Outage Seminar

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Forced Outages

- Full Forced Outages
- Partial Forced Outages (with derating)
- Maintenance Outages
- How are these figures derived?
- What are they used for?

How are figures derived

- In the Australian NEM: forced outage data collection process
- Supposed to be consistent with “IEEE Standard Definitions for use in reporting Electric Generating Unit Reliability, Availability and Productivity” (IEEE 762)

What are they used for

- Reliability studies
- Market modelling
- “Missing money” problem – if a generator doesn’t run, it doesn’t get paid (in an energy only market). To ensure capacity adequacy.

EFOR and EFORd

- EFOR (equivalent forced outage rate)
- EFORd (demand equivalent forced outage rate: FOR in times of demand)

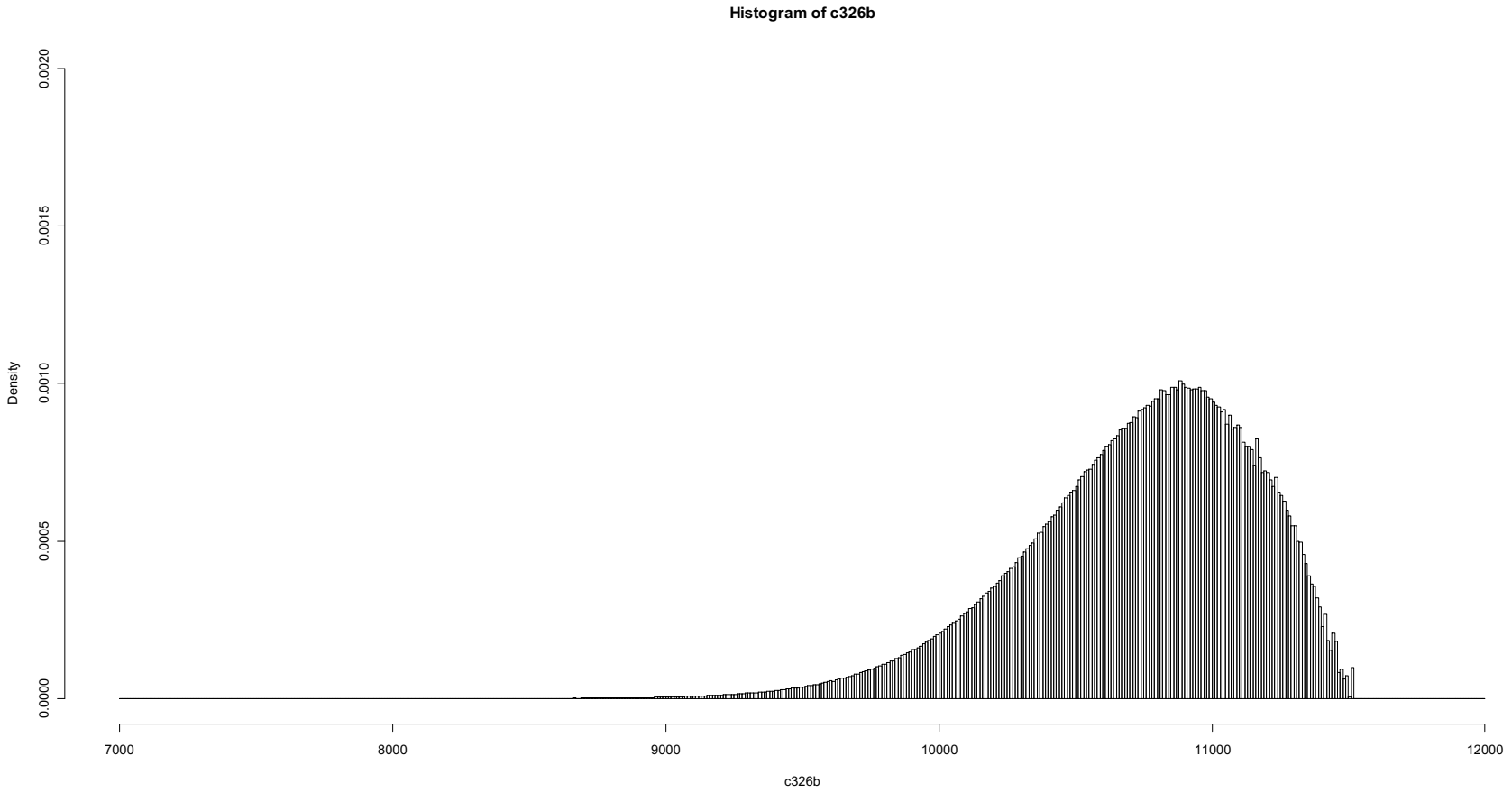
- *The term demand applied to a rate, as in EFORd, indicates that the probability of an occurrence has been estimated for periods when the unit is in demand to generate*
- https://www.nerc.com/comm/PC/Generating%20Availability%20Data%20System%20Working%20Gro1/092709282016%20GADSWG%20Presentations%20Binder.pdf

