125 years of data

EEA – 21st June, 2013

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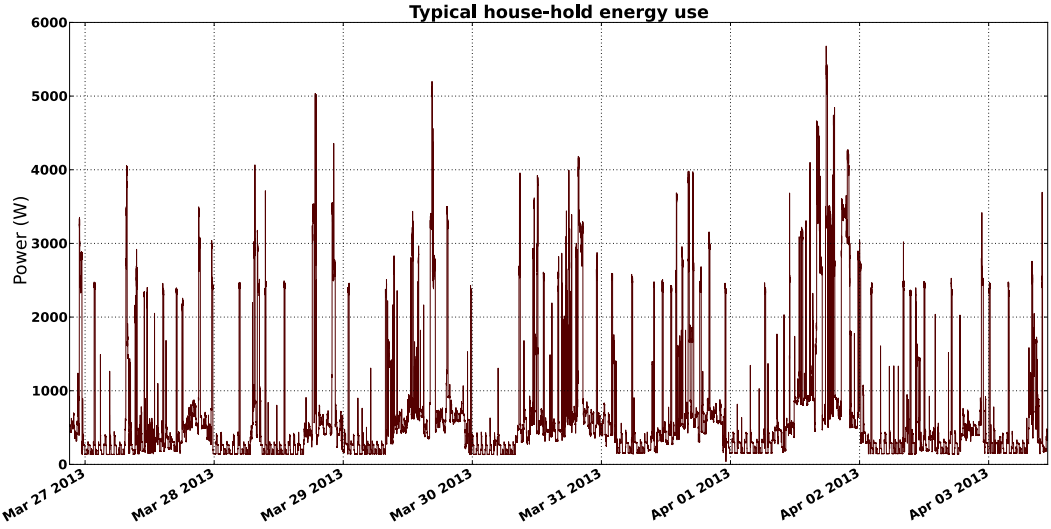
My home energy monitor – Current Cost + RaspberryPi

Current Cost energy monitor

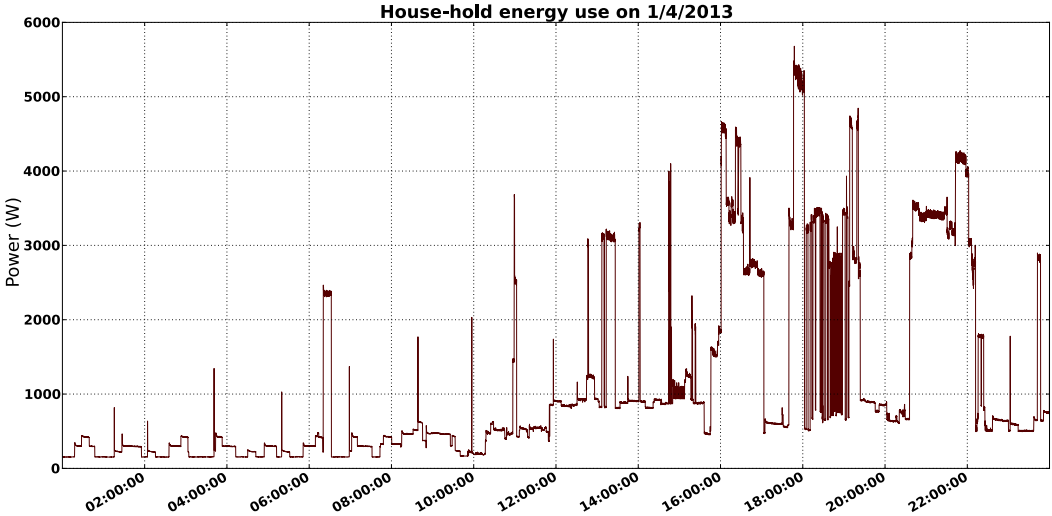
Raspberry Pi computer

- Python script
- MySQL database
- iPython

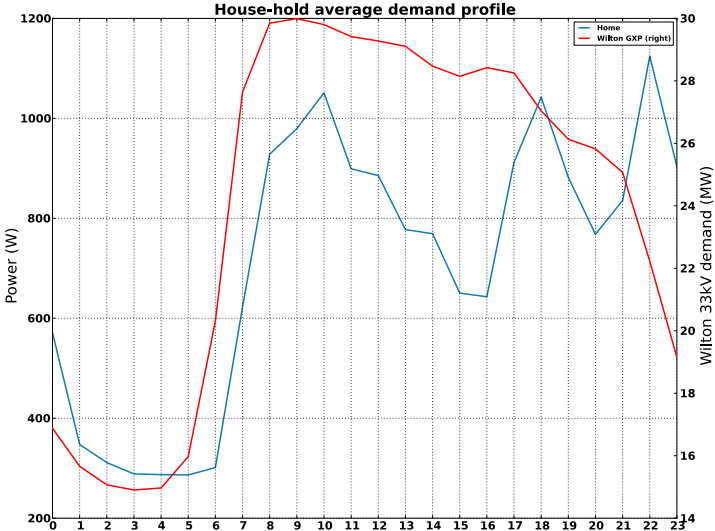
My home energy monitor – weeks worth of data



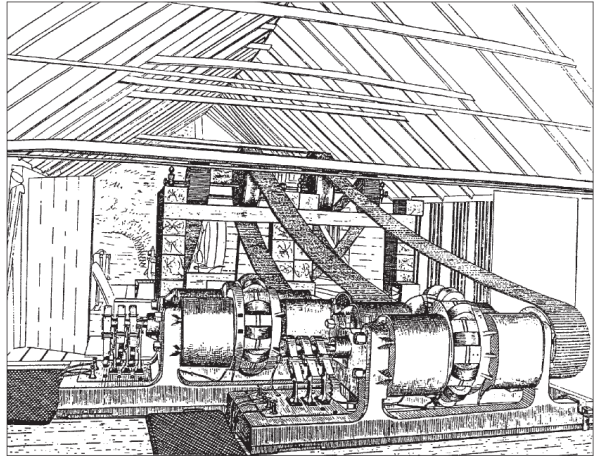
Home energy monitoring – a high usage day



