

# 125 years of data

EEA – 21st June, 2013

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# My home energy monitor – Current Cost + RaspberryPi

Current Cost energy monitor

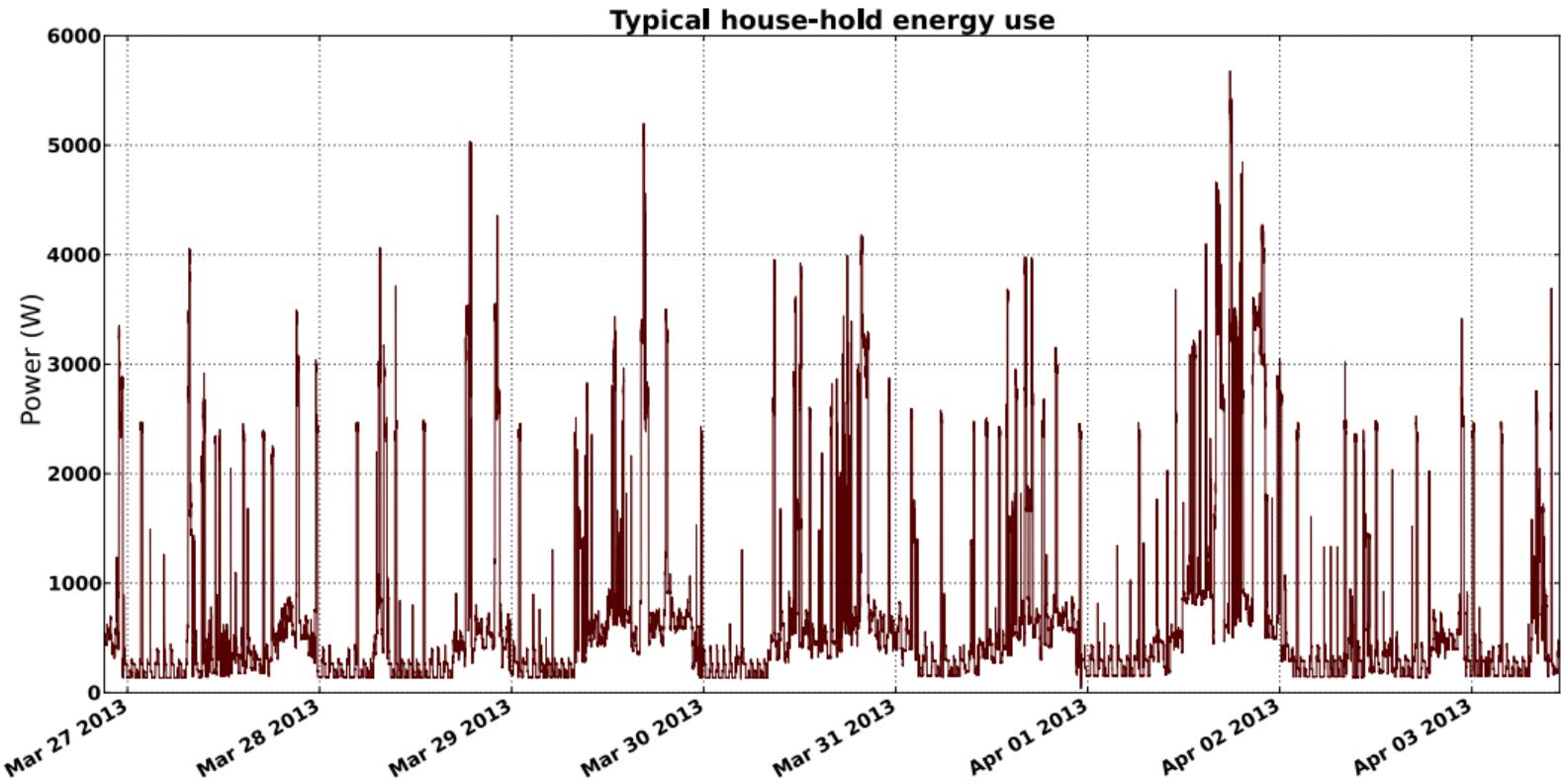


Raspberry Pi computer

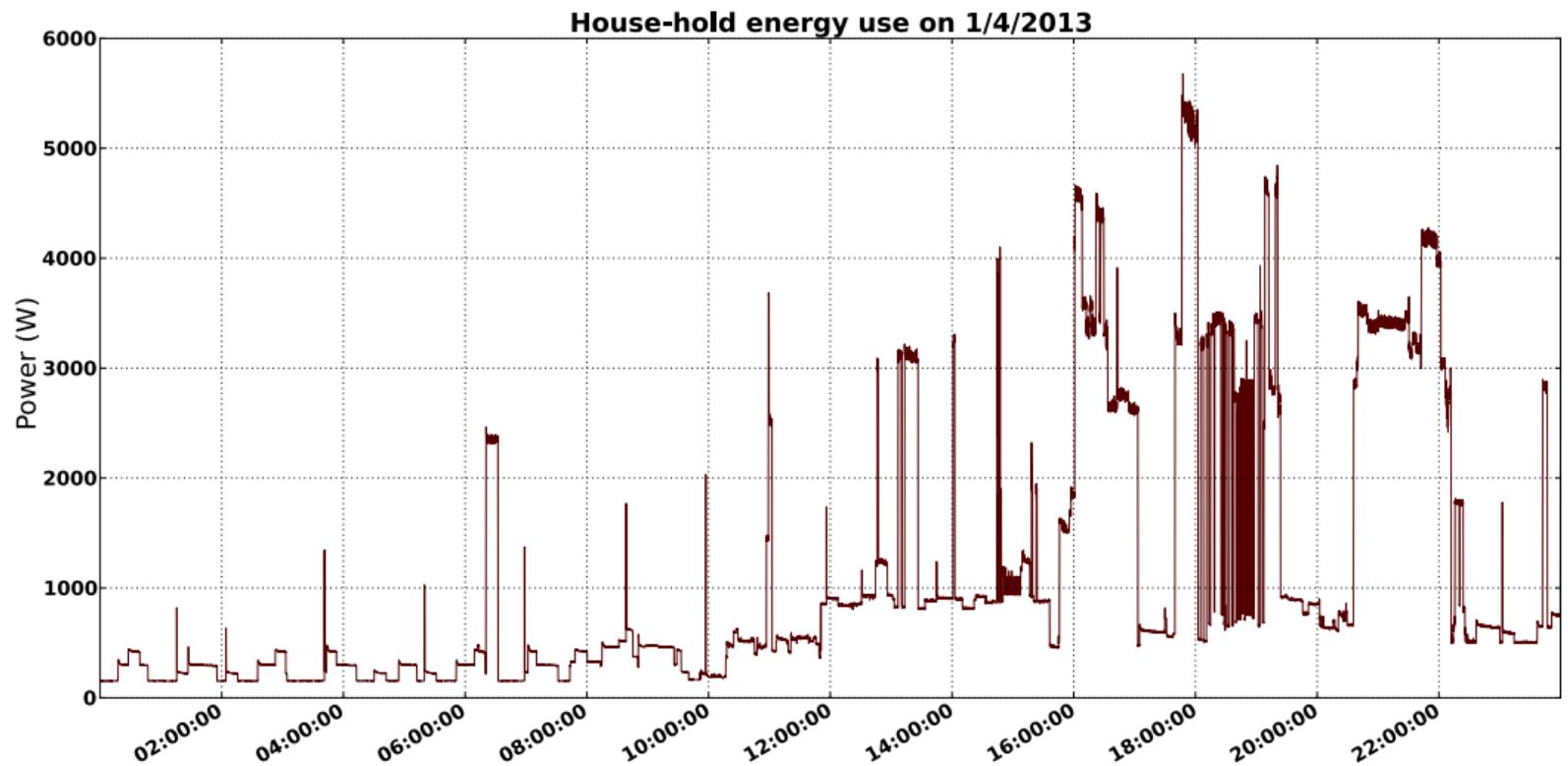


- ▶ Python script
- ▶ MySQL database
- ▶ iPython

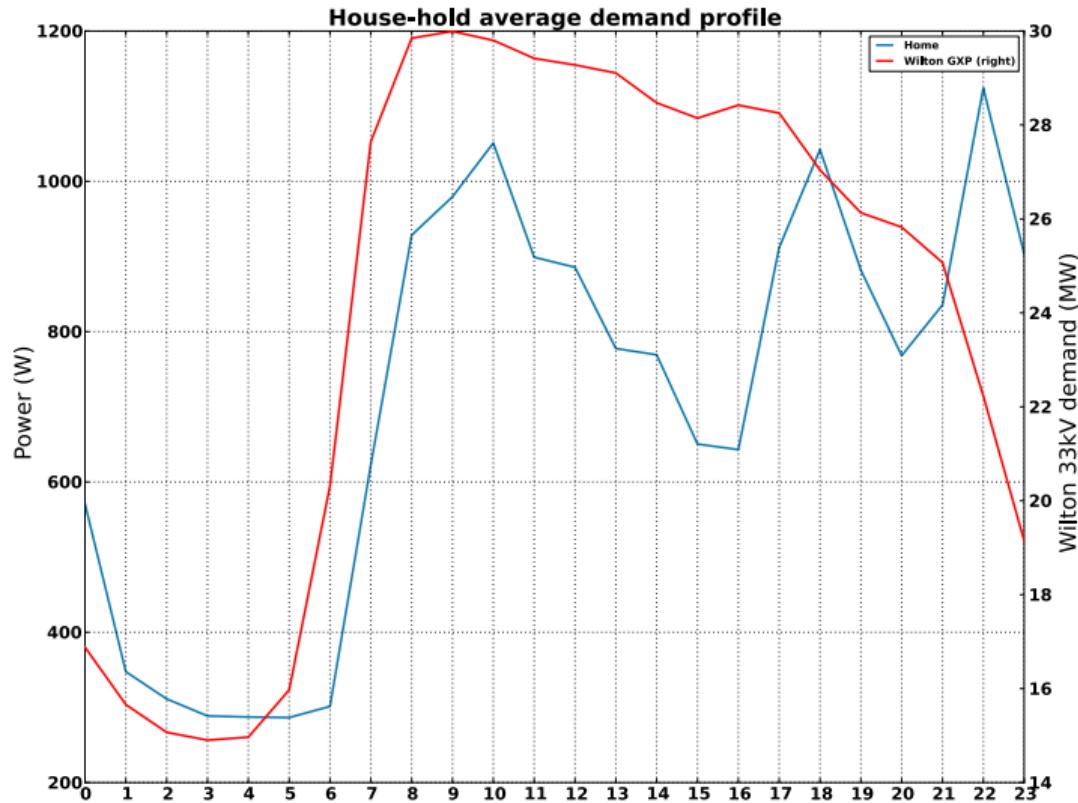
# My home energy monitor – weeks worth of data



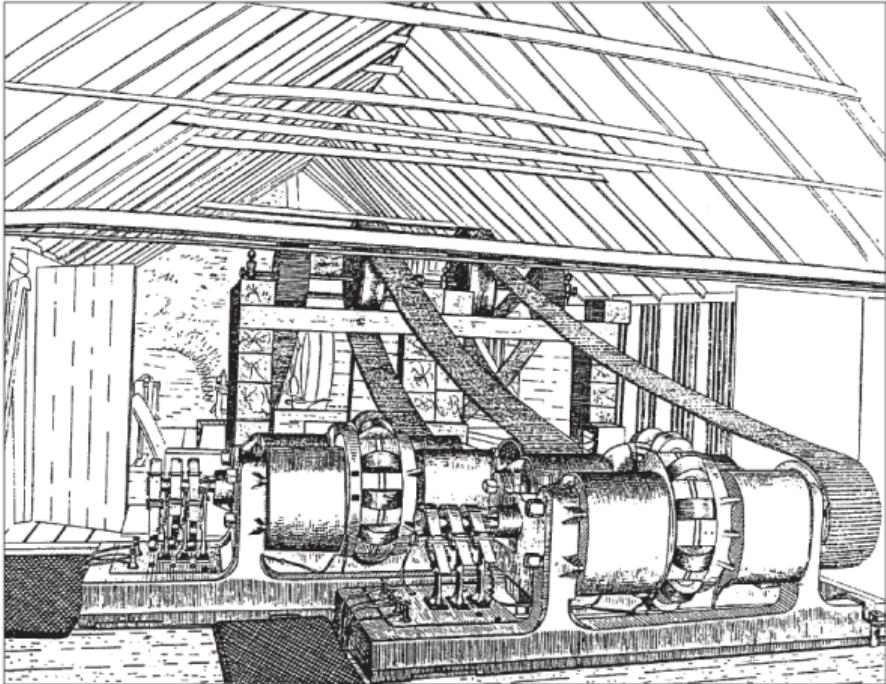
# Home energy monitoring – a high usage day



