Study Committee C1

Power System Development and Economics

Green Book

Power System Assets:
Investment, Management, Methods and Practices

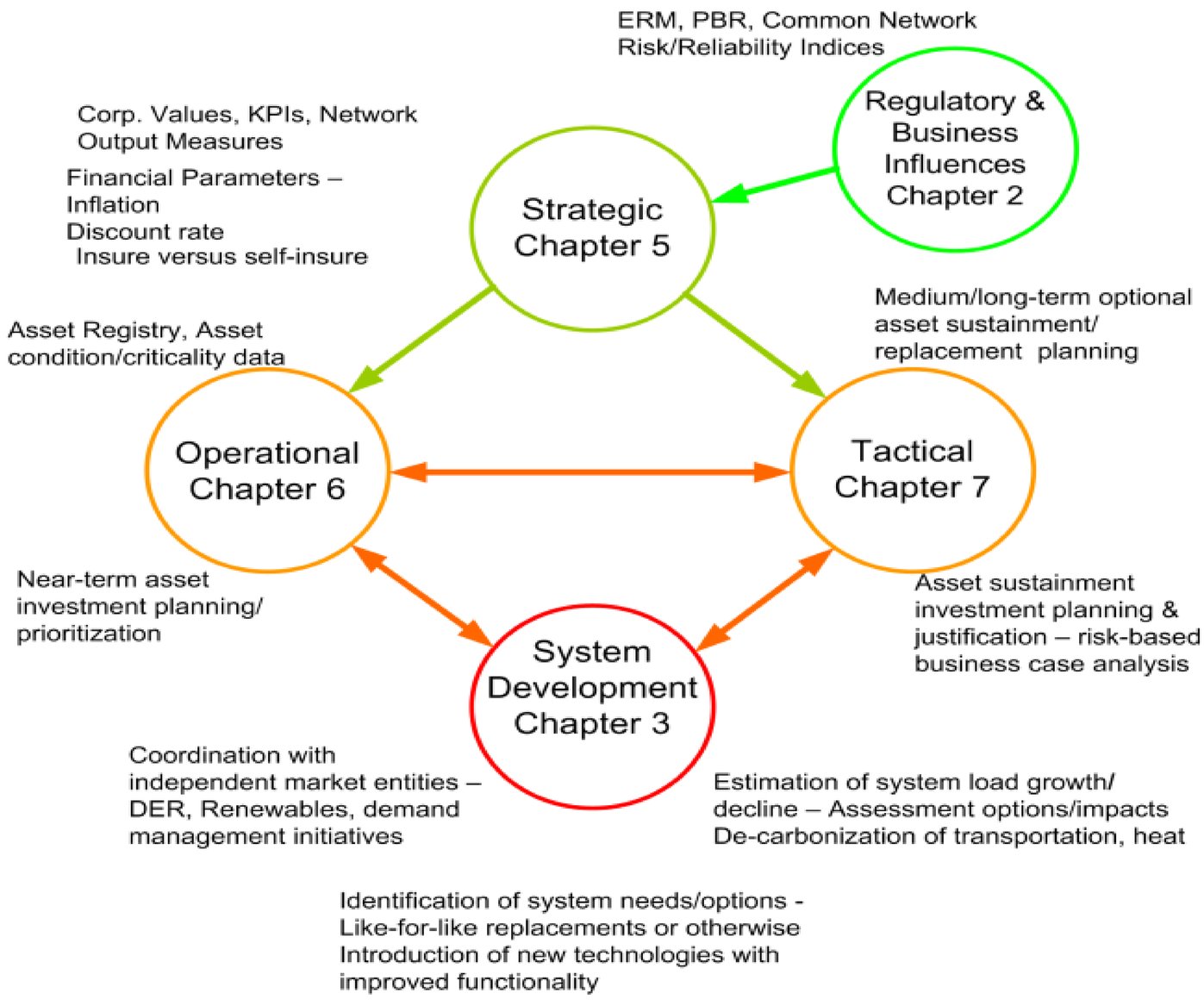
Outline

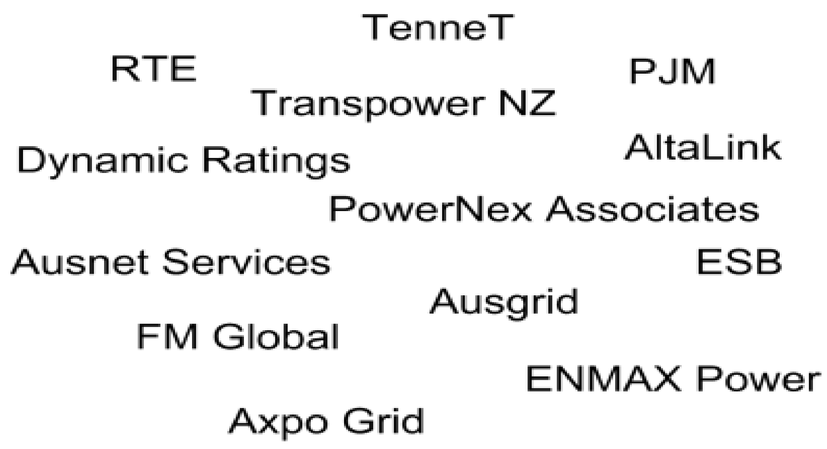
Part 1: The AM foundation

- Understanding asset ageing
- Asset management functions and interactions
- Regulatory/governmental influence
- Interactions between System development planning and asset sustainment planning
- Risk-based business case development

Part 2: AM Practices: 12 detailed Case Studies

- Targeted Equipment Servicing (as an Alternative to Replacement) of Disconnectors
- Overhead Transmission Line Asset Sustainment Investment
- Transformer Sustainment Investment Options
- Substation Reinforcement
- Transformer Repair/Replace Options
- Asset Fleet Management: “Bow Wave” Analysis
- Insurance As an Optional Asset Management Investment
- Risk-Based Overhead Line Corridor Clearance Management
- A New Reliability-Based Planning Measure for Grid Investment Prioritization
- Asset Failure Susceptibility Ranking
- Probabilistic Risk Assessment for Spare Transformer Planning