Profiling over 5 months of data

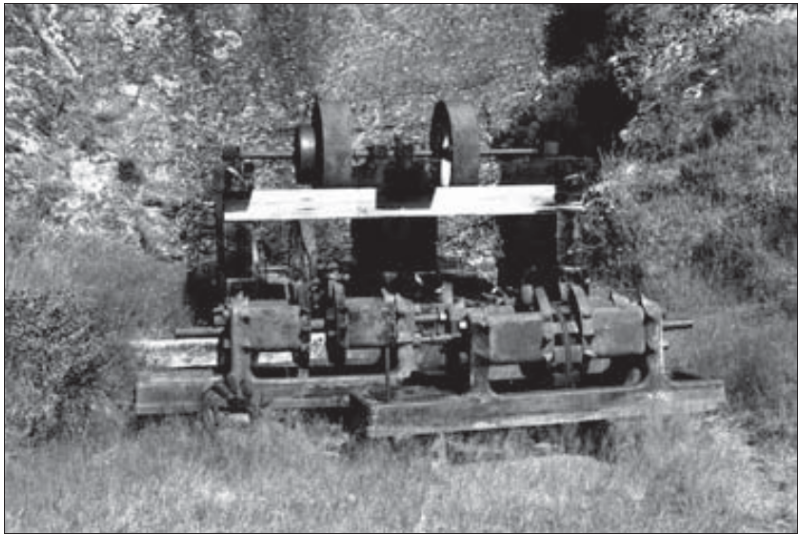


Bullendale – 127 years ago



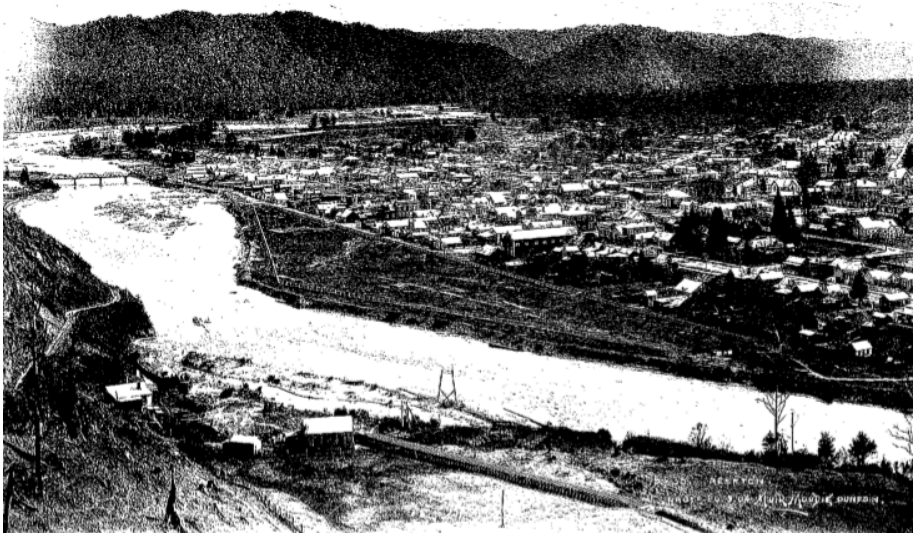
Source: People, Politics and Power Stations

Bullendale – 1986



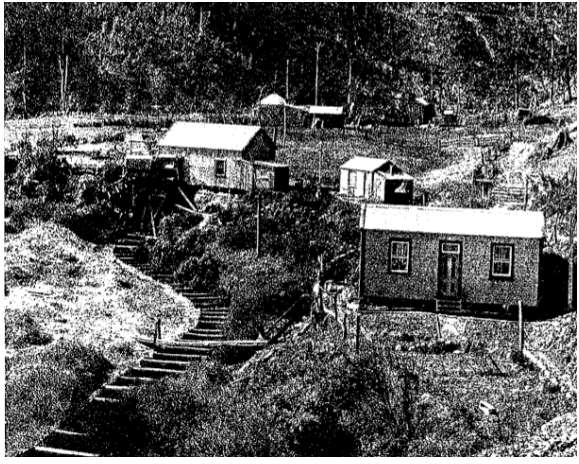
Source: Gold and electricity. Archaeological survey of Bullendale, Otago

Reefton – 125 years ago

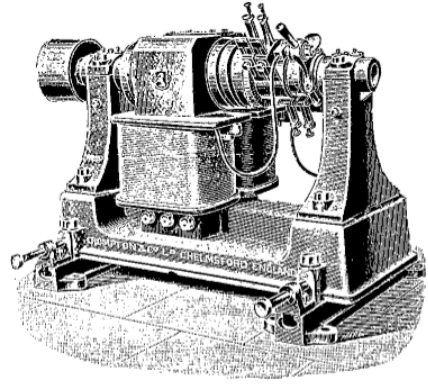


Source: People, Politics and Power Stations

Reefton – 125 years ago



Crompton DC bipolar dynamo



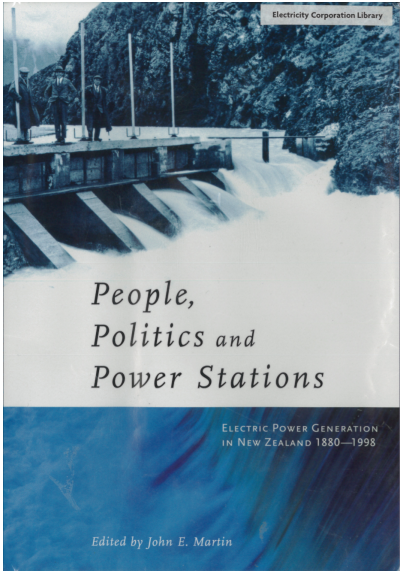
Source: People, Politics and Power Stations