Forced Outage Data Working Group

- Created in 2005 to address KEMA's recommendations resulting from its review of the 2004 MRL calculations
- KEMA: "The resulting forced outage rates used by NEMMCO are much lower than international experience."
- Due to not using partial outages
- KEMA: "NEMMCO should review international practice regarding outage reporting requirements and definitions."
- https://web.archive.org/web/20070902040934/http://www.nemmco.com.au/powersystemops/240-0009.pdf

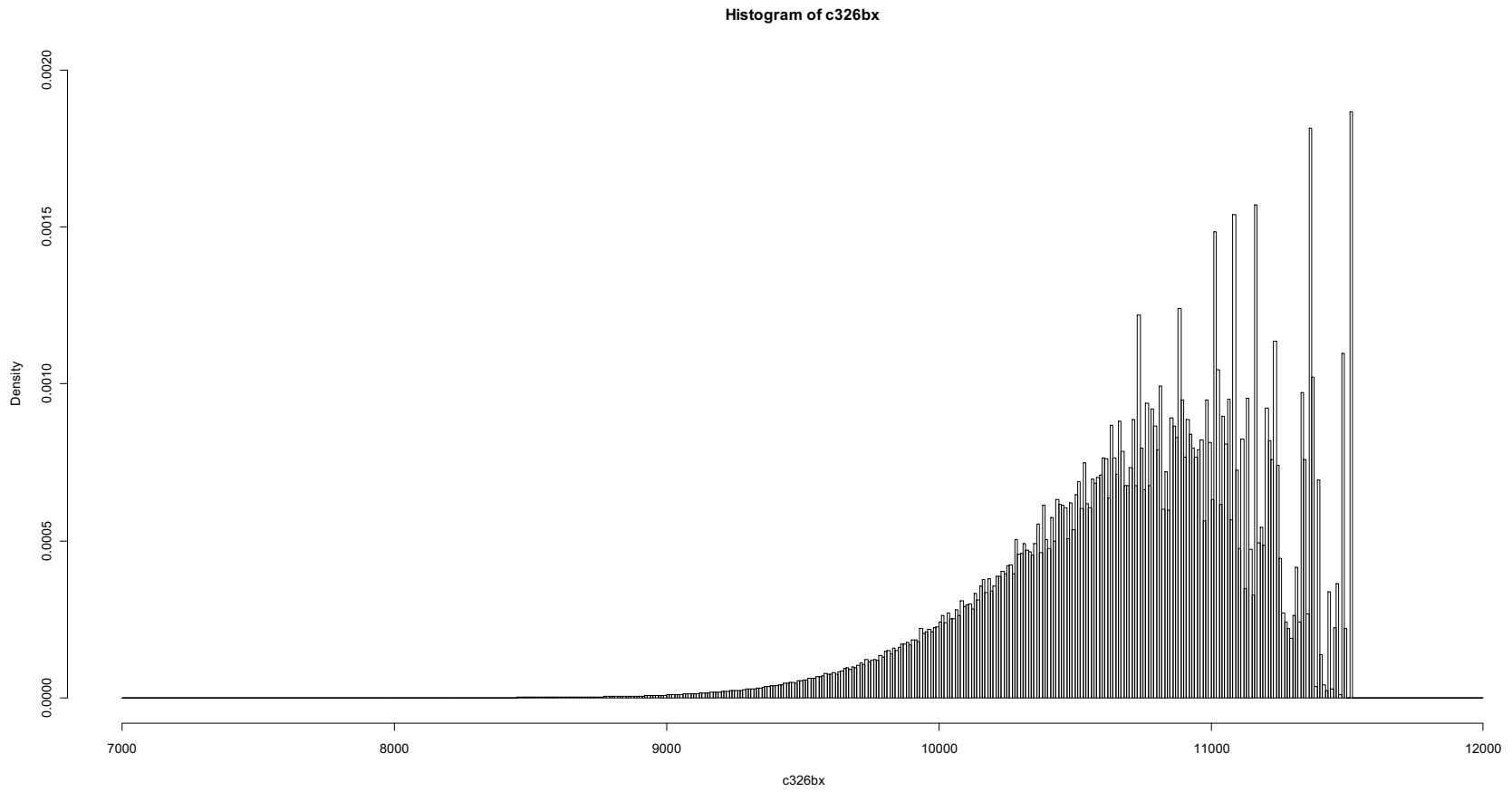
Why should we use partial outages?