# Profiling over 5 months of data

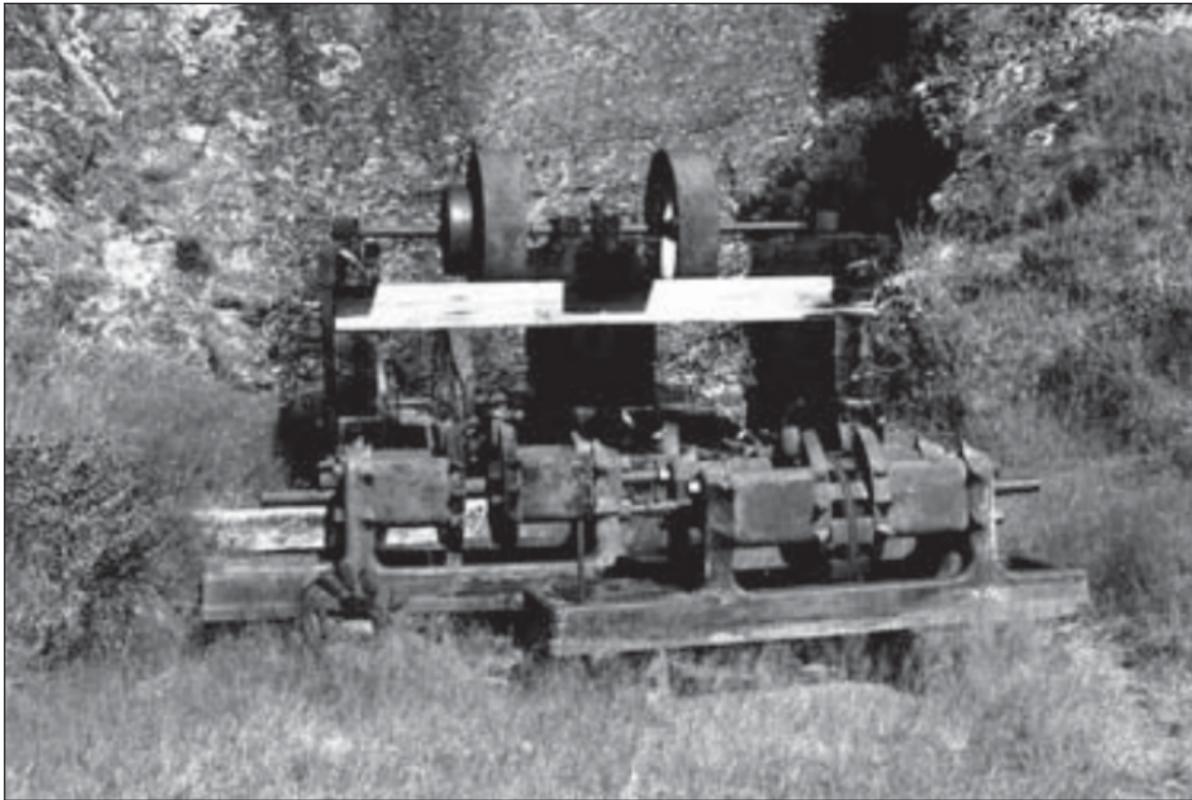


## Bullendale – 127 years ago



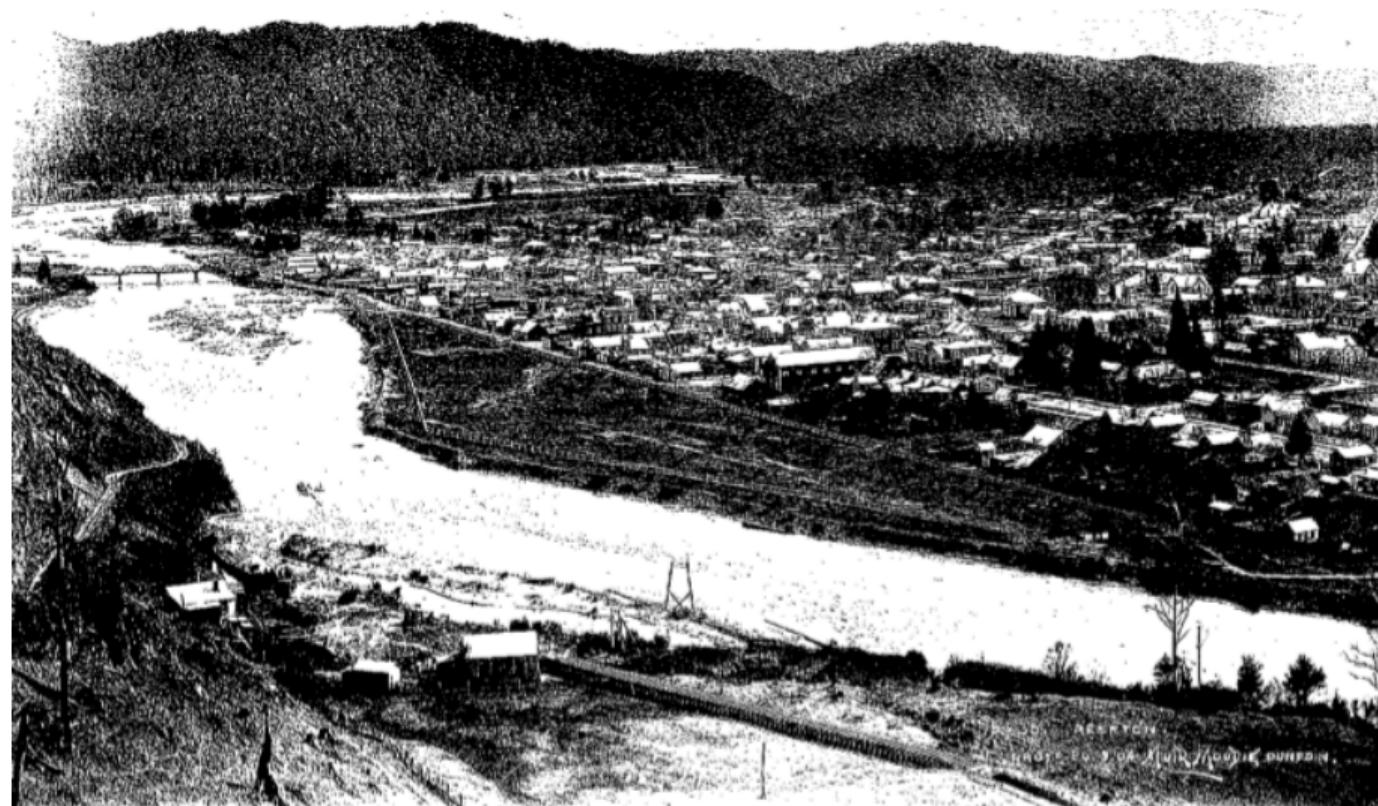
*Source: People, Politics and Power Stations*

# Bullendale – 1986



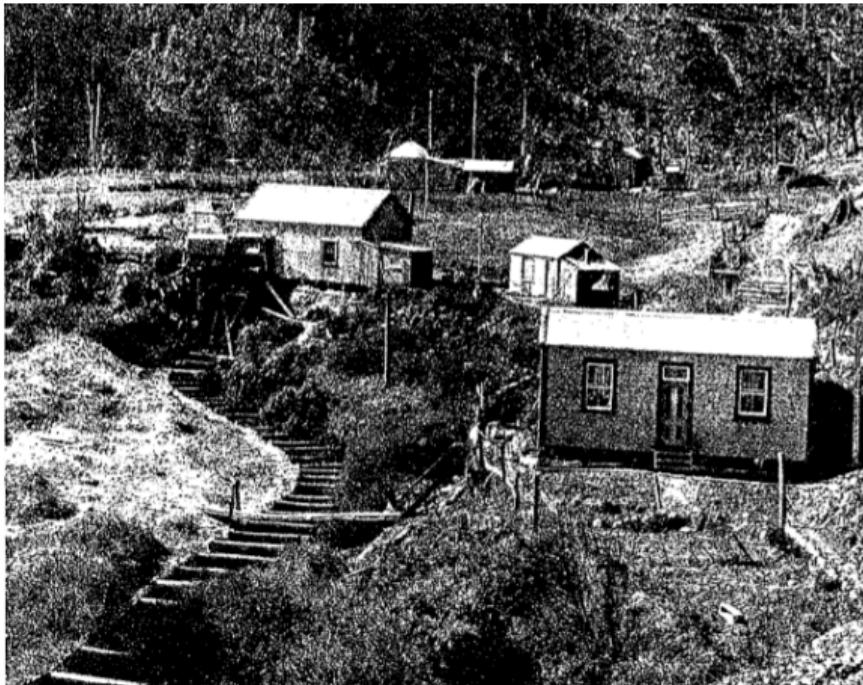
*Source: Gold and electricity. Archaeological survey of Bullendale, Otago*

