PECO Calculations

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Introduction

The impediments to fairly dividing the bills are two-fold.

1. Everyone should be paying for the baseline energy consumed daily regardless of household inhabitants.
2. Not everyone is at the house on the same days.

Procedure

To address this problem the following cost calculation procedure is conducted:

Step 1: Dataset

A dataset was created consisting of each person's days at the house, the total cost per kiloWatt hour for each day (because there's a per unit fee for distribution, generation, and transmission), and the amount of kiloWatt hours used.

The beginning of the dataset looks like the following:

```
d <- read.csv("data/PECOdata.csv") %>%
  filter(.,complete.cases(.))
head(d)
```

```
##       Date Aaron Kayleen Gabe Kian  Eli Mateo Usage Bill per.unit
## 1  11/5/20  TRUE    TRUE TRUE TRUE TRUE  TRUE    31    1  0.12987
## 2  11/6/20  TRUE    TRUE TRUE TRUE TRUE  TRUE    31    1  0.12987
## 3  11/7/20  TRUE    TRUE TRUE TRUE TRUE  TRUE    30    1  0.12987
## 4  11/8/20  TRUE    TRUE TRUE TRUE TRUE  TRUE    30    1  0.12987
## 5  11/9/20  TRUE    TRUE TRUE TRUE TRUE  TRUE    33    1  0.12987
## 6 11/10/20  TRUE    TRUE TRUE TRUE TRUE  TRUE    30    1  0.12987
```

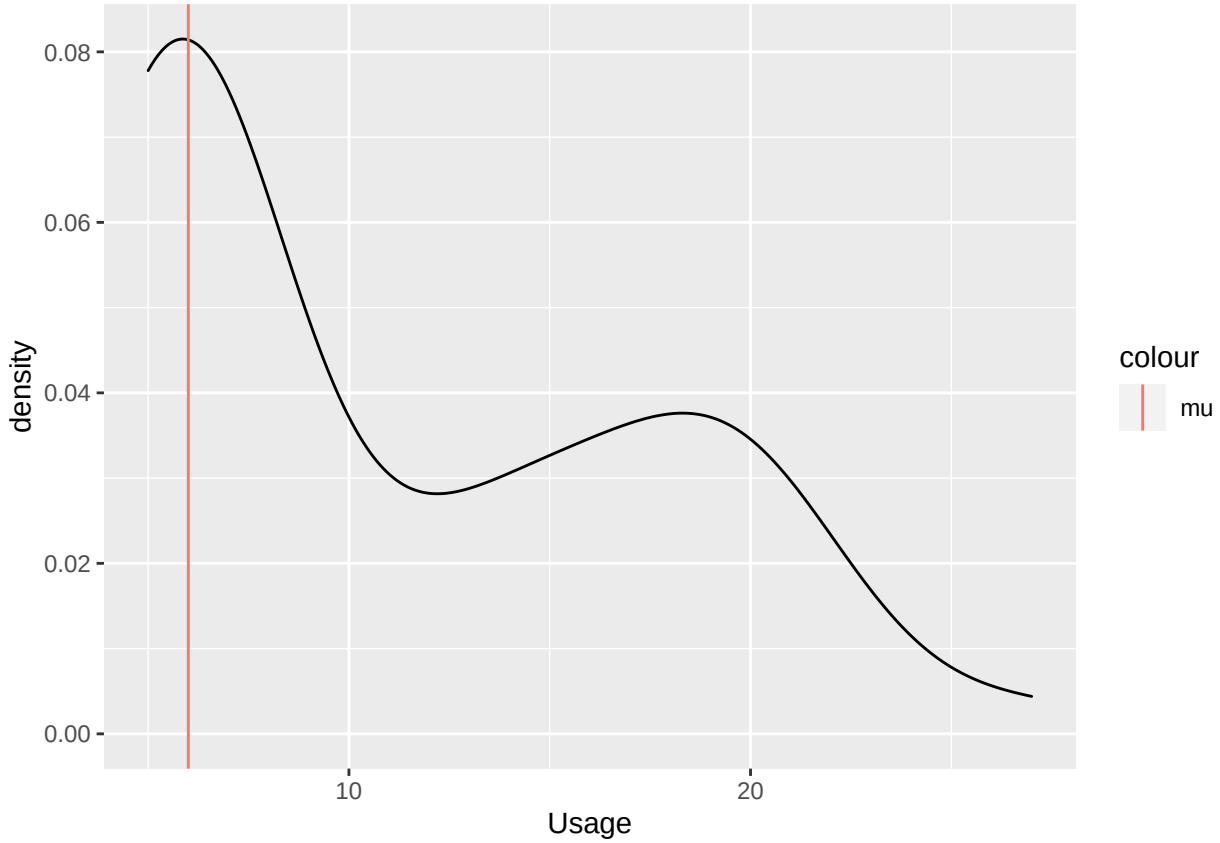
Step 2: Estimate Personal kWh Consumption