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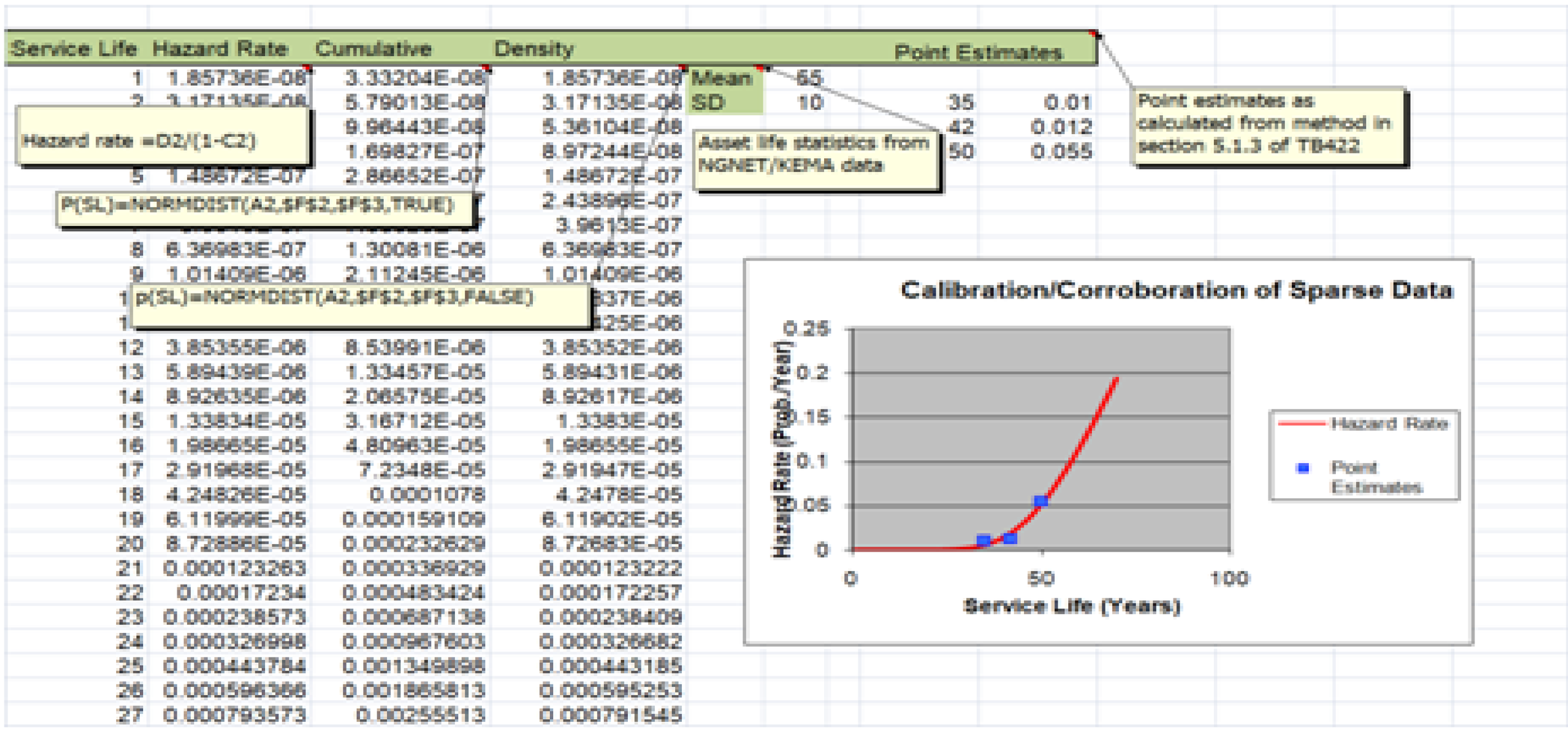
The book is focused on:

Practical methods to achieve results in the form of smarter asset investment decisions

The synergism or blending of system and equipment know-how, with probability/risk based methods and financial analysis.

Providing sufficient technical and analytical detail at a level comfortable for working level engineers and analysts, with minimal need to search for back-up reference or text book material.

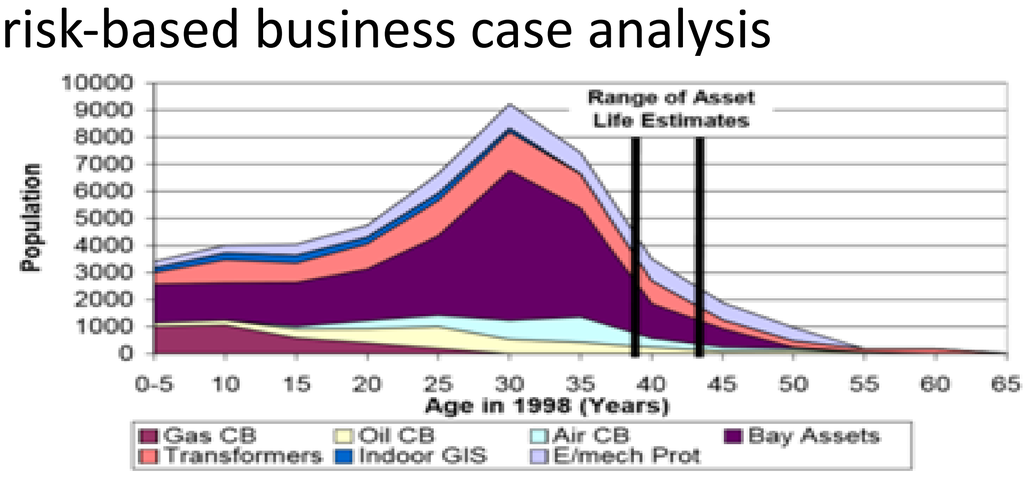


A typical illustration from the Green Book of an annotated spread sheet showing the underlying calculation formulae for fitting sparse failure data to an industry based hazard rate function

