CAENZ

eea
Electricity Engineers' Association

Workshop

Future Network Security of Supply Requirements

14 June 2007, SKYCITY Auckland Convention Centre

Sponsored by: Ministry of Economic Development Manatū Ōhanga — Electricity Commission

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CAENZ's Distributed Generation Programme is supported by:

Future Network Security of Supply Requirements

14 June 2007, SKYCITY Auckland Convention Centre

We acknowledge the support for our Workshop by:

CAENZ

The DIRECT Approach

NEW ZEALAND CENTRE FOR ADVANCED ENGINEERING

CAENZ: Our Mission

To advance New Zealand's development and well-being through new engineering perspectives, analysis and a broader understanding of emerging issues in engineering and related technologies.

CAENZ at a Glance

- Not for profit organisation established as a Trust in 1987 to mark one hundred years of teaching engineering in New Zealand.
- Based at the University of Canterbury, governed by a Trust Board and Executive Committee supported by an Advisory Board comprised of senior academics and industry leaders.
- In 2006 the Centre reached an important milestone with a new partnership with the Faculty of Engineering, University of Auckland, extending its relationships with the University of Canterbury and the Institution of Professional Engineers.
- CAENZ work is funded by grants, sponsorship and income from hosting educational events such as conferences and workshops.
- Its work is delivered through a projects portfolio covering five key technology areas – Ocean Resources; Infrastructure Systems; Risk Management; Sustainable Technologies; and Emerging Technologies.
- CAENZ now acts as a national centre within the engineering and technology sectors to provide an independent and non-partisan view on major issues of the day.

CAENZ: Our Roles

CAENZ as a Think-Tank

Foremost among the roles for CAENZ is the role of the think-tank. CAENZ facilitates the cross-pollination of knowledge across disciplines and institutional boundaries, as well as contributing to projects of national importance.

CAENZ as an Integrator

CAENZ plays a strong integrating role within New Zealand's engineering and technology sectors. Our work is characterised by networking and collaboration which, through broad participation, is addressing some of the most difficult challenges of our time.

CAENZ as an Awareness Raiser

CAENZ provides expert commentary and interpretation on major issues of the day, and highlights the vital importance of engineering thinking and technological advance for a strong and growing society.

CAENZ 'DIRECT Approach'

D Differentiated

Strongly networked – specialises in projects with multiple clients/partners

Stimulus for collaborative action

Forward thinking – dealing with tomorrow's issues today

I Independent

Not for profit – governed and funded by Trust

Self-funding – no shareholders requiring a return

Trusted information source – broad participation

R Relevant

Focused on NZ's national needs

Current NZ requirements in its 5 Programmes

Economic and social performance a priority

E Efficient

Low overheads from small office and core team

Established project management system

Specific time and resource allocation with each project

C Competent

Established track record in project delivery

Uses recognised subject matter experts on teams

Each project structured to suit end result/objectives

T Thought Leadership

Sources latest international thinking for New Zealand

Pathfinder projects that deliver research-based thinking and analysis

Specialises in knowledge transfer and events

Maintains close links with academic institutions

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CAENZ Project: Modernisation of the NZ Electricity System

The 1992 project Reliability of Electricity Supply brought together a multi-disciplinary group of professionals from throughout the country to analyse the downstream aspects of supply reliability as it affects customers, electricity retailers, generators, and transmission and distribution network operators. From this initial study CAENZ continues to bring a balanced perspective on the critical issues facing the electricity industry.

Positive Outcomes and Benefits

- The Electricity Commission has adopted the methodology (updated) for measuring the value of lost load (VoLL) as a component of the industry grid investment tests. Recommendations arising from the 1992 study for the establishment of a national reporting scheme on reliability statistics for power companies were also adopted.
- More than a dozen international speakers and contributors have been brought to New Zealand, playing a major part in bringing DG opportunities to the forefront of industry. This is in response to the need for a more diverse energy supply system for the country.
- Individual participants in the CAENZ programmes and Energy21 have championed the establishment of a New Zealand National Committee of CIGRE (see box), providing the latest international research and experience to the sector.