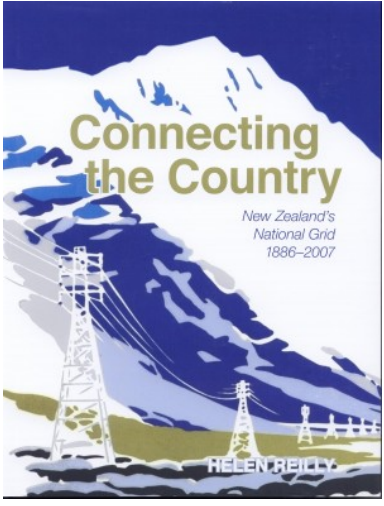
Reefton – today

Source: Wikipedia

EA Data Warehouse – today

What about historic data. . .





Historic data, NominalGenerationCapacity.txt (CDS)

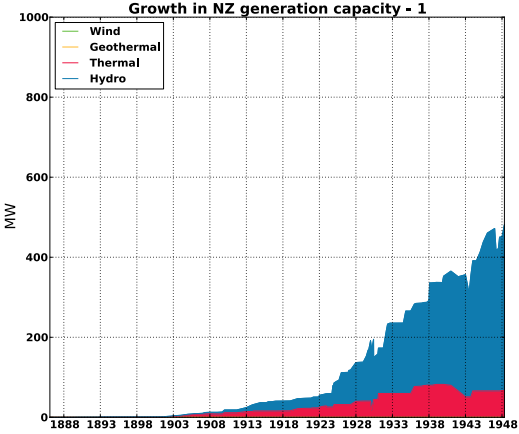
```
Step Time,+-Difference
Nominal.Hydro.Bullendale                          Head 185' First industrial supply in N.Z. that left th
   3/2/1886      50 Trial run. Two 50HP Pelton wheels drove two DC generators, 750RPM.
     1/1887       0 Breakdown.
     6/1887      60 I'll guess just a few months. Solid aron armatures replaced by laminated, so I'll
       1907       . Mined out.

Nominal.Hydro.Reefton                             Head 27' Reefton: first public supply in N.Z.
   1/8/1888@7pm  20 First demonstration of the first power station in N.Z. for the purposes of public
       1901      46 New 220V Fynn dynamo, part-driven by an added steam engine salvaged from a wreck
       1908      80 A 110HP Boving horizontal turbine replaced the 70HP Rafel turbine.
       1911       0 Power house destroyed by fire!
       1911     100 230V DC Lawrence Scott dynamo.
       1949       .   Reefton was connected to the national grid.
Nominal.Thermal.Reefton                           Steam power to support the Reefton hydro power scheme.
       1901      16 Guessed capacity of the auxiliary steam engine. A second boiler in 1920 (?) Inspe
       1920      75 GEC dynamo. a 25HP Davey Paxman horizontal engine, a 20HP Marshall horizontal eng
       1949       . In 1930 a standby diesel engine. Details lacking!

Nominal.Hydro.Wellington.PanamaStreet             Head ~100'? Water main supply, discharge to the harbou
     6/1889      30 Water mains supplied (at no charge) two 30HP "vortex" turbines driving a 15KW Gul
       1891    +110 Three 50HP turbines driving five generators were installed on the closure of the
```

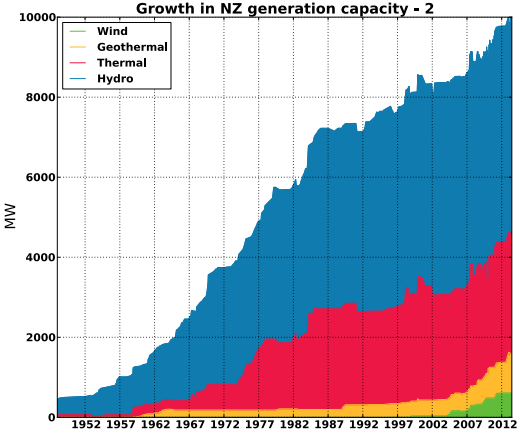
Historic data example – Cobb

Historic data, NominalGenerationCapacity.txt (CDS)