## Reefton – 125 years ago

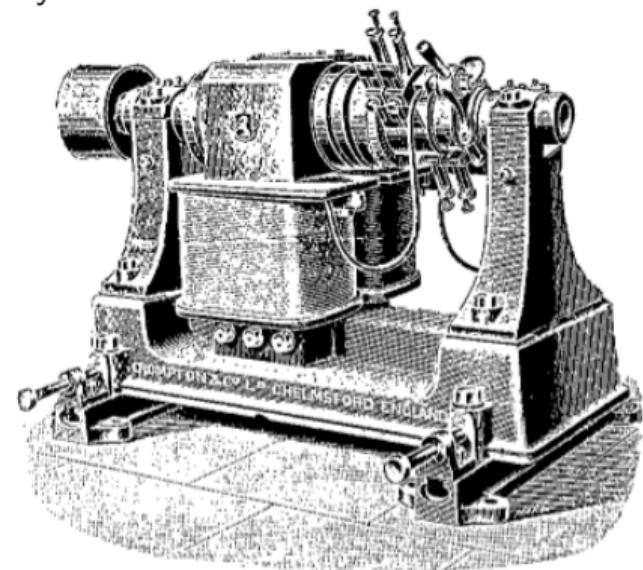


Source: People, Politics and Power Stations

# Reefton – 125 years ago



Crompton DC bipolar  
dynamo



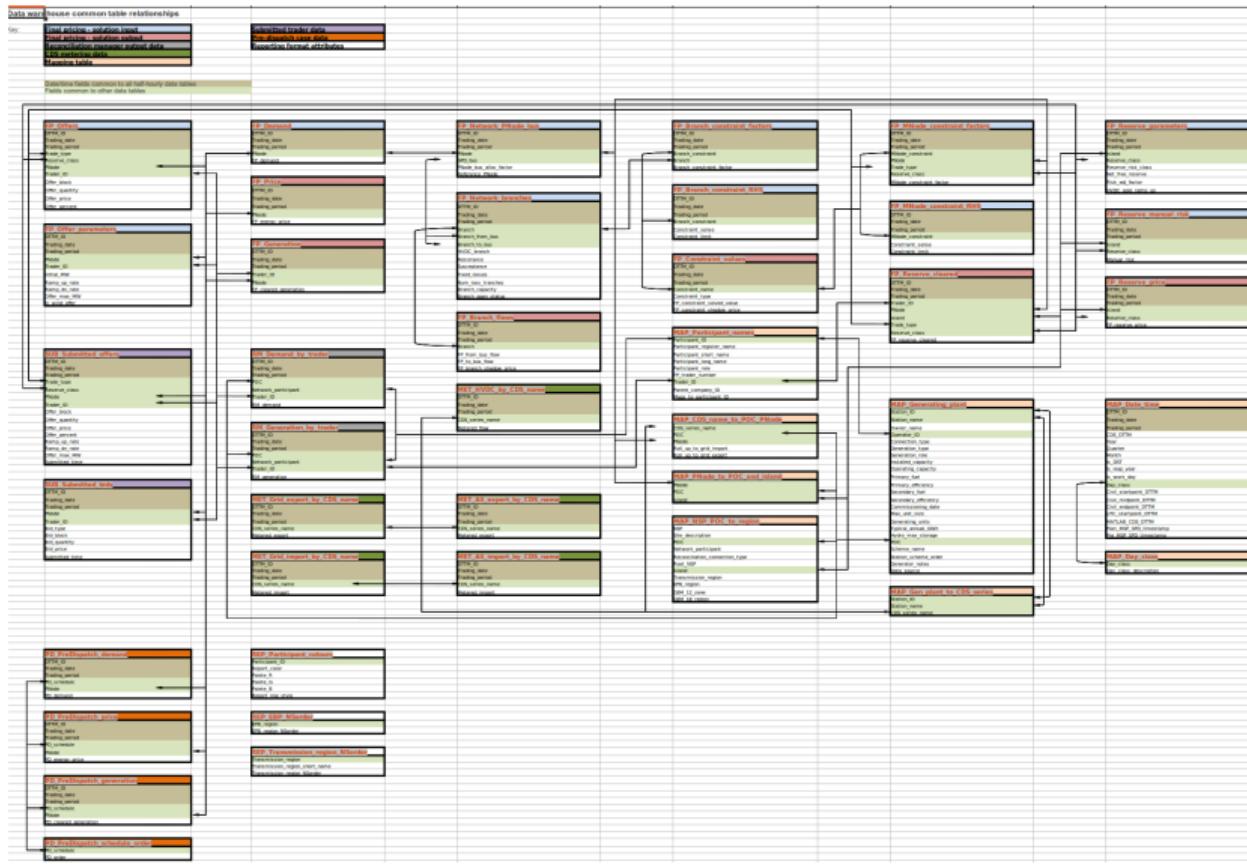
*Source: People, Politics and Power Stations*