Where We are Going

Networking and communication is a key to unlocking value within the New Zealand electricity sector through the improvement of the electrical system. CAENZ's Distributed Generation programme and its support for Energy21 and CIGRE are aimed at advancing broad-based economic and technical perspectives on electricity supply issues. A new report will be published in the CAENZ Commentary Series, which will offer a fresh analysis of the emergent DG market place. There is also a new study and Commentary currently in progress on the network implications of increased DG connections.

Energy21

Energy21 is the collective name for an industry-led initiative delivered by CAENZ to promote systems level modernisation of New Zealand's electricity system. Comprising a wide group of industry participants, Energy21 acts to promote and encourage cost-effective DG solutions through policy-based research, demonstration projects and seminars.

Energy 21 operates as an independent collaborative programme which is not aligned with any of the commercial motives in the current electricity supply chain. Contribution is through the delivery of policy-level research that acts to encourage and lead broad-based, systems-level thinking around modernisation, reconfiguration and improvement in our national energy supply and security.

Outputs lead and inform public debate on strategies for improving electricity security including the 'mainstreaming' of DG, Demand Responses, and System Optimisation.

E21 website: www.caenz.com (linked under 'Directory')

The CAENZ Record

Publications

1992	Reliability of Electricity Supply
1992-2000	Electricity Supply and Demand to 2015 (a series of six independent forecasts in collaboration with Leyland Consultants)
2003	Distributed Generation: a Study of Opportunities
2004	Energy21 News: publication of a new journal for Distributed Energy resources.
2005	Diesel Genset Applications Guide for Distributed Generation Investment
2006	DG: Understanding the Market – Possible Policy Interventions
2007	The Economic and Systems Impacts of Increased Distributed Generation Connection within New Zealand's Electricity Network

Seminars in association with the Electricity Engineers' Association (EEA) Annual conference

2002	DG Opportunities for NZ
2003	Market Development and Investment Opportunities
2004	Mainstreaming DG
2005	Implementing NZ's DG options
2006	DG and the Consequences for NZ's Power System
2007	Future Network Security of Supply Requirements

CIGRE

New Zealand now has its own National Committee of CIGRE (NZNC), joining 55 other countries world-wide. New Zealand's electrical power engineers will benefit from greater involvement in CIGRE and be able to exchange experience directly with like-minded electrical engineers from many countries around the world. CAENZ provides Secretariat services for the NZNC and hosts the website.

Aims and Objectives

The aims of CIGRE in New Zealand are to:

- Foster interest, within the New Zealand electricity supply industry, in the activities of CIGRE by encouraging local NZ CIGRE membership
- Promote networking among NZNC Members and others in related fields
- Enhance the collective technical skills and knowledge of the electricity supply industry in New Zealand
- Develop and enhance co-operation with any other agencies or organisations with objectives similar to the NZNC of CIGRE.

CIGRE website: www.cigre.org.nz

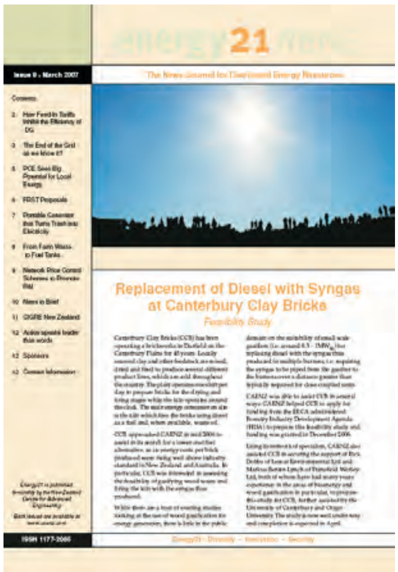
For more on CAENZ and CAENZ's programmes, visit www.caenz.com

CAENZ

energy21

Energy21 is an industry-led initiative delivered by CAE to promote the systems-level modernisation of New Zealand's electricity energy system. Energy21 aims to encourage cost-effective solutions, through strategies such as the "mainstreaming" of Distribution Generation, Demand Responses and System Optimisation.