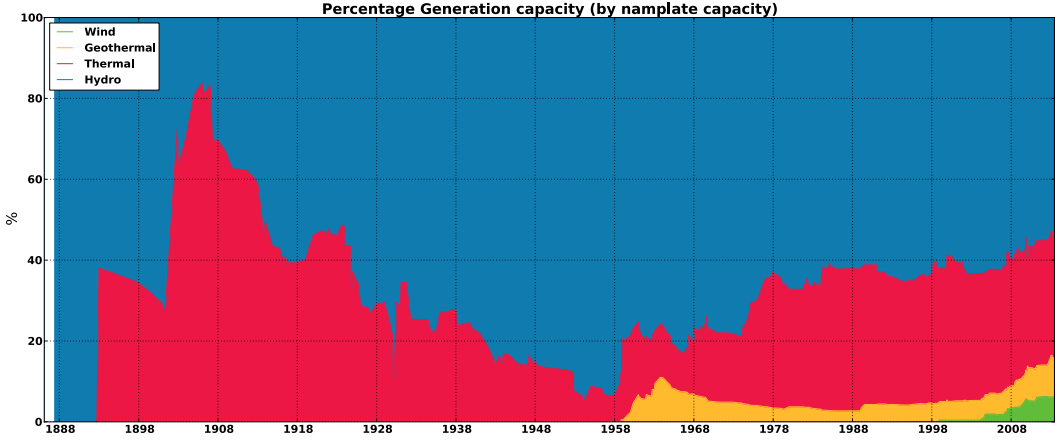
```
Nominal.Hydro.Cobb                                  Head 1876' then 1950' after the earth dam of 107' repl
 23/ 5/1944@3pm       3000 Trial generation, supplied to the Golden Bay Power Board via Motupipi subs
 28/ 5/1944@4:40pm    9000 Three generators working. First transmission to the Stoke substation.
 14/ 6/1944@1pm      12000 Four 3MW single-jet pelton wheels. Ceremony in the afternoon, with Cobb ta
 17/12/1949@11pm         0 Old intake tunnel closed, as it was in the way of the new dam's spillway i
 18/12/1949@5pm      12000 Temporary intake connected to the long tunnel through the hill.
       1950          13000 Run on overload.
     1/1953          10000 Summer water shortage, again. Lake Cobb's exit had been blasted open, and
     3/1954          13000 A March deluge! Full power, then.
 19/ 9/1954@6:20pm   10000 New penstock and generators start, the old overhauled. Two 10MW double-jet
 20/ 9/1954@5:15pm  +10000 Second new generator started.
     2/1955          16000 Lack of water forced a 20% cut.
     3/1955          32000 Another March deluge, but this time less fear of overtopping the dam under
     4/1955          25000 Run out of water already!
     5/1955          32000 Some filling allowed, the lower lake backing to Lake Halley. The desperate
 26/ 1/1968              0 Harry's mistake! Generator 1 was under maintenance, and the water valve wa
 27/ 1/1968@9:30pm   20000 Generators 5 and 6 back in service after much scrabbling. I'll guess that
     2/1968          32000 I'll guess all are back.
     1/1975              0 Drought. Shutdown to keep silt out of the works!
     3/1975          32000 I'll guess that March again refilled the lake.
 16/11/1981@1:09am       0 Landslide! Carried away a section of both pipelines.
 19/ 8/1982          20000 First two generators activated. All had absorbed moisture in the cool powe
 20/ 8/1982          32000 Full power.
```

Nameplate generation growth





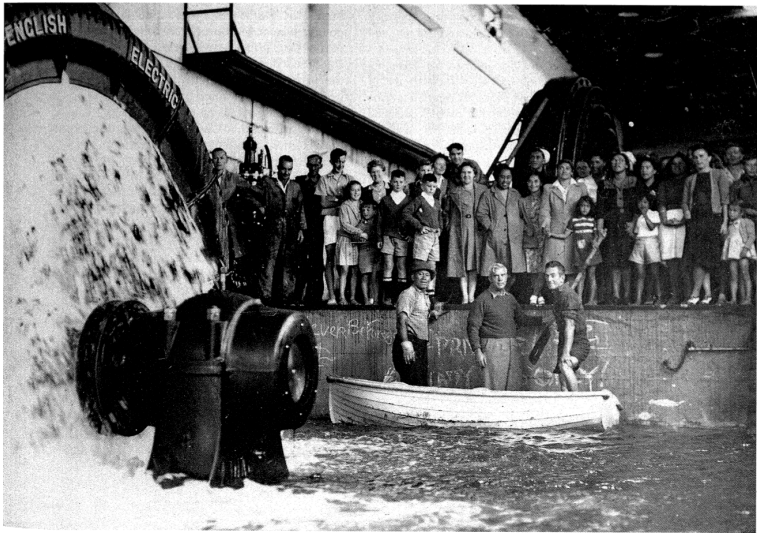
% growth by generation type



Insteresting historic generation events

```
Nominal.Hydro.Reefton                          Head 27' Reefton: first public supply in N.Z.
      1911       0 Power house destroyed by fire!
Nominal.Hydro.Kourarau                         Two power stations and pipes not shown on the topograp
    12/1924       0 Power house drowned by a flood!
     4/2005    -700 Station A again flooded.
     8/2006       0 Cracks in the upper station's penstock, water coming down the hillside...
Nominal.Hydro.Waikato.Arapuni                  Head 175'
   4/6/1929   15000 Early start before the power house was finished, Auckland being needy.
   7/6/1930       0 Seepage. Leakage. Cracks! Voids! Ground movement! EMERGENCY! Criticism! Censorshi
Nominal.Hydro.DawsonFalls                      Head 220' Dawson Falls Lodge. Mains electricity arrive
  21/2/1935       0 Flood!
Nominal.Hydro.Matahina                         Head 200'
     2/1967       0 Leakage discovered, subsidence...
    12/1987       0 Decomissioned in December for repairs after the Edgecumbe earthquake of the secon
Nominal.Hydro.Cobb                             Head 1876' then 1950' after the earth dam of 107' repl
  26/ 1/1968             0 Harry's mistake! Generator 1 was under maintenance, and the water valve wa
  16/11/1981@1:09am      0 Landslide! Carried away a section of both pipelines.
Nominal.Hydro.Kaniere.KaniereForks             Head ~250' Conversion of goldminer's works.
       1973       0 Collapse of the Johnson's flume.
     6/1979       0 Fire! The generators had to be rewound. A rat chewing at cables was suspected.
     6/1981       0 Fire again!! This time the machines had overheated.
Nominal.Hydro.Ruahihi                          Head 280' Canal from Lake McLaren, superceding the Mcl
  20/9/1981@1:50pm . Canal failure! Wipeout!
```