## Reefton – today

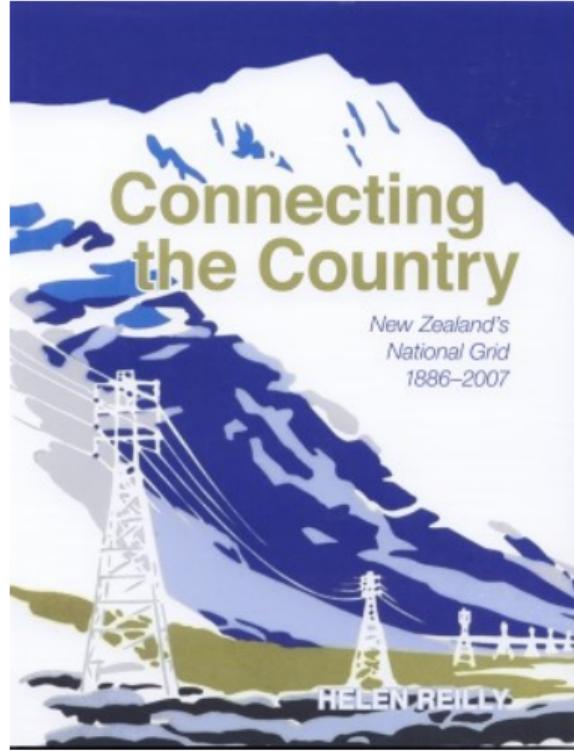
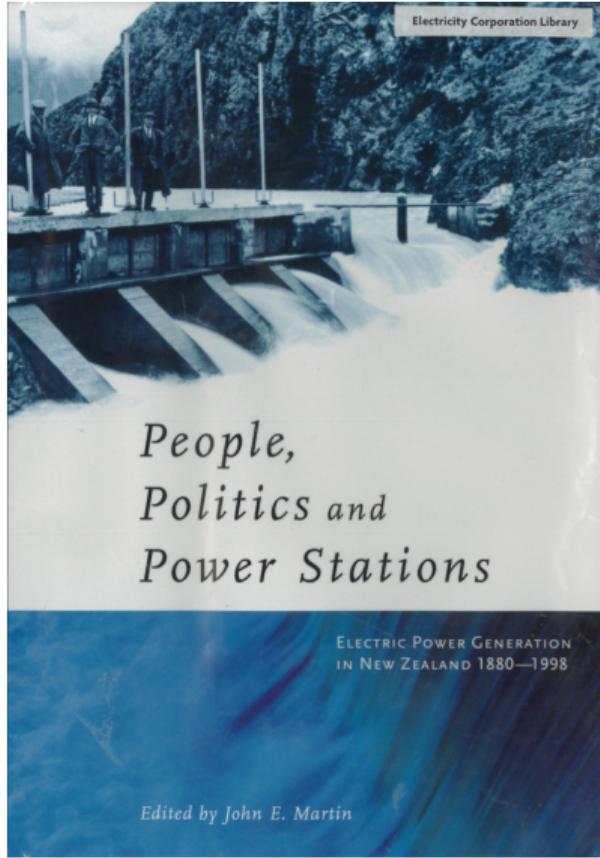


Source: Wikipedia

## 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 harbour

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

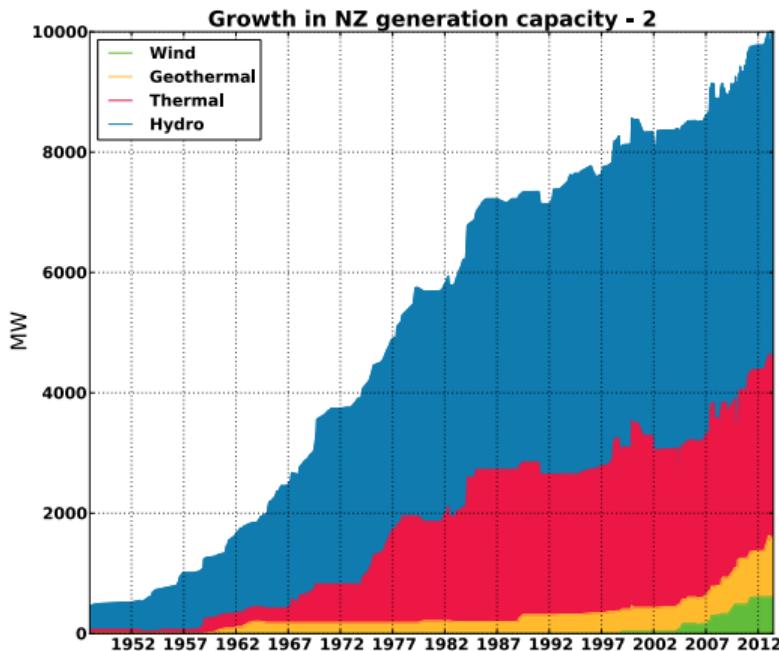
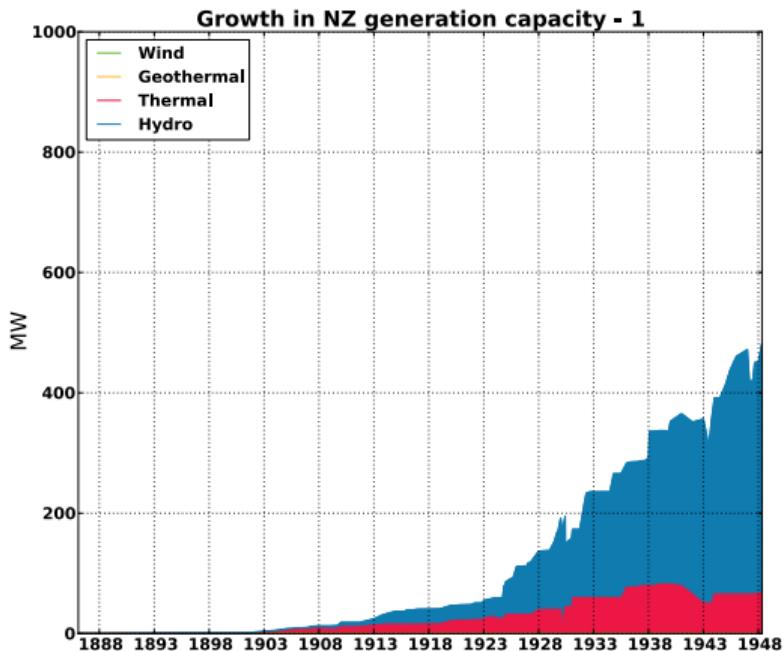
## Historic data, example, Cobb)



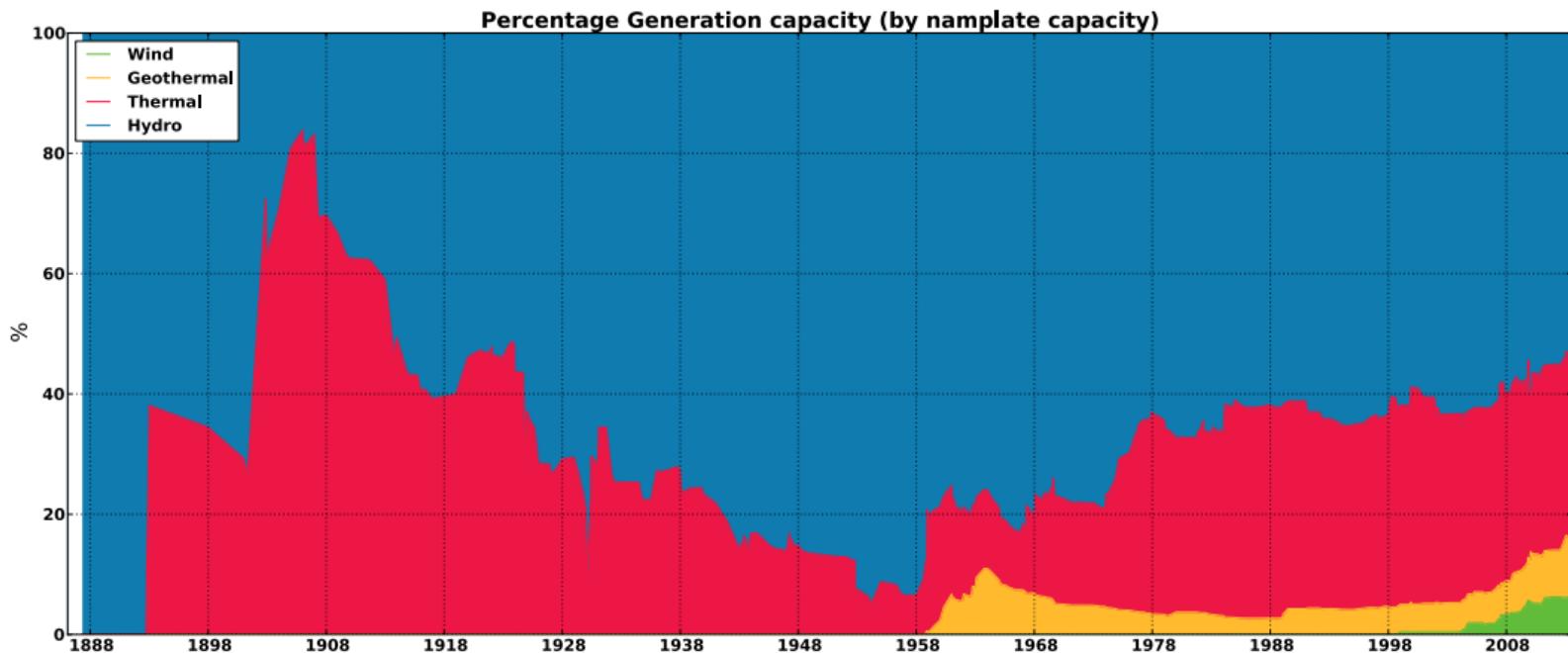
# Historic data, NominalGenerationCapacity.txt (CDS)