We look for days when there is no one at the house to calculate the uninhabited median kiloWatt hour consumption. Call this μ. I compute mu in the following way:

```
mu_data <-
  d %>%
  filter(Aaron == F &
           Kayleen == F &
           Gabe == F &
           Kian == F &
           Mateo == F)
mu <-
  mu_data %>%
  summarise(mu=median(Usage)) %>%
```

```
  pull()

ggplot(mu_data)+
  geom_density(aes(x=Usage))+
  geom_vline(aes(xintercept=mu,col="mu"))
```



With $\mu = 6$, we then say that each person consumes $\frac{\mu}{6}$ kWh per period. Each persons total consumption per period is usage by:

$$u_t^{name} = \begin{cases} \frac{\mu}{6} + \frac{i_t^{name}}{\sum_{n \in names} i_t^n} \cdot (\texttt{Usage} - \mu) & \texttt{Usage} \geq \mu \ \& \text{ inhabited} \\ \frac{\texttt{Usage}}{6} & \text{otherwise} \end{cases}$$

In the above formula i_t^{name} is a indicator variable that takes 1 if the person is at the house at time t, and 0 otherwise. Note that if there is no one at the house we simply divide usage by 6.

This usage formula has the desirable feature that the sum of each person's usage is always equal to the total usage. The reason why this function is piecewise is because in the cases when household consumption is less than μ, which happens, it is possible for the people at the house to pay less than those not there, not the right result.

Now let's compute this usage:

```
d_long <-
  d %>%
  pivot_longer(cols=-c(Date,Usage,Bill,per.unit))
d_long <-
  d_long %>%
```

```
  group_by(Date) %>%
  mutate(
    usage_est=
      case_when(
      (Usage>=mu) & (sum(value)>0) ~mu/6+(value/sum(value))*(Usage-mu),
      TRUE~Usage/6
    )
  )
```

Note that a random sample of the total usage minus the total estimated usage are zero

```
set.seed(1234)
  d_long %>%
  group_by(Date) %>%
  summarise(difference=Usage-sum(usage_est)) %>%
  ungroup() %>%
  sample_n(6) %>%
  head()
```

```
## `summarise()` regrouping output by 'Date' (override with `.groups` argument)
```

```
## # A tibble: 6 x 2
##   Date     difference
##   <chr>         <dbl>
## 1 11/26/20          0
## 2 1/24/21           0
## 3 12/18/20          0
## 4 1/24/21           0
## 5 1/25/21           0
## 6 11/7/20           0
```

Step 3: Compute Personal Daily Contribution

We have now given each person a kWh contribution, and since we have a per period price, the only step left is multiplying these two to compute each persons daily electric bill.

