Forecasting periods of maximum electricity consumption

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Introduction

- Reduce energy consumption during peak times in the winter period.
- Add a surcharge to the three half-hour periods of highest energy consumption.
- These ‘Triads’ must be spaced by at least 10 days.

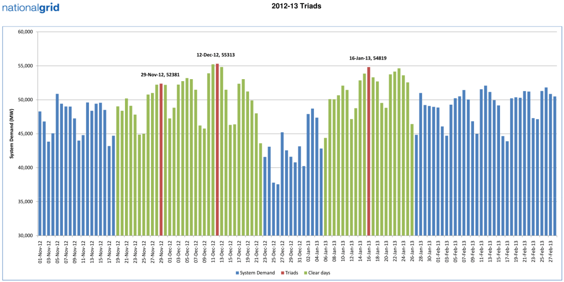


Figure: www2.nationalgrid.com

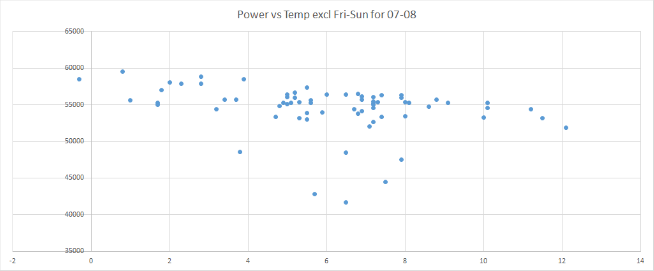
Dissecting the Problem

We want to correctly identify the three triads, with a small number of warnings.

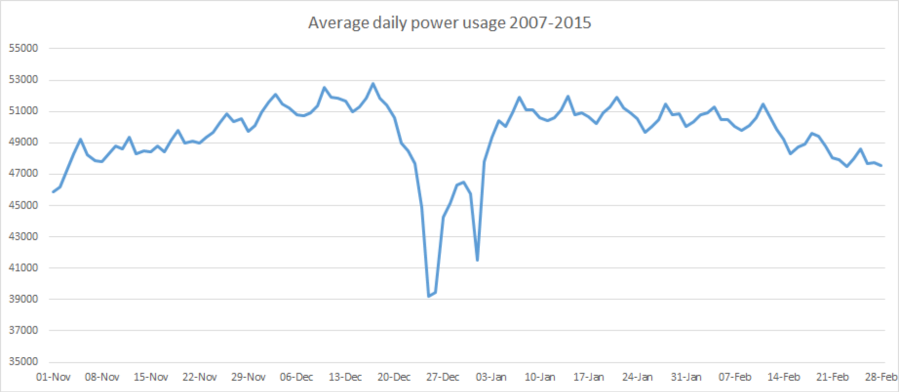
- Capture three minima in the system.
- Use forecast data in our method.
- Include historical data.
- The triads have to be spaced by at least 10 days.

Assumptions

- Discount weekends and holidays.
- Cold weather is the only thing that determines energy consumption.
- There is no feedback - giving customers a warning won't change the position of a triad.



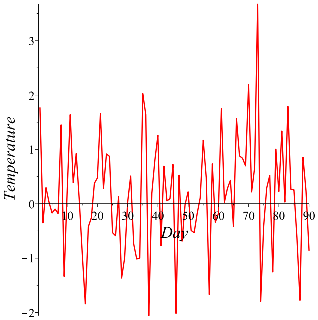
Assumptions: Continued



The Secretary Problem

A simplification of our problem.

- We look at the secretary problem.
- Give one warning and try to give it on the worst day.

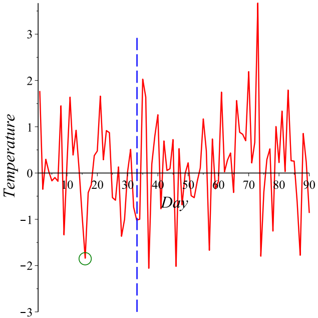


Optimal Algorithm

- Do not choose the first r days.
- Give a warning on the first day worse than the first r days.

$$P_{\text{success}}(r) = \frac{1}{n} \sum_{i=r+1}^{n} \frac{r-1}{i-1}$$

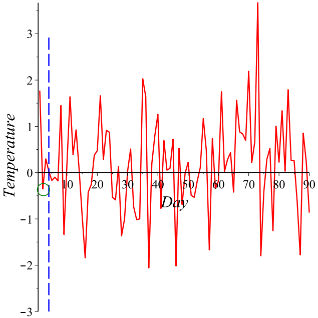
- It can be shown that for large n, optimal $r = n/e$, and $P_{\text{success}}(n/e) = 1/e$.



An Extension of the Secretary Problem

- We now allow k warnings, and want to guess the minimum.
- We adjust the secretary problem, find r using a numerical method.

$$P_{\text{success}}(r) = \frac{n-r}{n} + \frac{1}{n}\sum_{i=r+k}^{n} \frac{(i-k-1)!(i-r)!}{(i-1)!(i-k-r)!k!}$$



Here $k = 3$, which gives $r = 4$, and $P_{\text{success}}(4) = 0.852$.

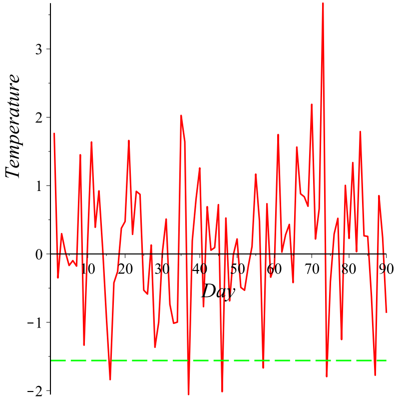
Benefits and Limitations

+ We can choose how many warnings we want to give.
+ Easy to implement.
+ Has a much smaller rejection region

– How good it is for three minima?
– The distributions are i.i.d.
– It doesn't account for historical data.

