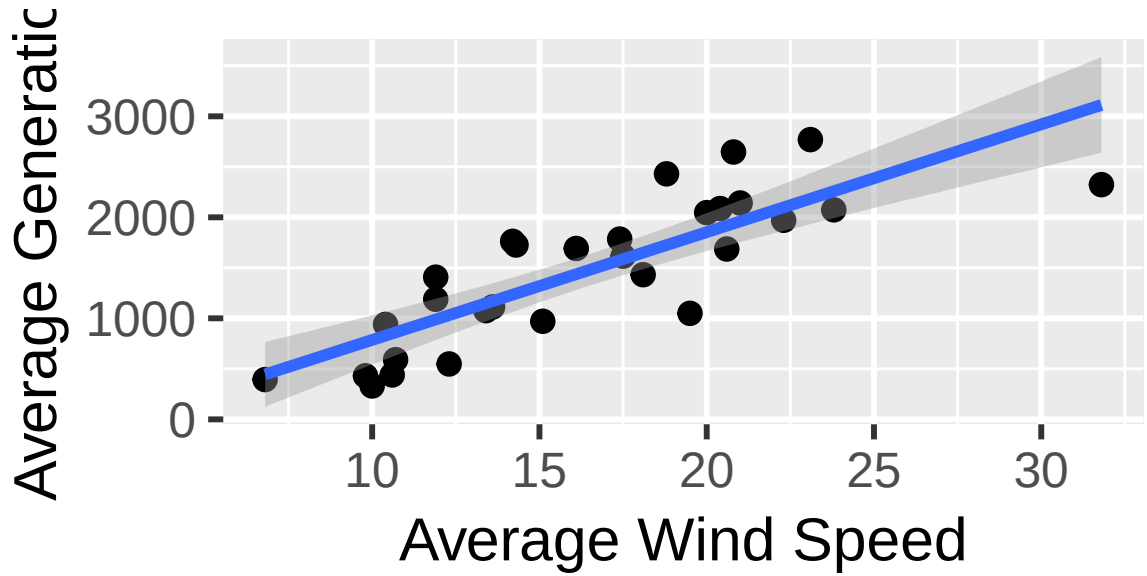
Generate Model

```
mod <- lm(data=join_t,AvrWindGeneration~AVRWind)
mod
```

```
##
## Call:
## lm(formula = AvrWindGeneration ~ AVRWind, data = join_t)
##
## Coefficients:
## (Intercept)      AVRWind
##      -280.8        106.7
```

Predicting Values

```
ggplot(data = join_t,aes(x=AVRWind,y=AvrWindGeneration)) +
  geom_point()+xlab("Average Wind Speed") +
  ylab("Average Generation")+geom_smooth(method="lm")
```




```
predict(mod, newdata = data.frame(AVRWind=25))
```

```
##        1
## 2386.727
```