April 1947



Source: People, Politics and Power Stations

Insteresting historic generation events

```
Nominal.Hydro.Pupu                              Head 300' Conversion of a goldminer's water race.
       1981       . A "flashover" ruined the generator.
Nominal.Hydro.Wheao                             Head ~400' Downcanal of Flaxy.
       1983   24000 Two turbines. Destroyed by canal failure just before completion, 30'th December 1
Nominal.Hydro.OmanawaFalls                      Head 100' Underground power house.
     4/1985       0 Cotton insulation on the winding failed! I'll guess the months.
Nominal.Hydro.Glenorchy                         Head 210' Pipeline from the Ox Burn dam.
     1/1994       0 Very heavy rain caused floods and landslides. Detritus reached the roofline of th
Nominal.Hydro.Tokaanu                           Head 682'
       1996  240000 Volcanic ash from the 1995 Mount Ruapehu eruption damaged the turbines. Refurbish
Nominal.Hydro.Rangipo                           Head 788' Underground power house.
     4/1996       0 Ash from eruptions at Ruapehu badly damaged the turbines
Nominal.Hydro.RoaringMeg.Lower                  Head 1000'
    11/1999       0 Flood! The control equipment was ruined.
Nominal.Hydro.Opuha                             Head 160' Overwhelmed by a flood during construction,
 13/01/2001       0 The washout weir washed out.
    11/2003       0 Fire destroyed the generators! Or possibly in 2005.
 17/05/2009@6:10  0 Another washout.
Nominal.Wind.GebbiesPass                        Wind turbine, test installation.
  10/3/2005       0 Wrenched apart by wind swirl!
Nominal.Hydro.Karaponga                         Head ~30 feet. Guesswork: the dam is 18'5"
     9/2010       0 Penstocks imploded!
```

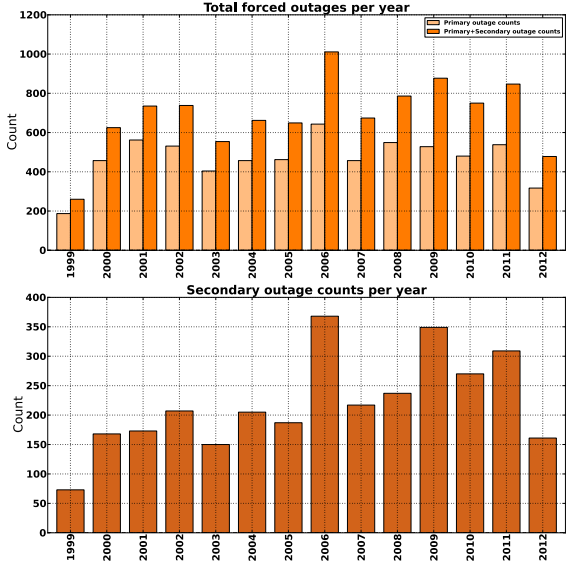
22 October 1968

Source: http://www.flickr.com/photos/sharman/6690836457/

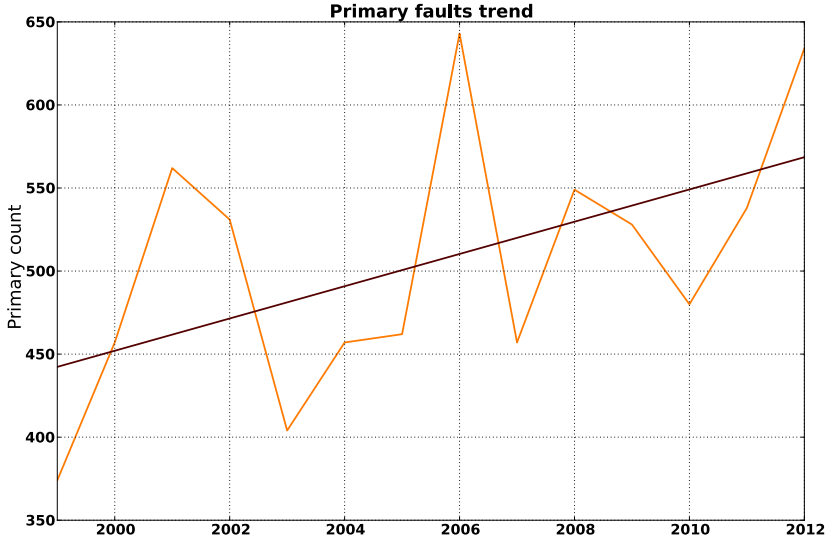
What about Transmission? Unplanned Outage Data (CDS)

Ident	Flt_Item	Rem_Item	Start	End \
SS99101	LIV-NSY1	LIV-NSY1	1999-07-02 11:20	1999-07-02 11:30
		NSY-TF-1	1999-07-02 11:20	1999-07-02 11:40
		NSY-TF-2	1999-07-02 11:20	1999-07-02 11:41
		NSY-ROX1	1999-07-02 11:20	1999-07-02 11:30
SS99102	CML-FKN2	CML-FKN2	1999-07-02 22:13	1999-07-02 22:36
		FKN-TF-4	1999-07-02 22:13	1999-07-02 22:38
SS99103	CML-FKN2	CML-FKN2	1999-07-02 22:50	1999-07-02 23:00
		FKN-TF-4	1999-07-02 22:50	1999-07-02 23:16
SS99104	CML-FKN1	CML-FKN1	1999-07-02 23:04	1999-07-02 23:11
		FKN-TF-2	1999-07-02 23:04	1999-07-02 23:12
SS99105	CML-FKN2	CML-FKN2	1999-07-02 23:09	1999-07-03 16:27
		FKN-TF-4	1999-07-02 23:09	1999-07-03 16:27