Queensland capacity histogram with partial outages (63 units)

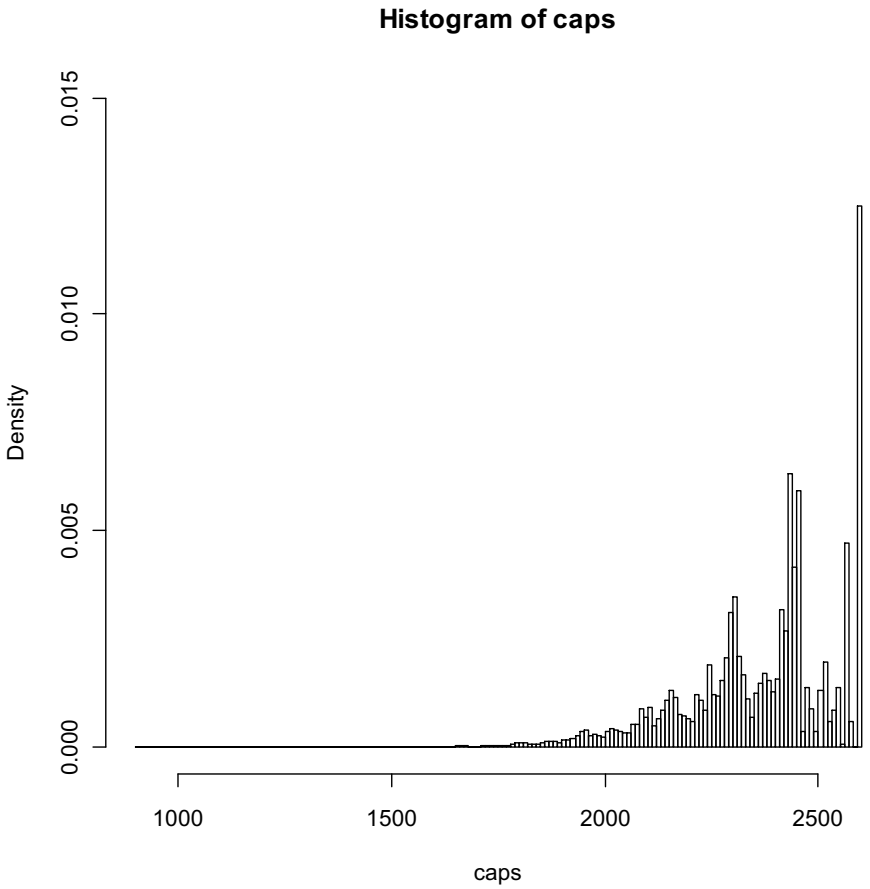


Why should we use partial outages?