Nominal.Hydro.Cobb	
23/ 5/1944@3pm	3000 Trial generation, supplied to the Golden Bay Power Board via Motupipi substation.
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 talking.
17/12/1949@11pm	0 Old intake tunnel closed, as it was in the way of the new dam's spillway.
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 was
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 power
20/ 8/1982	32000 Full power.

# Nameplate generation growth



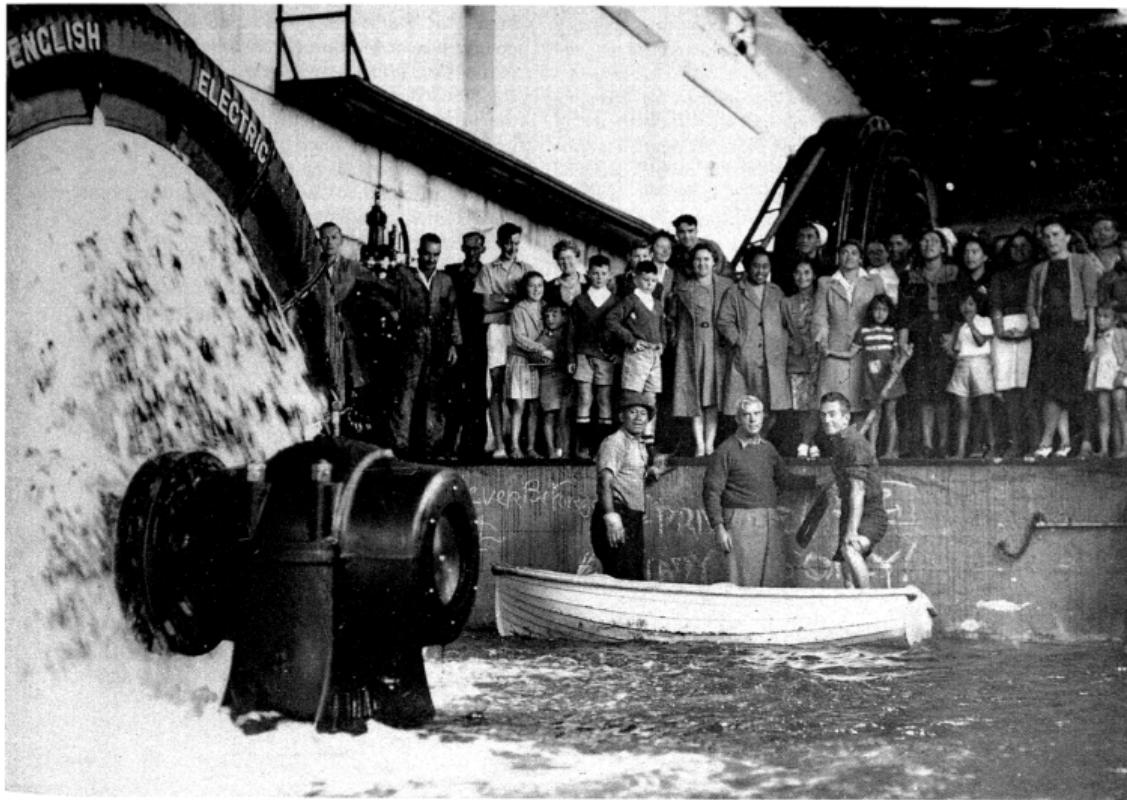
# % growth by generation type



# 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 topograph
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	Decommissioned in December for repairs after the Edgecumbe earthquake of the second
Nominal.Hydro.Cobb	Head 1876'	then 1950' after the earth dam of 107' replaced
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 McI
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 1983
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 the dam.
Nominal.Hydro.Tokaauu	Head 682'
1996	240000 Volcanic ash from the 1995 Mount Ruapehu eruption damaged the turbines. Refurbished in 1998.
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
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