Transmission annual forced outage counts



Transmission – primary fault trend



Transmission – Primary fault trend - OLS regression results

OLS Regression Results

Dep. Variable:	counts	R-squared:	0.268
Model:	OLS	Adj. R-squared:	0.207
Method:	Least Squares	F-statistic:	4.403
Date:	Thu, 11 Apr 2013	Prob (F-statistic):	0.0577
Time:	12:45:40	Log-Likelihood:	-78.224
No. Observations:	14	AIC:	160.4
Df Residuals:	12	BIC:	161.7
Df Model:	1		

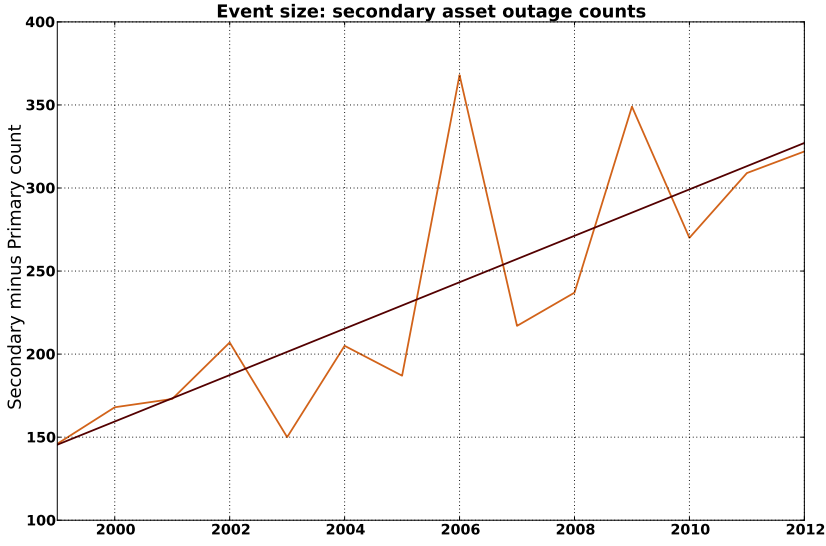
	coef	std err	t	P>|t|	[95.0% Conf.	Int.]
const	442.3143	35.394	12.497	0.000	365.198	519.431
index	9.7099	4.628	2.098	0.058	-0.373	19.792

Omnibus:	1.625	Durbin-Watson:	2.141
Prob(Omnibus):	0.444	Jarque-Bera (JB):	1.281
Skew:	0.630	Prob(JB):	0.527
Kurtosis:	2.220	Cond. No.	14.7

Transmission – Primary fault trend – OLS regression results

- highly variable
- results borderline
- can't conclusively state primary forced outage rate is growing
- what about annual secondary outage counts?

Transmission – Secondary fault trend



Transmission – Secondary fault trend - OLS regression results

OLS Regression Results

Dep. Variable:	counts	R-squared:	0.611
Model:	OLS	Adj. R-squared:	0.578
Method:	Least Squares	F-statistic:	18.83
Date:	Tue, 09 Apr 2013	Prob (F-statistic):	0.000962
Time:	12:01:37	Log-Likelihood:	-73.147
No. Observations:	14	AIC:	150.3
Df Residuals:	12	BIC:	151.6
Df Model:	1		

	coef	std err	t	P>|t|	[95.0% Conf.	Int.]
const	145.4571	24.628	5.906	0.000	91.798	199.117
index	13.9736	3.220	4.340	0.001	6.958	20.989

Omnibus:	11.111	Durbin-Watson:	2.908
Prob(Omnibus):	0.004	Jarque-Bera (JB):	6.867
Skew:	1.466	Prob(JB):	0.0323
Kurtosis:	4.782	Cond. No.	14.7

Transmission – Secondary fault trend - OLS regression results

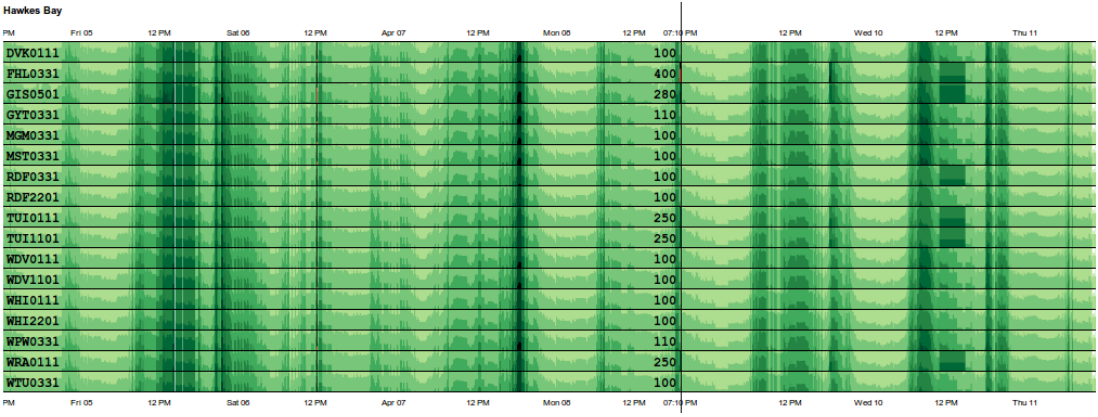
- results more statistically conclusive
- size of transmission outages, in terms of secondary equipment, is on the increase
- Average rate of growth $\approx$14 additional secondary outages/year, over past 13 years
- 95% confidence interval indicates between 7 and 21 additional outages per year
- **Conclusion:** More secondary assets are being tripped? **Why?**