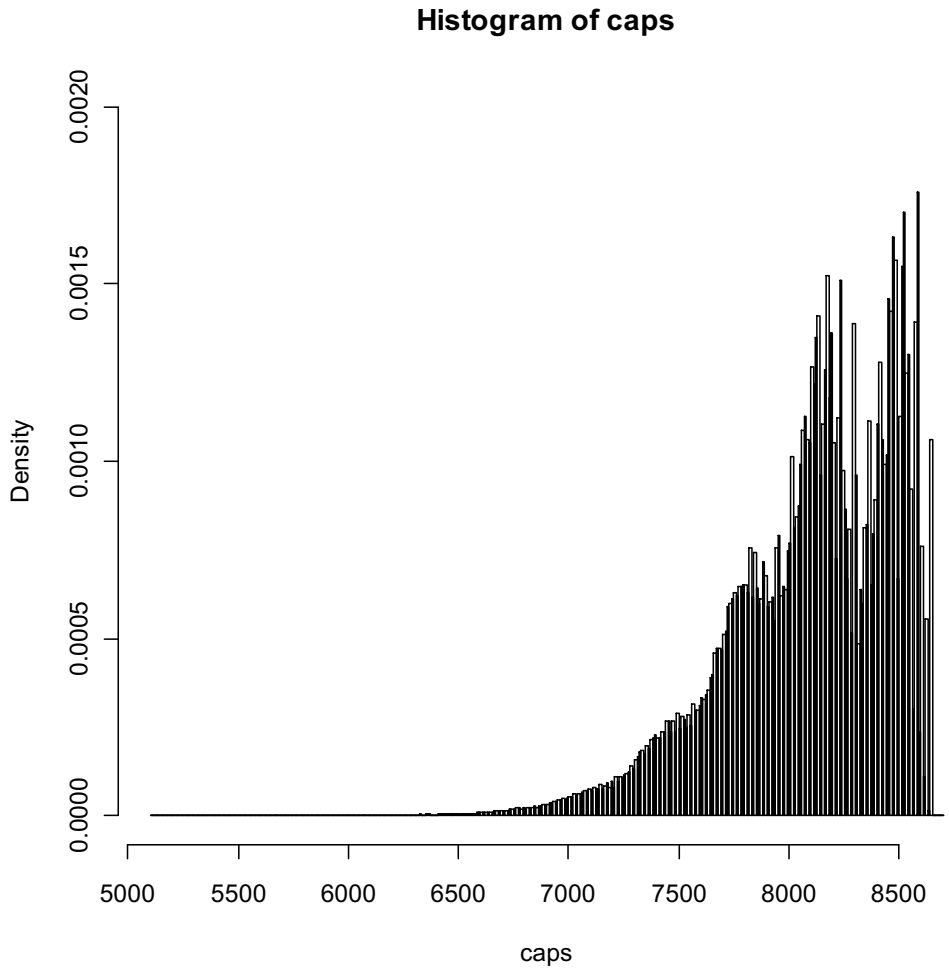
Queensland capacity histogram without partial outages (63 units)



Queensland gas



Queensland coal



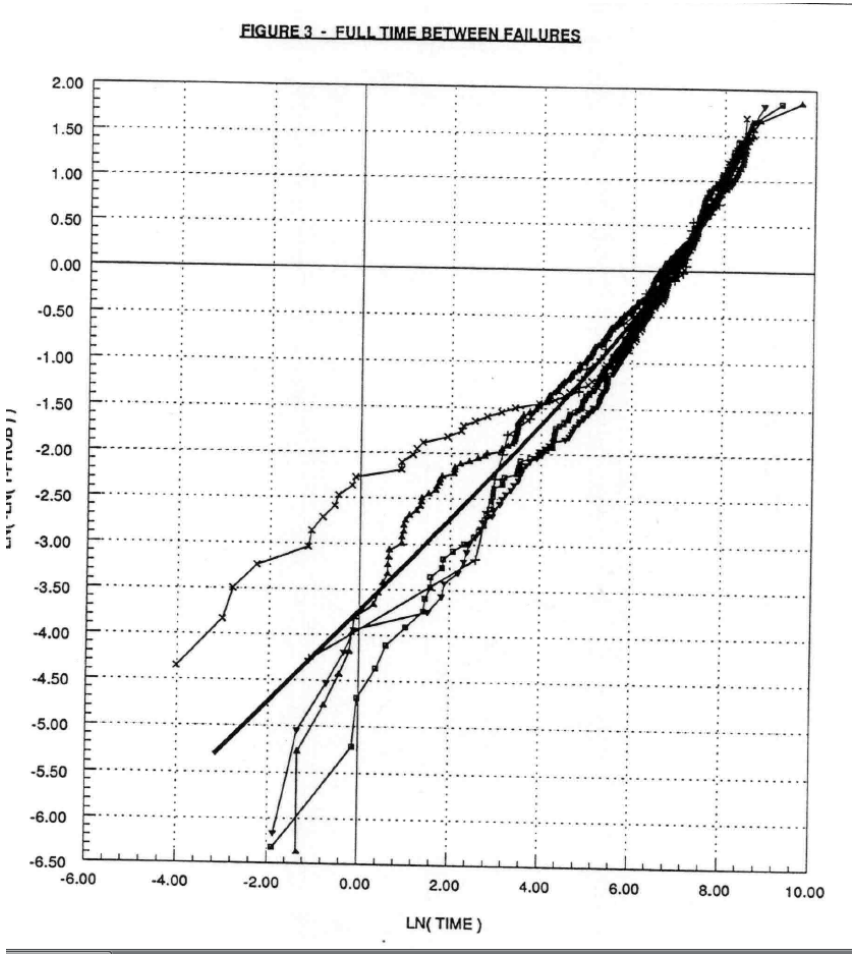
“Slow start” and “fast/rapid start”