An important component of the initiative is a regular newsletter, *Energy21 News*. This publication provides a source of DG information from around the world, web sites, etc, and is providing a much needed service to the electricity industry. There are now close to 150 people on the circulation list and this is steadily increasing.


energy21

Replacement of Diesel with Syngas at Canterbury Clay Bricks

Feasibility Study

Industry players with commercial interests in DG applications have supported CAE's efforts to research and publish specific resource based guidelines. The first to be published in 2005 was on the business case for diesel generator sets. Others are planned to follow dependent upon demand.

proposes a region-by-region energy resource analysis of DG opportunities; taking into account the diversity of different regions and their specific resource, location and network issues. The objective of the study is to increase the potential allowable DG capacity on local networks.

CAE believes that the Energy21 initiative has the potential to make a significant contribution to the modernisation of the country's electricity system. Our knowledge of the industry tells us that there is a high level of awareness of these issues, but without a systems-level approach uptake will be limited. CAE hopes that Energy21 will become a catalyst for change.

The following is a summary of the essential purpose and high-level objectives of the Energy21 Group.

Purpose:

- To contribute substantially to New Zealand's social, economic and environmental future through the promotion of innovative and durable improvements to the nation's electricity supply arrangements.
- To encourage and lead a broad-based systems-level review of New Zealand's electricity systems and infrastructure which will lead to extensive modernisation, reconfiguration and improvement in national energy security.
- To advance and promote a broad economic, technical and environmental perspective on national electricity system requirements, and to provide research capabilities for integrating these perspectives in planning and policy formulation.
- To lead and inform public debate on strategies for improving electricity security, including the "mainstreaming" of Distributed Generation (DG), Demand Responses; and System Optimisation.
- To provide a global view within the public debate, giving emphasis to efficiency and integrity as well as well electricity supply issues.

New Zealand Centre for Advanced Engineering
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Objectives:

To establish an industry-wide high-level group to inform public debate through informed comment and research focused on public policy and the practical/commercial issues faced during electricity system development.

Specifically:

- To respond to calls for advice on industry matters and prepare briefing papers to inform industry strategies;
- To maintain independence from current industry interests and motives through encouraging broad industry-wide representation;
- To position the initiative as an essential opportunity for long-overdue system modernisation, and for improvement to current supply arrangements; and
- To undertake policy-level research that aims to encourage a more strategic and integrated approach to DG investments.

E21 is proudly supported by:

For further information on CAE's DG Programme, vist www.caenz.com and select the "Distributed Generation' link under the 'Directory' heading. To download a copy of the Energy21 News, visit www.caenz.com and select the 'Energy21' link under the 'Current Newsletters' heading.

If you would like specific information or to follow up on any point raised in this flyer, or you would like to become part of the Energy21 network, please e-mail your request to: DG_info@caenz.com

EEA / CAENZ Workshop on Security of Supply

Future Network Security of Supply Requirements for New Zealand

8:30 am	*Registration*	*Tea and coffee available*
9:00 am	**Introduction**	
	Opening remarks and format	Tas Scott/George Hooper
9:10 am	**International Speakers**	
	Overview + UK experience	• John Scott (Ofgem - IET)
	CIGRE + Aus experience	• Phil Southwell (CIGRE AP C1)
	IEEE + US experience	• Mohammad Shahidehpour (IEEE - PES)
10:40 am	*Tea/coffee Break*	*Networking*
11:00 am	**Customer Needs**	
	Large Customer Group	• Telecom - Colin Foster
	Medium Customer Group	• Wiri Oil Services Ltd - John Knox
	Small Customer Group	• Grey Power - Peter Rutledge
	Rural Customer Group (2013+)	• Federated Farmers - Don Nicolson
	Present Performance Review	• Distributor Disclosures - Brian McGlinchy
12:30 pm	*Lunch Break*	*Networking*
1:30 pm	**National Regulator**	
	Electricity Commission	John Gleadow
2:00 pm	**Service Providers**	
	Generators/Retailers	• Greg Salmon (Meridian Energy)
	Transmission	• Tim George (Transpower)
	Distributors	• Glenn Coates (Orion)
3:30 pm	*Tea/coffee Break*	*Networking*
3:50 pm	**Panel Discussion**	
	NZ issues and EEA Guidelines	Panel - Speakers from above TBC
4:50 pm	**Summary of Workshop**	
	Main outcomes/consensus?	Tas Scott/Geoff Cardwell
5:00 pm	**Closure**	
	Concluding remarks	George Hooper

Biographies of Contributors

Colin Foster

Colin is a Chartered Professional Engineer with some 40 years experience in the telecommunications industry.