Real-time spot market monitoring

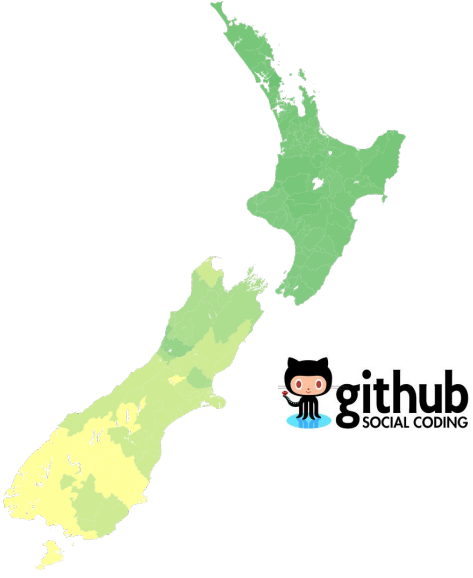
- fully open source Python based system developed:
  - connects to the NZX WITS FTP server
  - attempts download of most recent real time price file
  - prices parsed into memory, stored, statisics calculated, logged
  - if prices $>$ threshold, sends text alerts
  - prices graphed using Javascript/d3 (EA intranet)

Real-time spot market monitoring, weekly time-series data

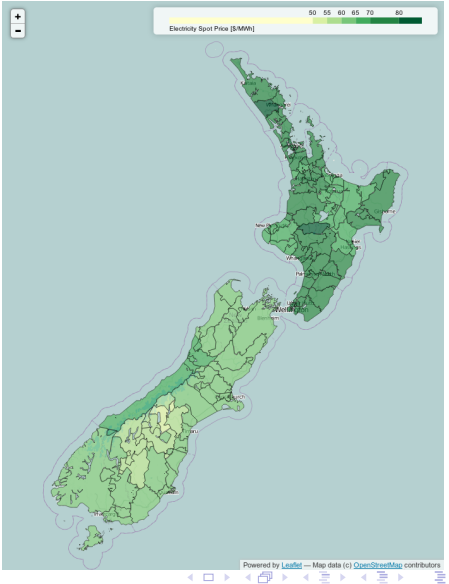
Example: Weekly horizon charts, updated every 5 minutes (Hawkes Bay GXPs)



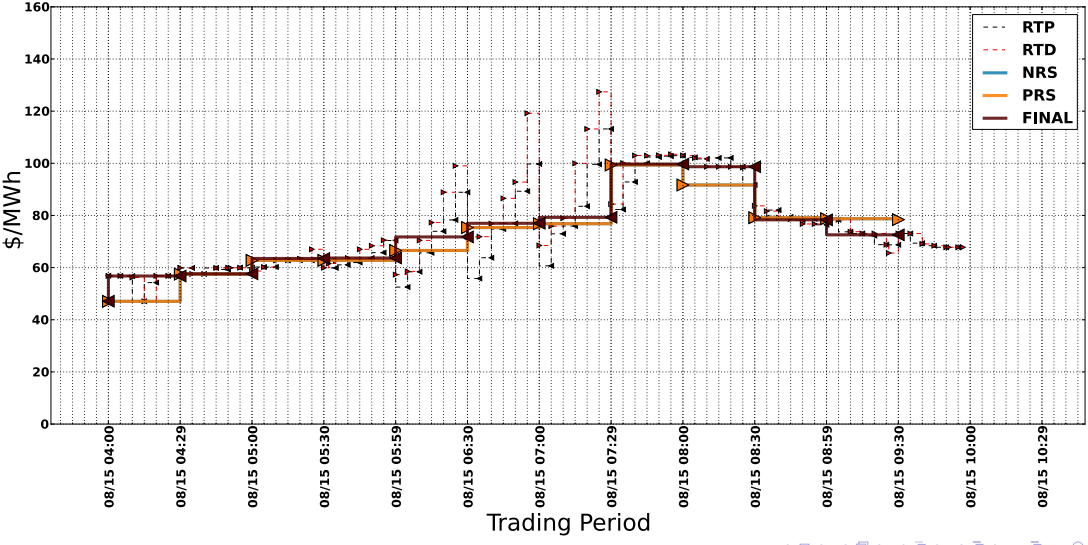
Real-time spot market monitoring, NZ jigsaw (Choropleth)



github
SOCIAL CODING



Observed differences in price series for the NZEM



POCP monitoring

- POCP = Planned Outage Co-ordination Process (POCP)
- database run by the System Operator
- a voluntary platform where participants can publish intended planned generation and transmission outages
- jointly developed by participants over 10 years ago
- currently under review by WAG/SO
- `http://nzeb.redspider.co.nz/` graphical interface + custom alerts etc.
- great for future planning, and outage assessment
- not-so-great for inspecting historic outages.
- a few issues with the way the current POCP database is setup...

POCP monitoring

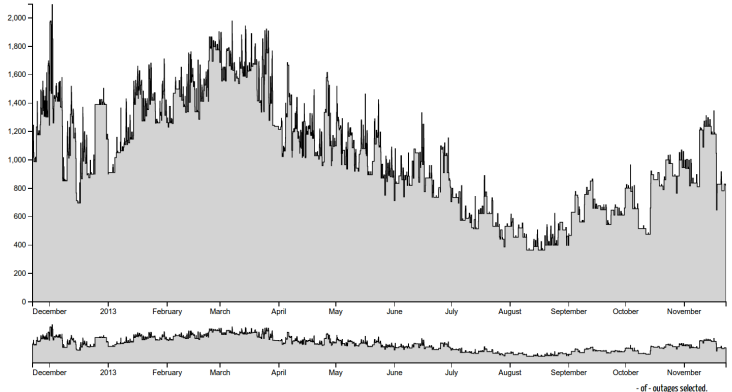
POCP generation outage data - All Generation

Notes:

1. best viewed with Chrome or Firefox;
2. selected outage list currently by Start datetime only;
3. maximum of 100 outages listed at anyone time;
4. POCP data is horribly inconsistant (various time-dependent logic has been applied to get the data in this form - there may be issues);
5. Coming soon to a browser near you, selectors for company/island and generation type...
6. Automatic updates *should* occur daily at 1am/7am/1pm and 7pm.