- Concepts in 2-4-C and Prophet
- Prophet documentation is non-existent
- *“Rapid start plant breakdown only if they are dispatched at the relevant time period.”*
- *“Although forced outage rates are reported for fast start plant, they are not meaningful unless the plant is operated frequently.”*
- “Rapid start might be broken” button

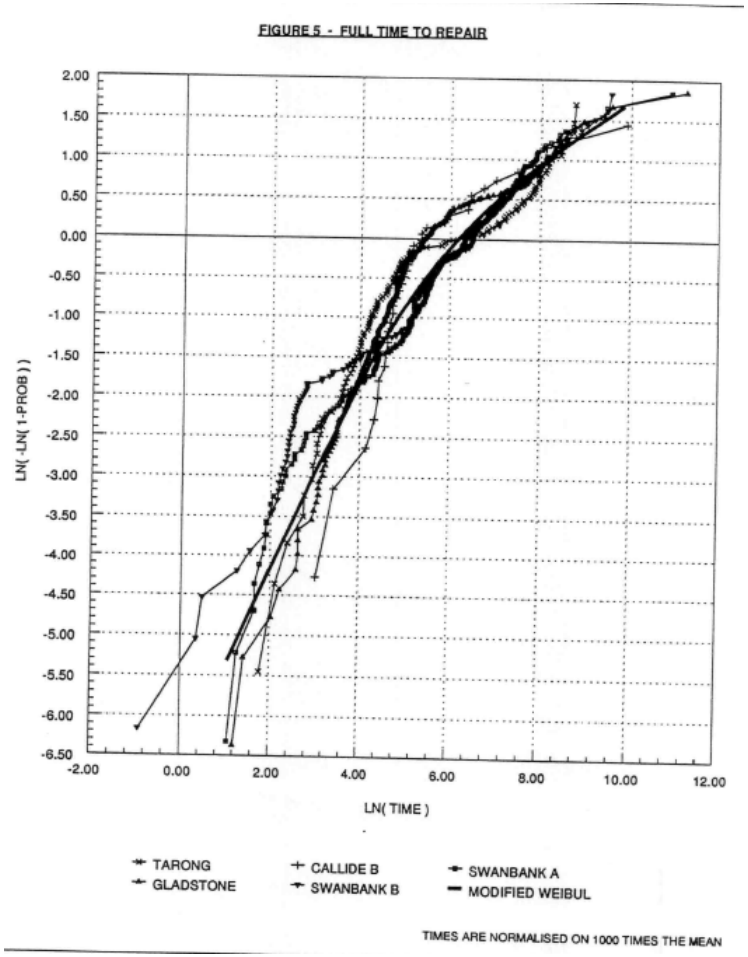
2-4-C and the Tas Walker paper

- “The Availability of Generating Plant” was a 1993 paper by Tas Walker for the QEC
- Examined Tarong, Gladstone, Callide B and Swanbank A+B partial and full outages, 1975 – 1992
- Performed a Weibull plot of time versus “probability” – looking for straight line

Full Time Between Failures Weibull Plot



Full Time Between Repairs Weibull Plot



Magic numbers (fixed)

$$t = \frac{(-\ln (1 - F))^a}{s} \cdot F^b \qquad (7)$$

where:
t is the time
F is the cumulative probability of failure
a is an exponent
b is an exponent and
s is a scaling factor to ensure the distribution averages to the appropriate mean value.