An Alternative Method

- We assume we know the distribution that the weather takes.
- We find a threshold value C, if the temperature is lower than C, assign a warning.

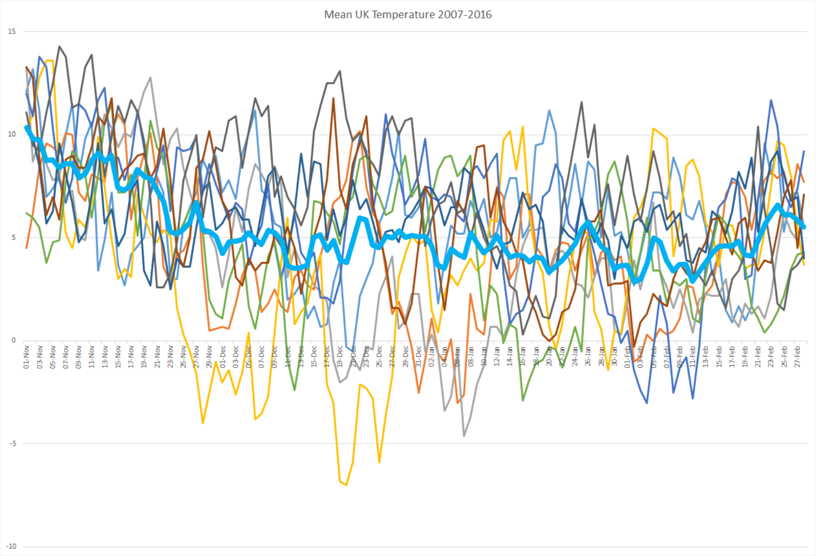


Benefits and Limitations

+ Easy to implement.
+ Choose accepted accuracy.
+ Take into account historical data.
+ Captures 3 minima.

– Historical data is all over the place!
– We haven't included forecasting, or spacing between triads.

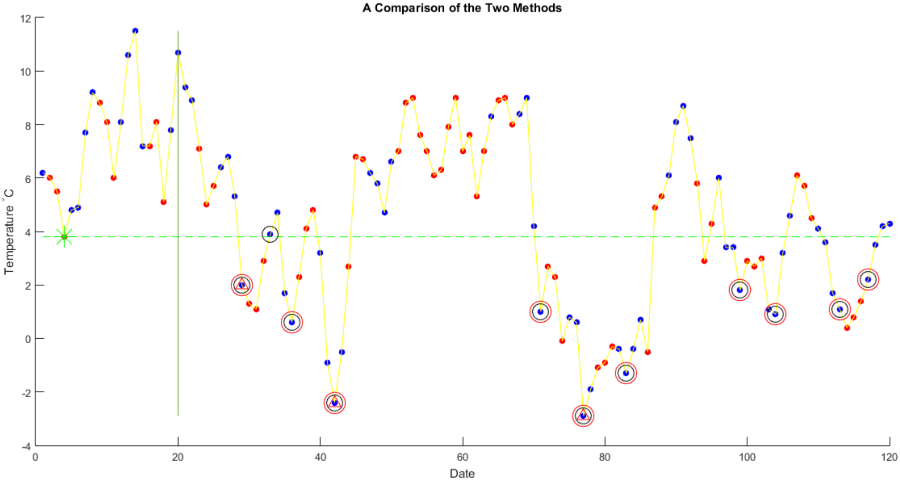
Historical Data



Including Forecasting

- We assume we have an accurate forecast for today and tomorrow.
- On day k, if day $k+1$ is forecast to be worse, we don't assign a warning to day k, UNLESS day k is a Thursday!
- We also use previous data from the same week.

An Example of the Algorithm



Applying the Algorithm

2007	2007	2008	2008	2009	2009	2010	2010	2011	2011	2012	2012	2013	2013	2014	2014	2015	2015
41	41	24	24	31	31	25	25	23	23	29	29	-	81	25	25	23	23
47	47	32	32	47	47	29	29	35	31	36	33		91	34	34	44	39
50	50	38	38	65	65	36	36	44	35	42	36			38	38	65	44
64	64	41	41	68	68	43	43	49	44	71	42			45	45	67	65
111	111	45	45	74	74	50	50	77	49	77	71			66	66	72	67
		67	67	81	79	64	64	85	64	83	77			76	76	75	72
		75	75	87	81	81	81	92	77	99	83			81	81	81	75
		81	81	93	87	88	88	94	85	104	99			90	90	89	81
		88	88	100	93	92	92	100	92	113	104			94	94	95	89
		94	94	103	100			105	94	117	113			103	103	101	95
		101	101	107	103			112	100		117			109	109	103	101
				110	107				105					115	115	108	103
				114	110				112							117	108
					114												117

Threshold temperature:

2.70	2.76	4.50	5.84	4.90	5.67	3.00	2.21	6.70	6.95	3.80	4.15	2.70	3.46	5.90	6.11	6.90	8.17

Number of warnings issued:

5	5	11	11	13	14	9	9	11	13	10	11	0	2	12	12	13	14

N.B. NPower issue an average of 17 warnings per year.

Naive threshold temperature: average 9.7 warnings issued

Derived threshold temperature: average 10.1 warnings issued

Conclusions

- We've created a mathematically justified algorithm
- We've used less warnings then N-Power
- However:
  - What about the triad spacing?
  - What about uncertainty in forecasting?
  - Do warnings produce negative feedback?

Thanks for listening!