Total NZ | Total NI | Total SI | Hydro (NI) | Hydro (SI) | Thermal (NI) | Geothermal (NI) | Wind (NI) | Wind (SI)

Genesis (NI) | Genesis (SI) | Meridian (NI) | Meridian (SI) | MRP (NI) | MRP (SI) | Contact (NI) | Contact (SI) | Trustpower (NI) | Trustpower (SI)



- of - outages selected.

POCP monitoring

POCP generation outage data - North Island Generation

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Total NZ | Total NI | Total SI | Hydro (NI) | Hydro (SI) | Thermal (NI) | Geothermal (NI) | Wind (NI) | Wind (SI)

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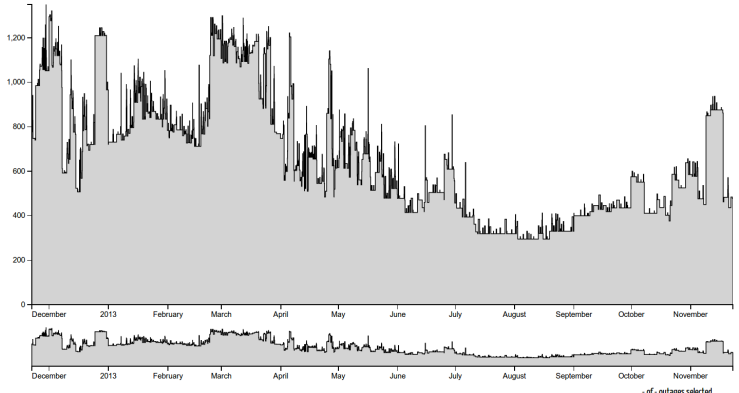

- of - outages selected

POCP monitoring

POCP generation outage data - South Island Generation

Notes:

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2. selected outage list currently by Start datetime only;
3. maximum of 100 outages listed at anyone time;
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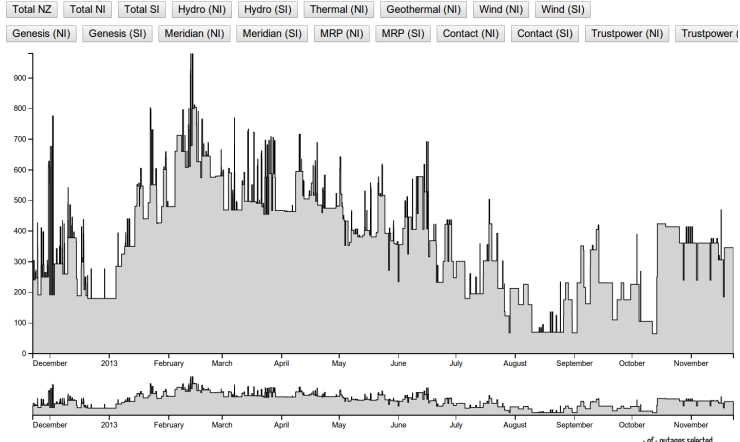
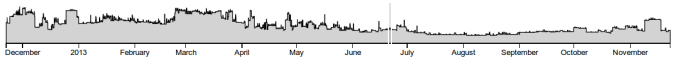


POCP monitoring



14 of 959 outages selected.

2013-06-21					
12:30:00	2013-06-21 15:00:00	MTI_10	Mighty River	35.2	51233
10:00:00	2013-06-21 12:30:00	MTI_9	Mighty River	35.2	51232
2013-06-20					
23:00:00	2013-06-21 15:00:00	HWA_STN	Trustpower	31	TRUS8975HWA
2013-06-17					
07:30:00	2013-06-26 17:00:00	ARA_2	Mighty River	26	51160
07:00:00	2013-06-26 19:00:00	ATI_2	Mighty River	18.5	44682
2013-06-14					
21:00:00	2013-06-30 08:00:00	TRC_1	Contact Energy	42	1964
2013-06-11					
07:00:00	2013-07-10 20:00:00	PRI4	Genesis	22	47563
2013-05-13					
17:00:00	2013-06-25 05:00:00	KPO_3	Mighty River	32	51254
2013-04-29					
06:00:00	2013-10-20 18:00:00	OHK_3	Mighty River	26.5	39668
2013-04-02					
07:00:00	2013-07-11 19:00:00	MTI_2	Mighty River	35.2	44829
2013-03-11					
07:00:00	2013-06-25 17:00:00	ARI_5	Mighty River	24	49958
2013-02-10					
00:00:00	2025-12-31 00:00:00	HLY3	Genesis	245	50283
2013-01-01					
00:00:00	2013-06-30 12:00:00	KAG_1	Mighty River	10	50134
2012-11-14					
07:00:00	2013-08-02 17:00:00	ARI_8	Mighty River	24	44180

Open Source Software

IP[y]: IPython
Interactive Computing

- paper/presentation based entirely on open-source, freely available software
- iPython notebook, interactive Python development within web-browser
- iPython with Numpy/Pandas used daily, replaced Matlab, Excel and R.
- browser based interactive visulisation growing extremely quickly
- Javascript/d3 leading the pack.

Thanks – questions?

. . . On Wednesday the 24'th of November 1886, bright light had been brought to the bars of Dawson's, Kater's, Stevenson's and William's hotels by showman Walter Prince via underground cable through attaching a one kilowatt generator to the Oxley's brewery's steam engine. The test required regular visits of the spectators between the hotel and the brewery, and there was high demand at each point of supply. As a result, many were carrying an overload and it was not only the hotel that was lit up. . . ."

from 'Electrical development in New Zealand'
H.J. Beech