This equation has been fitted to the measured results and is shown in Figures 3 to 6. The values for exponents a and b, and for factor s are shown below, with s chosen to achieve a mean of 1.0:

	FULL		PARTIAL	
	TBF	TTR	TBF	TTR
a	0.7	2.7	1.5	2.6
b	1.3	-1.9	0.7	-1.9
s	0.57699	4.9749	1.13863	4.5618

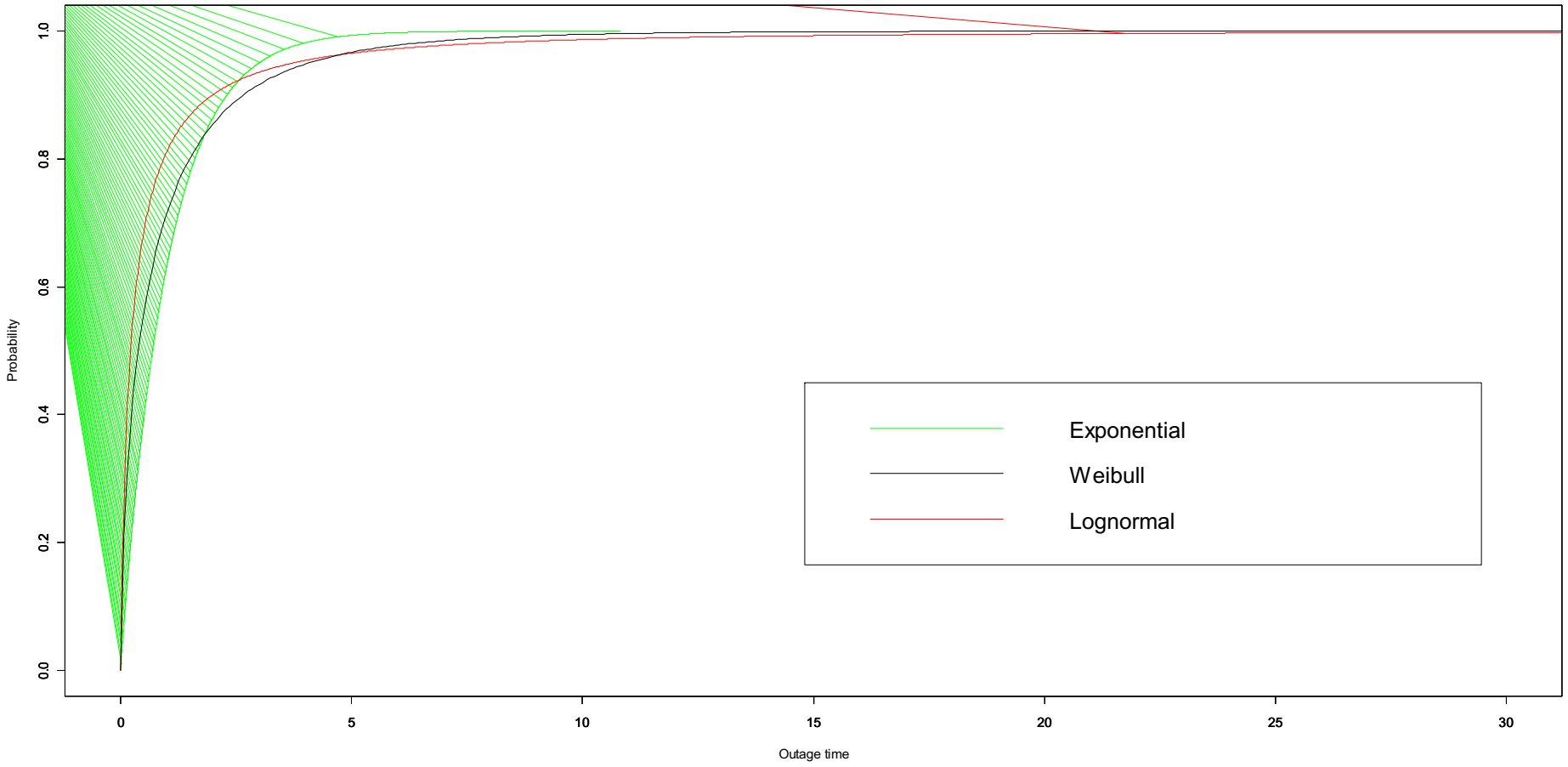
Parsimony

- Don’t use a three parameter distribution when a two parameter distribution will explain all the data