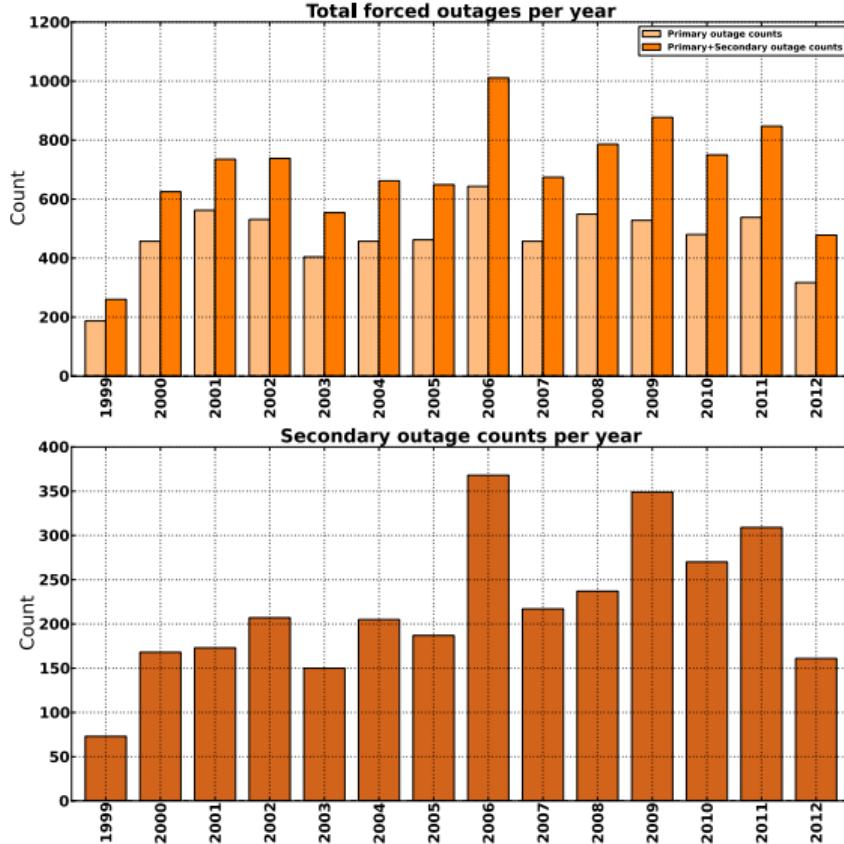


Source: <http://www.flickr.com/photos/sharman/6690836457/>

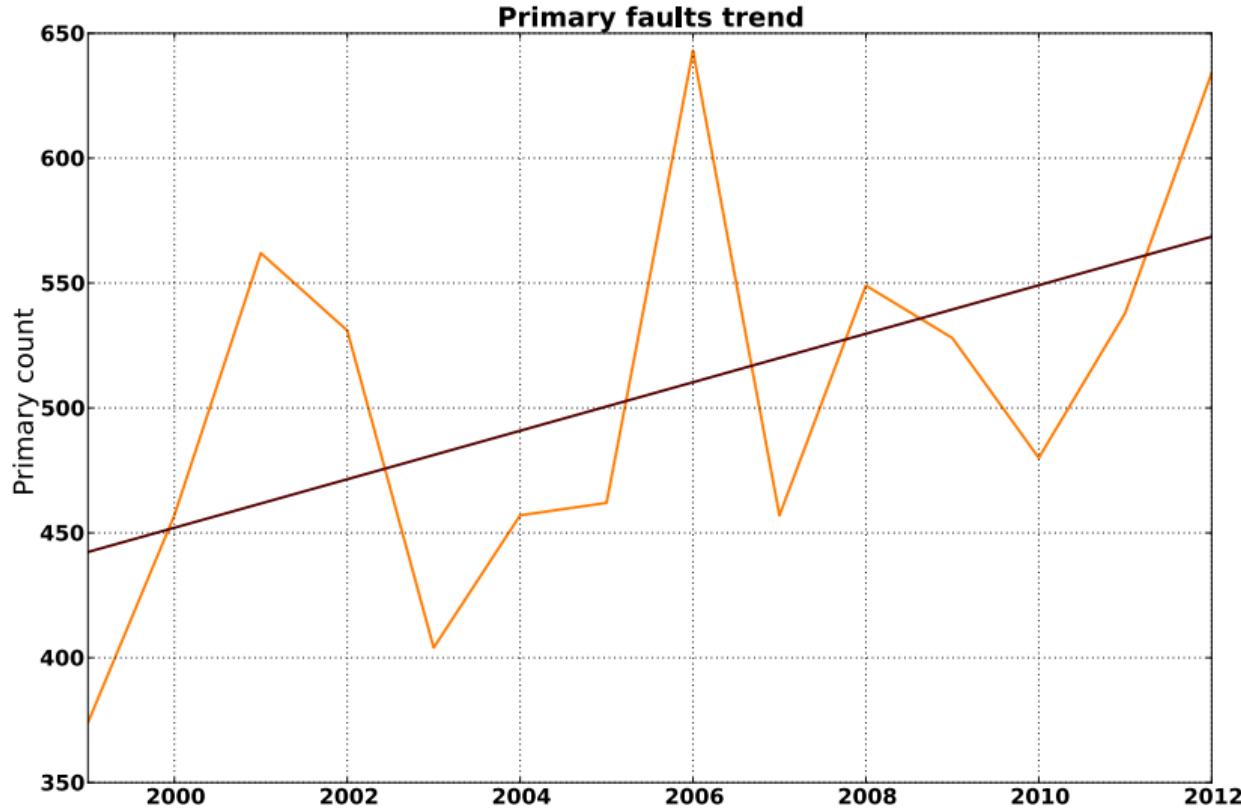
## What about Transmission? Unplanned Outage Data (CDS)

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

```
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```

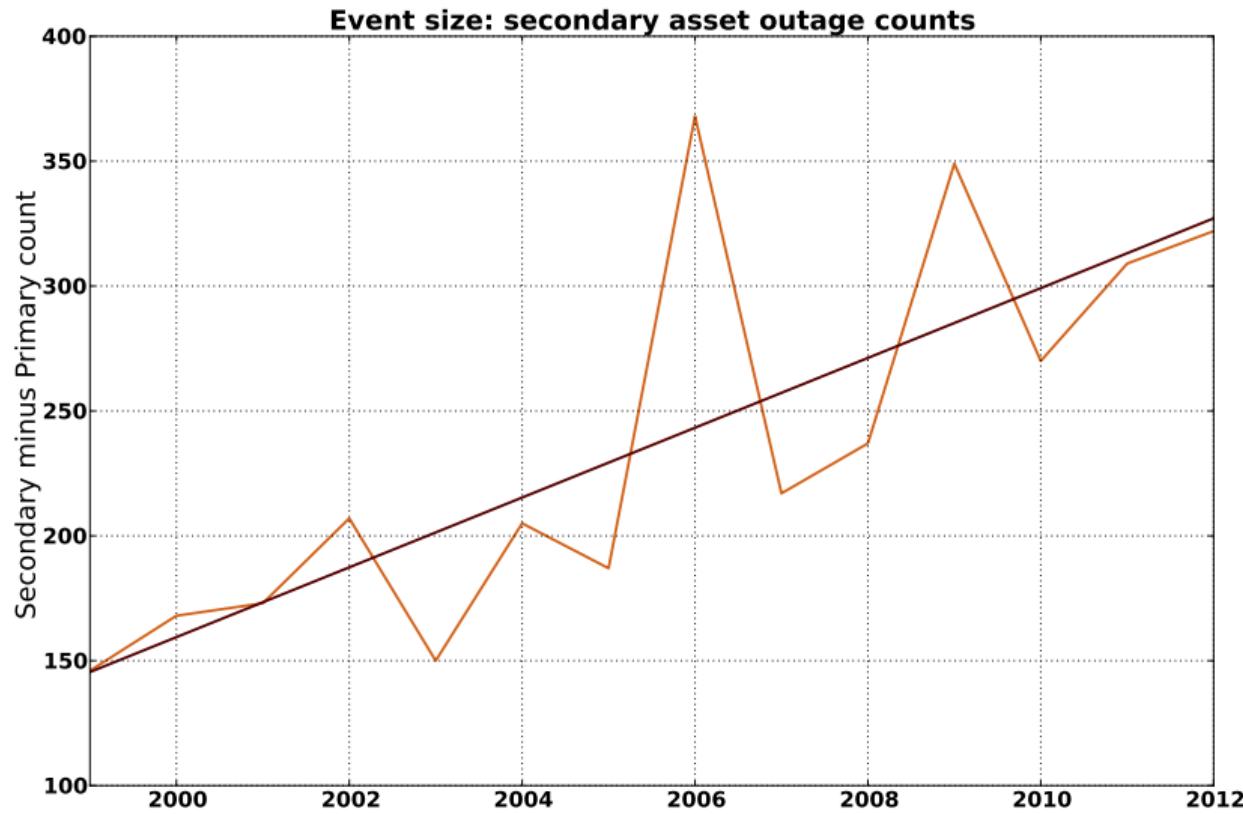
Omnibus:	1.625	Durbin-Watson:	2.141
Prob(Omnibus):	0.444	Jarque-Bera (JB):	1.281
Skew:	0.630	Prob(JB):	0.527
Kurtosis:	2.220	Cond. No.	14.7