Challenge

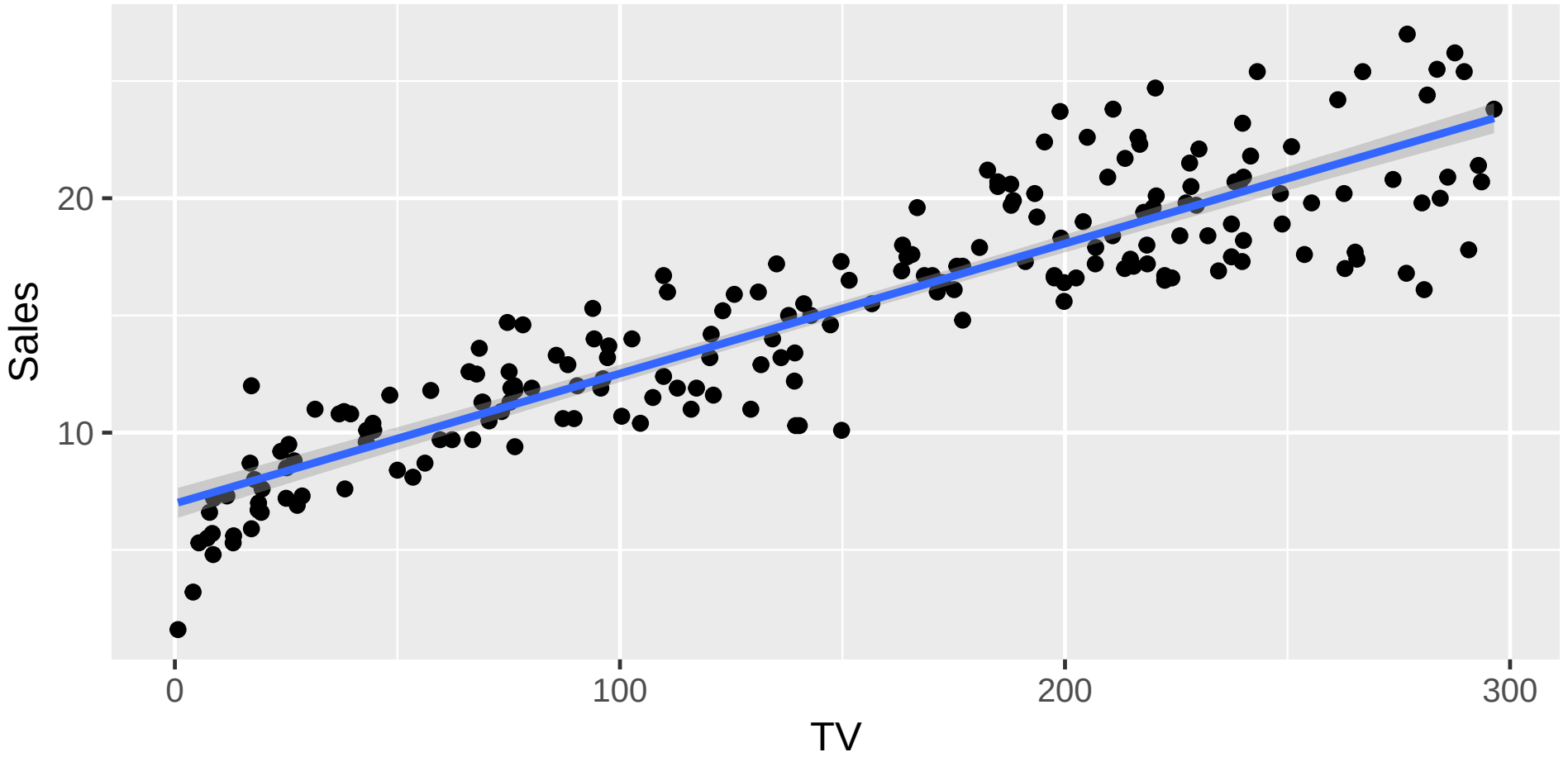
Generate linear models with the advertising data

```
adv <- read_excel("../../datasets/Advertising/AdvertisingData.
slice(adv,1:8)
```

```
## # A tibble: 8 x 4
##      TV Radio Newspaper Sales
##   <dbl> <dbl>     <dbl> <dbl>
## 1 230.   37.8      69.2  22.1
## 2  44.5  39.3      45.1  10.4
## 3  17.2  45.9      69.3  12
## 4 152.   41.3      58.5  16.5
## 5 181.   10.8      58.4  17.9
## 6   8.7  48.9      75     7.2
## 7  57.5  32.8      23.5  11.8
## 8 120.   19.6      11.6  13.2
```

Visualise Relationship

```
ggplot(data = adv,
       aes(x=TV,y=Sales)) +
  geom_point()+geom_smooth(method="lm")
```



Summary

- Shows use of **dplyr**, **ggplot2** and **lm**
- Linking data to explore relationships
- Building a simple linear model
- Predicting future values