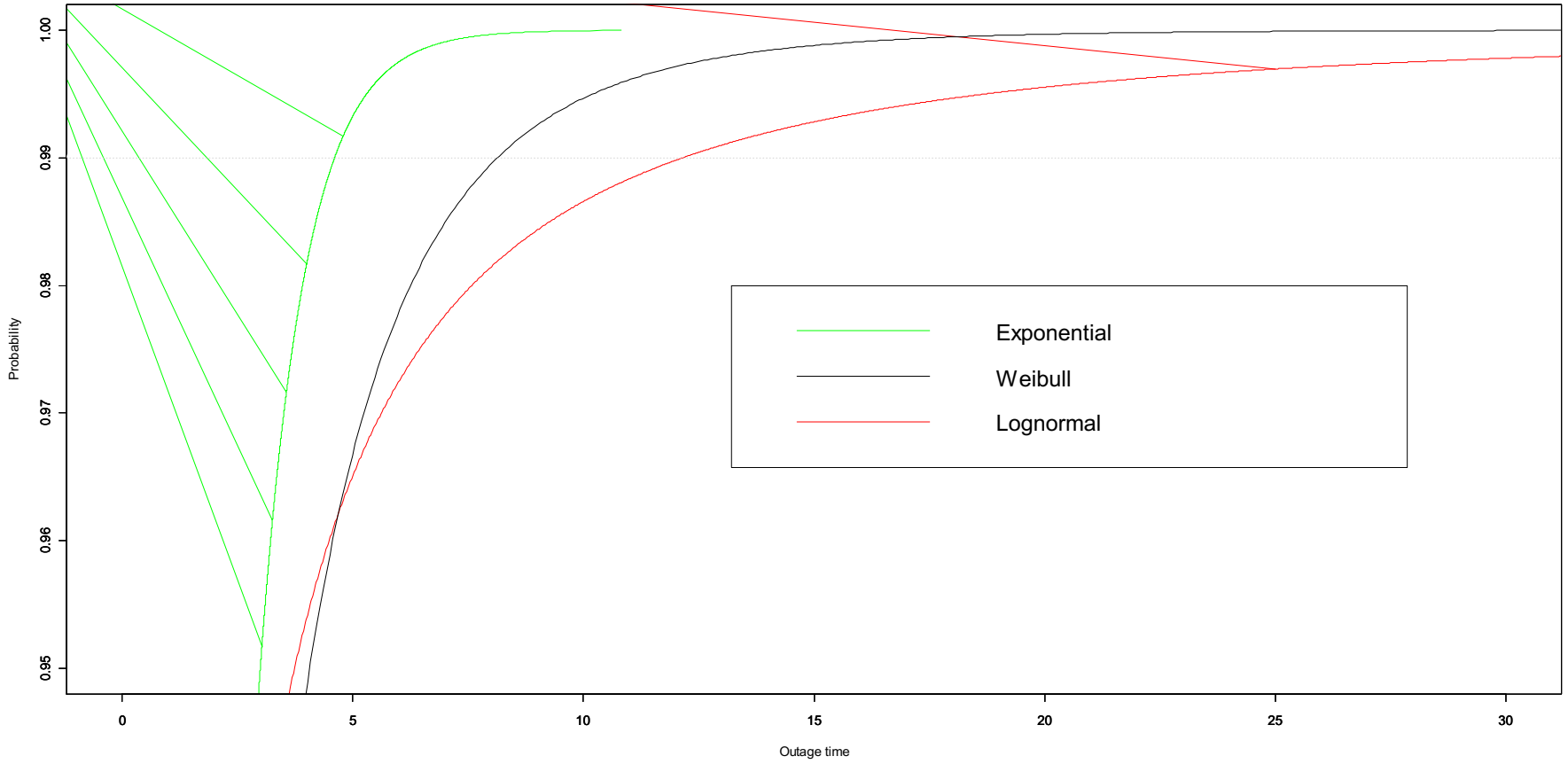
Theoretical approach

- Weibull for time-to-failure
  - If shape parameter = 1, this is exponential – failure rate is constant over time
  - If shape parameter < 1, failure rate decreases over time (actual value about 0.62)
- Log-normal for time-to-repair (actual sdlog value about 1.73)
- Examination of more historical data demonstrates this pattern strongly for full TTFs and TTRs
- Exponential (memoryless) is simplest approach