```
=====
```

## 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?**

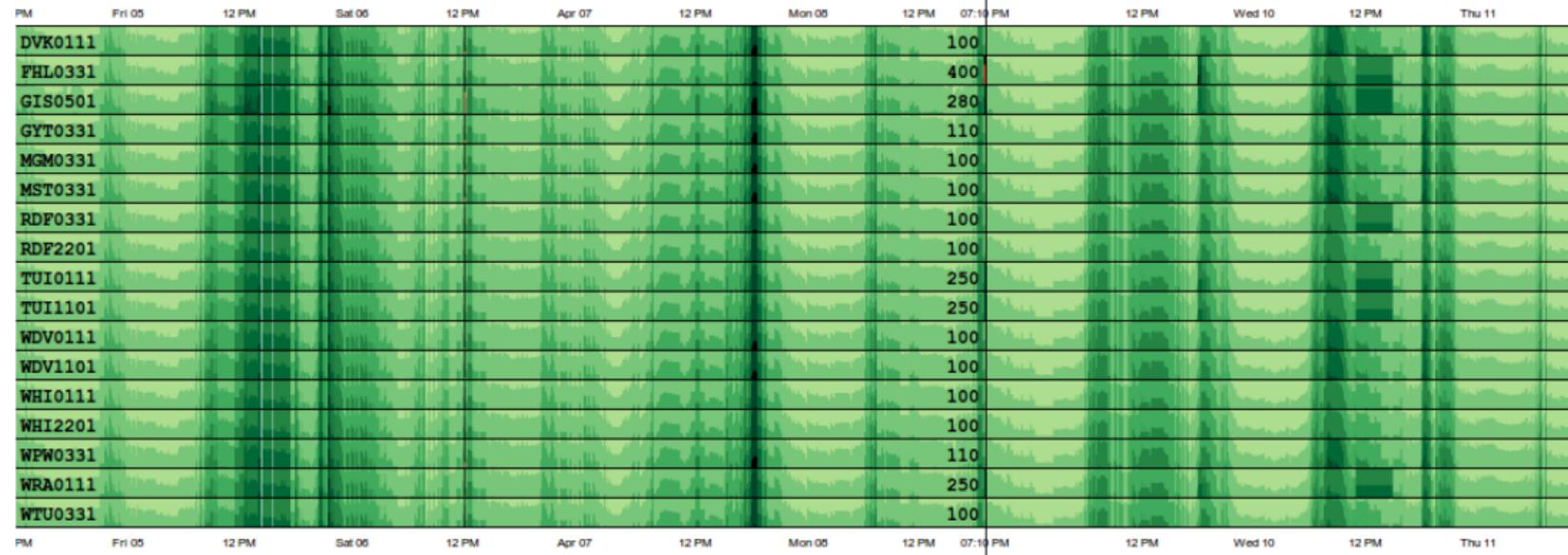
# Real-time spot market monitoring

- 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, statistics calculated, logged
  - if prices > threshold, sends text alerts
  - prices graphed using Javascript/d3 (EA intranet)

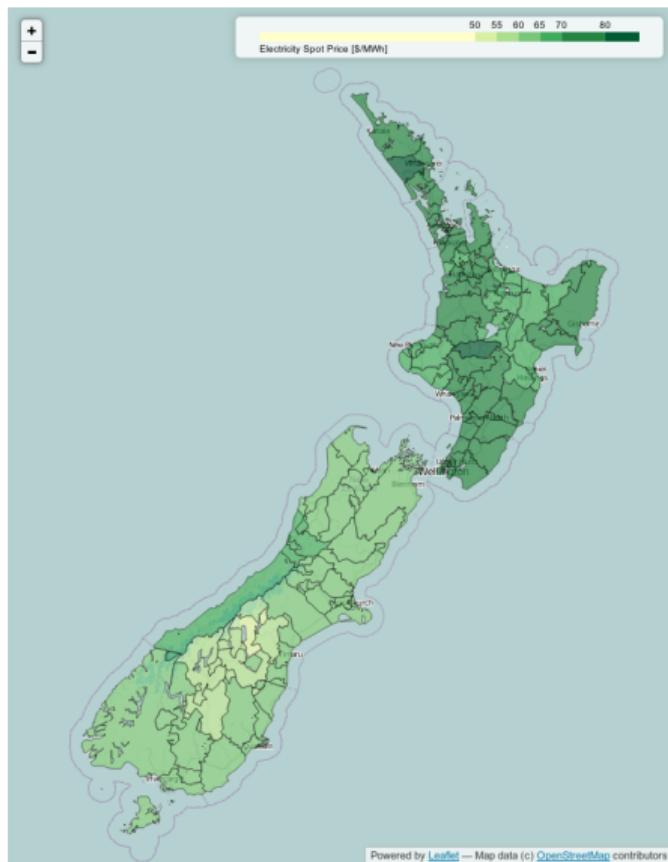
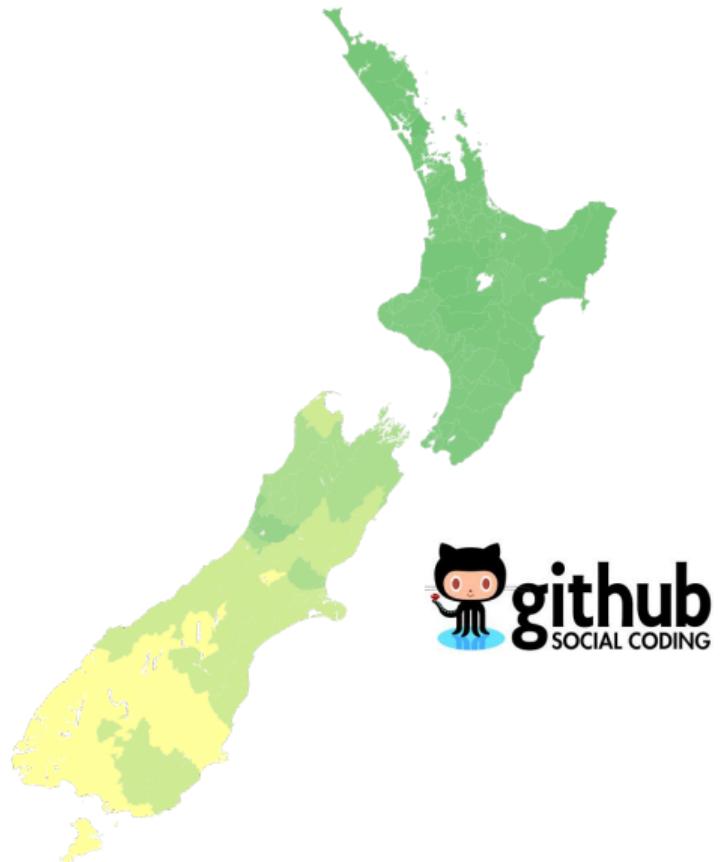
# Real-time spot market monitoring, weekly time-series data

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

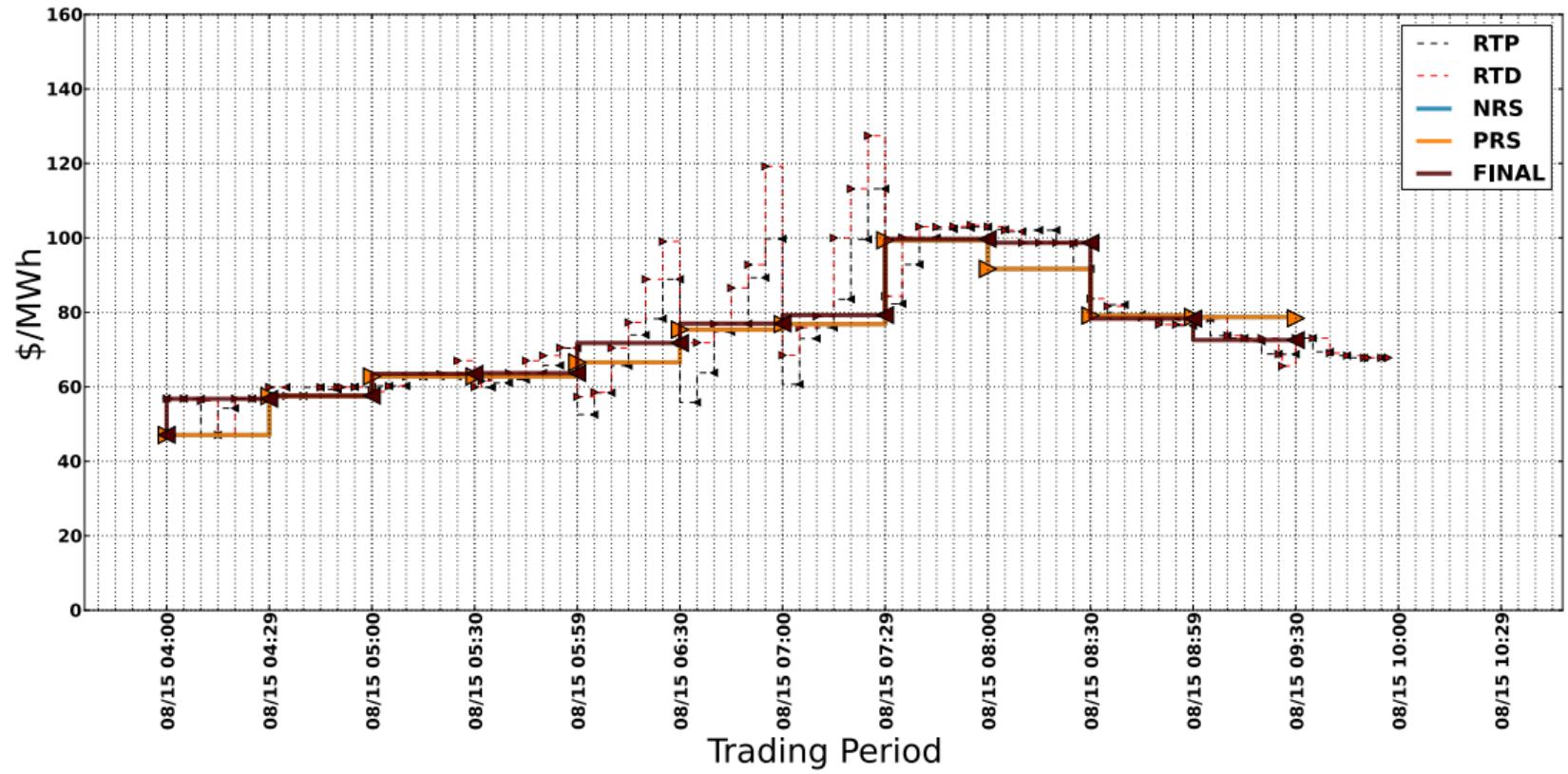
Hawkes Bay



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



# Observed differences in price series for the NZEM



## POCP monitoring

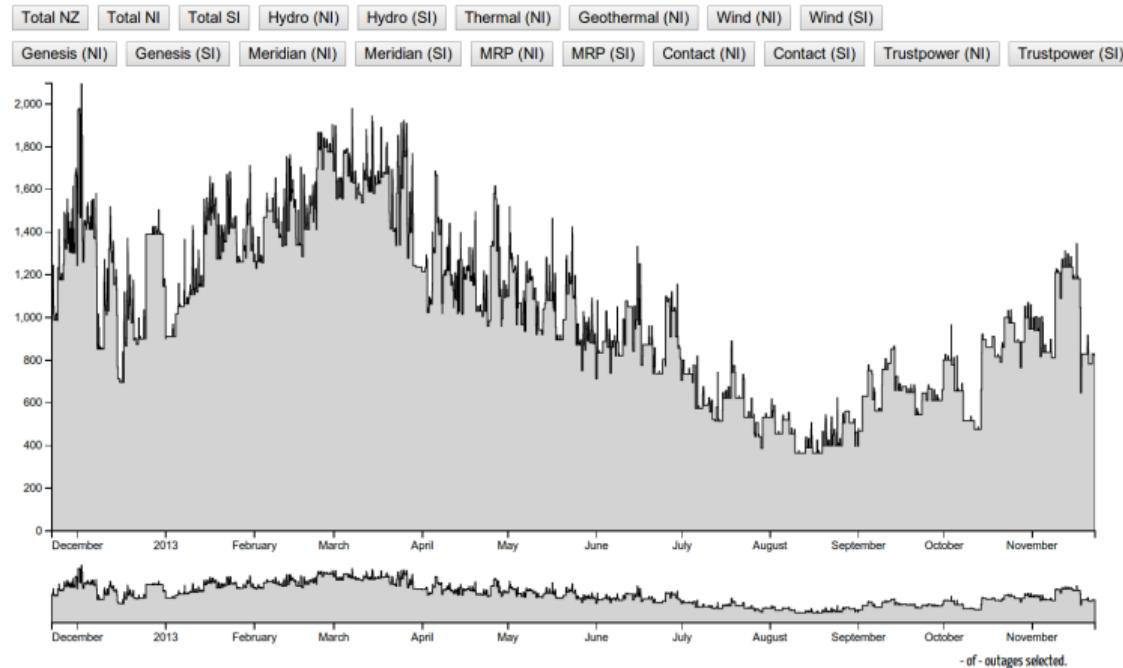
- ▶ POCP = Planned Outage Co-ordination Process (POCP)
- ▶ database run by the System Operator
- ▶ a voluntary platform where participants can publish intended planned generation and transmission outages
- ▶ jointly developed by participants over 10 years ago
- ▶ currently under review by WAG/SO
- ▶ <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. POPC data is horribly inconsistent (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.



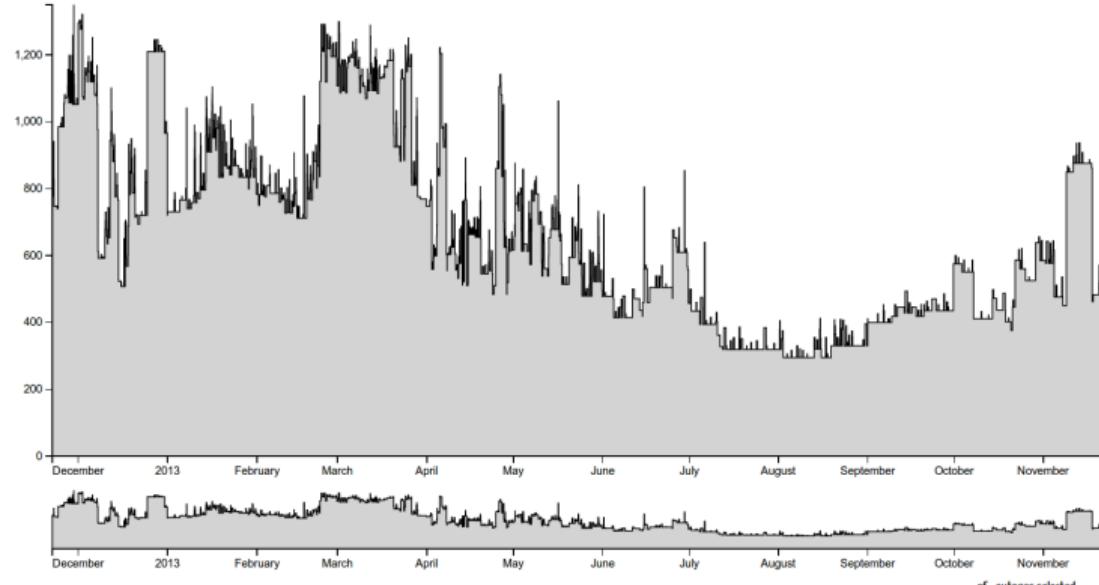
# POCP monitoring

## POCP generation outage data - North Island 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 inconsistent (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<sup>should</sup> 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)



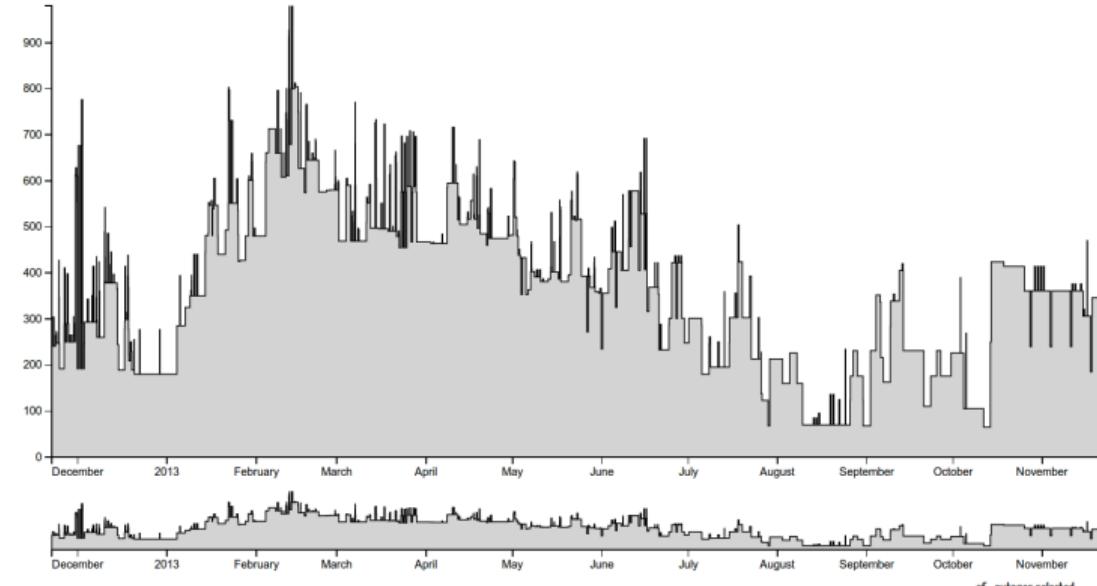
# POCP monitoring

## POCP generation outage data - South Island Generation

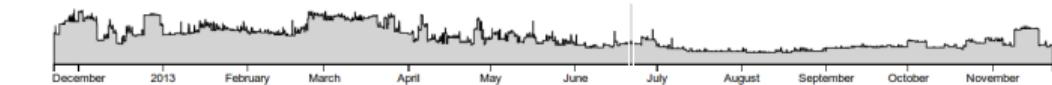
Notes:

1. best viewed with Chrome or Firefox;
2. selected outage list currently by Start date/time only;
3. maximum of 100 outages listed at anyone time;
4. POCP data is horribly inconsistent (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 \(SI\)](#)