Asset management – A work in Progress

The book attempts to fill a gap in documenting risk-based business case analysis methods

The “Bow Wave” problem, anticipated more than 2 decades ago, is treated in an extensive case study in Part 2



A method to assess and value risk is described in chapter 8 on business case analysis in Part 1. The actuarial method allows monetized risk to be compared with optional Capex/Opex investment costs over a planning period to develop a rigorous risk basis for asset management investments.

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Asset management – A work in Progress

”When considering a non-recurring single risk over a defined time period, the risk event has two expected outcomes, either the risk will occur resulting in the full consequence cost or the risk event will not occur resulting in a zero-consequence cost.
For this reason the use of summated risk costs for financial provision over a defined time period works best when there is a large collection of risks. This is because if only a small number of risks are being considered, a financial provision based on summated risk cost will either be larger or smaller than is actually required.” [ofgem NGNET Risk Annex discussion]
An actuarial method to assess and value risk is described in chapter 8 on business case analysis in Part 1. The method allows monetized risk to be compared with optional Capex/Opex investment costs over a planning period to develop a rigorous risk basis for asset management investments.

1	**GSU Transformer**																
2	**Service life in 2019**		15														
3	Service life at end of planning period		30	= 1-SUM(B17:P17)													
4	Prob. of failure after planning period		0.8763														
5	Impact Costs (k$)	$	17,250														
6																	
7																	
8	Equipment Replacement Cost Year Zero (k$)	$	7,000														
9																	
10																	
11																	
12	**Inflation Rate**		0.03														
13	**Discout Rate**		0.05														
14	**Start year 2019**		**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**
15	**Years Ahead**		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
16	Inflated Impact Costs		24978	25727	26499	27294	28112	28956	29824	30719	31641	32590	33568	34575	35612	36680	37781
17	Probability of Impacts		0.0006	0.0008	0.0012	0.0016	0.0022	0.0030	0.0040	0.0053	0.0069	0.0089	0.0112	0.0140	0.0173	0.0212	0.0255
18	Risk Averse Probability of Impacts		0.0007	0.0010	0.0014	0.0019	0.0026	0.0036	0.0047	0.0062	0.0080	0.0102	0.0129	0.0160	0.0196	0.0238	0.0285
19	Expected Impact Costs		17	26	37	51	74	103	141	191	254	333	431	552	698	872	1077
20	Expected Discounted Impact Costs		17	23	32	43	58	77	100	129	164	204	252	307	370	440	518
21	Per Unit Discounted Premium		1	1.9524	2.8866	3.7232	4.5460	5.3295	6.0757	6.7864	7.4632	8.1078	8.7217	9.3064	9.8633	10.3936	10.8986
22	Expected Per Unit Discounted Premium		0.0006	0.0016	0.0033	0.0059	0.0100	0.0160	0.0244	0.0360	0.0515	0.0719	0.0980	0.1307	0.1711	0.2200	0.2782
23	Risk Premium	$	256	$ 256	$ 256	$ 256	$ 256	$ 256	$ 256	$ 256	$ 256	$ 256	$ 256	$ 256	$ 256	$ 256	$ 256
24	Present Value of Risk premium	$	244	$ 233	$ 222	$ 212	$ 201	$ 191	$ 182	$ 174	$ 165	$ 157	$ 150	$ 143	$ 136	$ 130	$ 123
25	NPV of the Cost of Risk (k$)	$	2,662														
26																	

Impact costs of failure in 2019	
Outage	10000
Installation	3000
Engineering	750
Cost of replacement power	0
Safety	1000
Environment	1500
Regulatory/ Investor	1000
TOTAL	17250