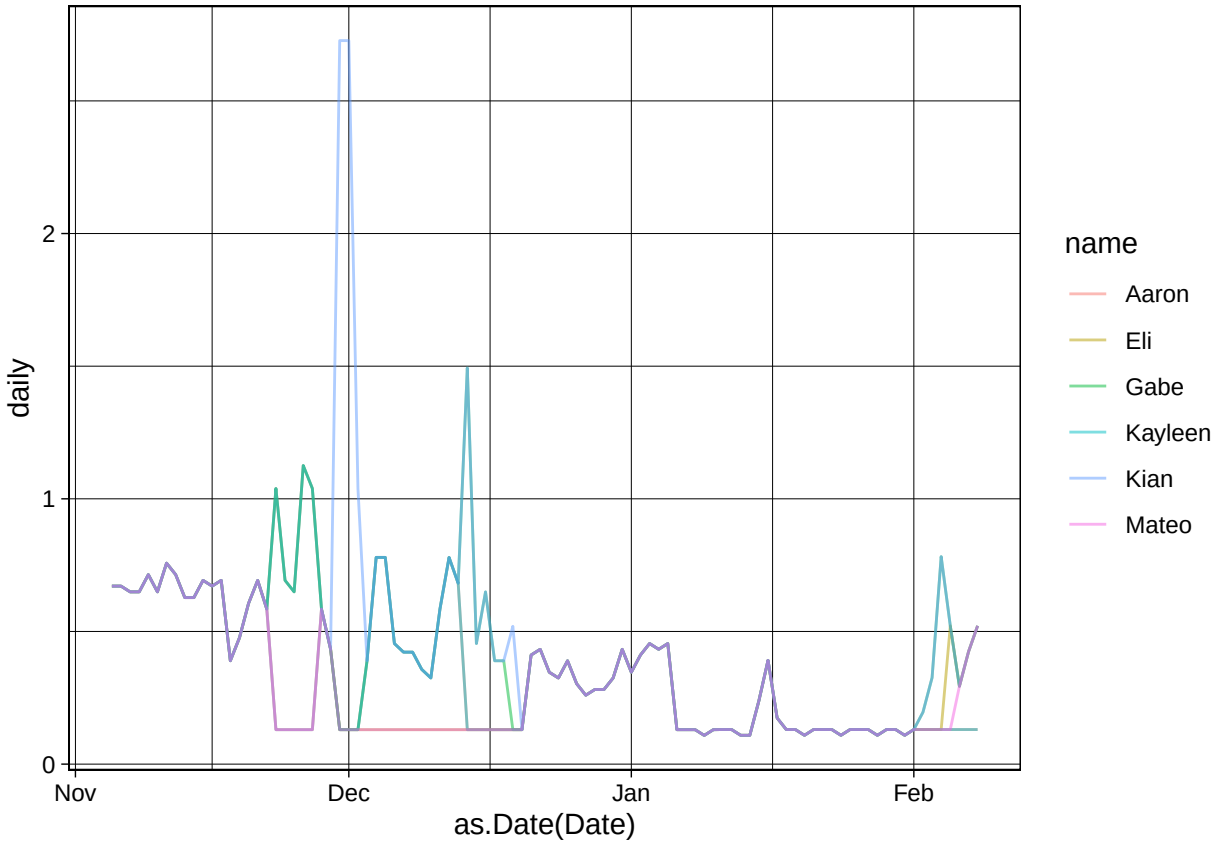
We can do that in the following way:

```
final_data <-
  d_long %>%
  mutate(daily=usage_est*per.unit) %>%
  group_by(name) %>%
  mutate(total=sum(daily)) %>%
  ungroup() %>%
  mutate(Date=lubridate::mdy(Date))
```

```
knitr::kable(final_data %>% select(name,total) %>% unique() %>% arrange(total),format = 'latex')
```

name	total
Mateo	27.35445
Eli	27.74550
Aaron	34.94836
Kayleen	34.94836
Gabe	39.82599
Kian	42.42333

Plot Our expenses over time



Okay that's great, but there are fixed costs

Let's add fixed costs, we know that the total expense should be the sum of each of the bills: \$122.09+74.65+40.82=237.56. Okay easy enoug, take the residual not yet covered by the sum of our individual contribution and divide it by six.

We currently have accounted for \$207.24599

That leaves \$30.31401. Adding an additional 5.052335 to each person. This brings everyone's totals to:

name	total_w_fixed
Mateo	32.41
Eli	32.80
Aaron	40.00
Kayleen	40.00
Gabe	44.88
Kian	47.48