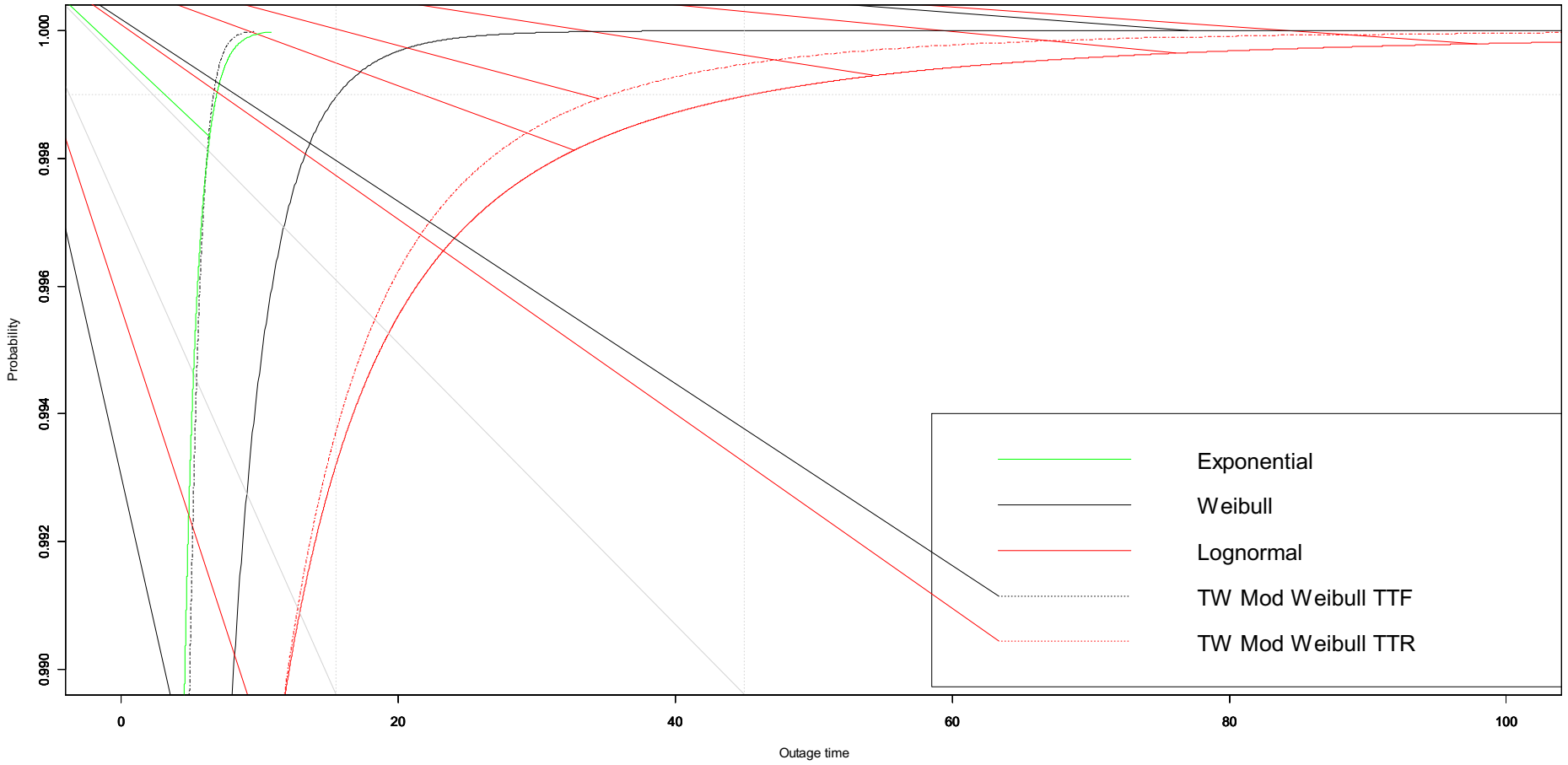
Weibull / log-normal (what's the difference)



Zoom in


Probability
1.00
0.99
0.98
0.97
0.96
0.95
0
5
10
15
20
25
30
Outage time
Exponential
Weibull
Lognormal

Zoom in more


Probability
1.000
0.998
0.996
0.994
0.992
0.990
0
20
40
60
80
100
Outage time
Exponential
Weibull
Lognormal
TW Mod Weibull TTF
TW Mod Weibull TTR

Conclusion 1

- AEMO data collection needs to reflect outages only in “demand” periods.
- For low utilisation units or units in the Available, but not committed state an outage ***should be recorded as “forced” only for the minimum reasonable period of repair***, i.e. if the outage duration could have been reduced in the presence of a strong commercial driver, only the estimated shorter duration should be recorded.

Questions

- Maintenance not considered in “unserved energy” studies – how important is it? It is not constant either.
- Are Monte Carlo simulations the right approach for all problems? (“if all you have is a hammer, everything looks like a nail”, KEMA approach)
- How many iterations do we need for a particular purpose?