Risk Aversion	Probability of Impacts
Neutral	1
Averse	0.03

9.5503

Expected discounted premium for no failure in planning period= P21*B4

=B8+B5*(1+B12)

=POWER(B17,(1-j5))

=B16*B18

=B19/POWER((1+b13),B15)

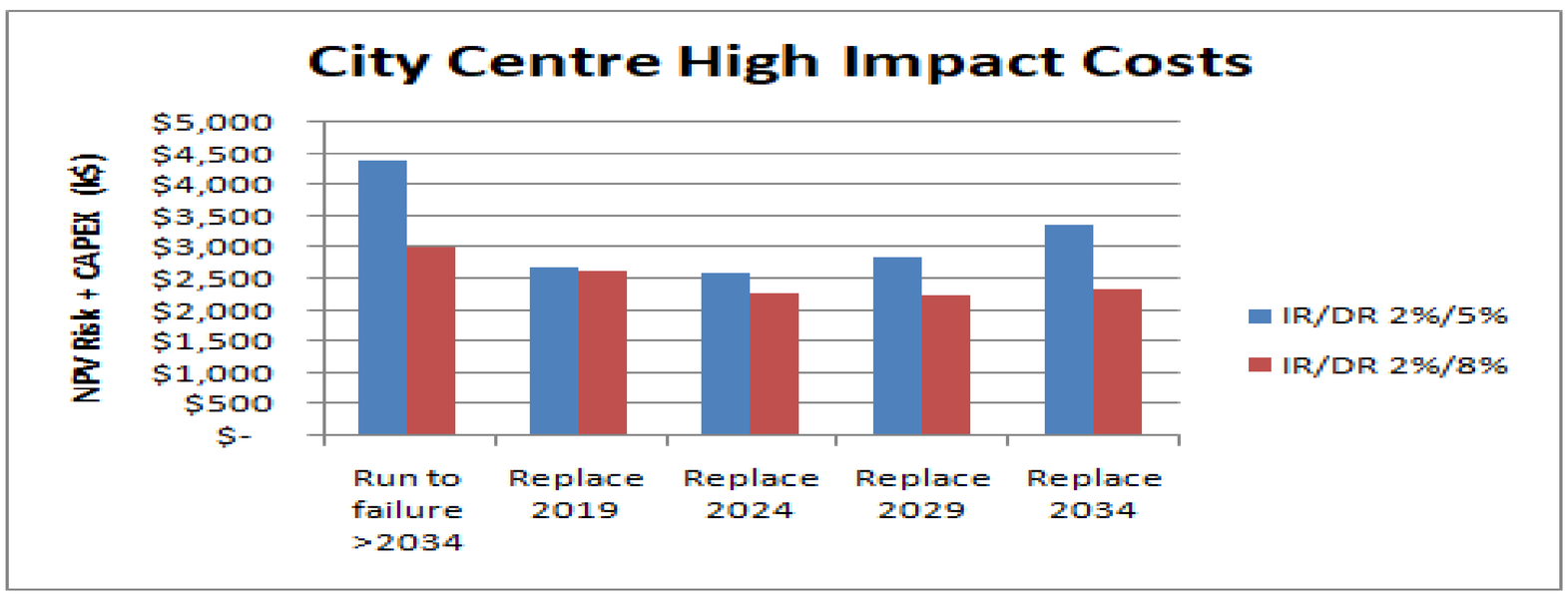
=B21+1/POWER((1+$B$13),B15)

=B21*B17

=SUM(B20:P20)/(SUM(B22:P22)+M8

=B23/POWER((1+$B$13),B15)

=SUM(B23:P24)



The outlook & need for AM Methods:

The energy transition – increased pressure on grid
System resiliency – increased extreme weather events
Regulatory activism and scrutiny increasing
Complex markets & players looking for positive risk/reward opportunities
Efficient, effective asset management methods increasingly important
Need to make smart investment decisions quickly