# POCP monitoring



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
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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
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2013-06-11

07:00:00	2013-07-10 20:00:00	PRI4	Genesis	22	47563
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2013-05-13

17:00:00	2013-06-25 05:00:00	KPO_3	Mighty River	32	51254
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2013-04-29

06:00:00	2013-10-20 18:00:00	OHK_3	Mighty River	26.5	39668
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2013-04-02

07:00:00	2013-07-11 19:00:00	MTI_2	Mighty River	35.2	44829
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2013-03-11

07:00:00	2013-06-25 17:00:00	ARI_5	Mighty River	24	49958
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2013-02-10

00:00:00	2025-12-31 00:00:00	HLY3	Genesis	245	50283
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2013-01-01

00:00:00	2013-06-30 12:00:00	KAG_1	Mighty River	10	50134
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2012-11-14

07:00:00	2013-08-02 17:00:00	ARI_8	Mighty River	24	44180
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## IP[y]: IPython Interactive Computing

- ▶ paper/presentation based entirely on open-source, freely available software
- ▶ includes all data analysis, visualisations, and entire text of this paper/presentation
- ▶ iPython notebook allows interactive Python code development within a web-browser
- ▶ the notebook, and many Python packages such as Numpy and Pandas have been the authors daily tools now for two years, replacing both Matlab, Excel and R.
- ▶ client-side (browser based) interactive visualisation growing extremely quickly
- ▶ Javascript/d3 and its various modules appear to be 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