He is a Portfolio Manger for property and engineering services in Telecom NZ. Part of the responsibilities within the portfolio, include the technical requirements for electricity supply to all sites nationally, as well as the processing and continuity of power supplies to be used by telecommunications equipment.

Peter Rutledge

Peter Rutledge began his career in NZED and worked in that Department for 5 years. He joined the Otago Electric Power Board as Assistant Engineer for 3 years and then moved to the Central Canterbury Power Board in Hornby where he was employed for 21, years rising to the position of General Manager. He resigned from that position in1983 to join Worley Consultants of Auckland, and took up assignments in Indonesia and Bangladesh for the next 5 years. In 1989 he returned to NZ to work in the Electricity Supply Authorities Association. Peter rejoined Worley Consultants in 1993 and worked in Cambodia for three years, and then in Thailand, Vietnam and Nepal.

Peter is currently a member of the RMAG of the Electricity Commission as a consumer representative.

Greg Salmon

Greg Salmon is a Transmission Advisor at Meridian Energy. He has nine years experience in the electrical power industry and extensive experience in transmission risk assessment and mitigation. He worked at Transpower during the market implementation and was instrumental in developing transmission constraints to manage security of supply. He has also worked in Australia to develop processes to produce limit equations for Tasmania's entry into the NEM.

Greg has worked at Meridian Energy for four years where one of his key responsibilities has been managing nodal risk and providing advice into the pricing process on transmission risks. He also manages the ancillary services contracts and provides feedback into the regulatory environment on matters of security of supply and common quality. He is involved in Electricity Commission working panels looking at the potential of demand side to play a greater part in market operation.

John Scott

John Scott is the Technical Director for Ofgem, the British electricity and gas regulatory body. He takes a close interest in the engineering challenges faced by the electricity and gas network companies and has developed Ofgem's regulatory policies to incentivise greater technical innovation where this will bring longer term customer benefits.

John's background was Director of Engineering for National Grid Company in the UK and previously the manager of the electricity National Control centre.

John is a Fellow of the Institution of Engineering & Technology, he chairs the IET's Professional Network Executive (Power Systems & Equipment), and is a member of the Energy Sector Panel. He is vice chair of the EU Technology Platform – SmartGrids - that is addressing the Future of Electricity Networks for Europe.

Mohammad Shahidehpour

Mohammad Shahidehpour is the Carl and Paul Bodine Distinguished Professor and Chair of the Electrical and Computer Engineering Department at Illinois Institute of Technology (IIT) where he has been a professor since 1983.

He is the author of 300 technical papers and five books on large-scale optimisation and energy scheduling, and his research involves the operation, control, and planning of electric power systems. He has served as the Editor of the IEEE Transactions on Power Systems since 1994, Guest Editor of the Energy and Power magazine, and Guest Editor of the Special issue of the IEEE Transactions on Power Systems.

Dr. Shahidehpour has lectured extensively in countries across the globe on electricity restructuring issues and has been a visiting professor in several universities. He is a Fellow of IEEE.

Phil Southwell

Phil Southwell is the General Manager Strategy & Corporate Affairs Division of Western Power. He has 35 years experience in the electrical power industry and has extensive experience in power system development and business management.

Since 1996, Phil has been involved in the deregulation of the power industry in Western Australia. He has been an active contributor to the electricity reform process, and has been integral to positioning Western Power for its new roles in the electricity market.

Phil is the Australian member of the International CIGRE Study Committee C1, which covers System Development and Economics and is convenor of that body's Australian Panel. He is also a member of the University of WA Industry Advisory Council which influences the course content provided to electrical engineers. Phil is also a board member of the Australian Power Institute, recently formed to promote the collaborative education of electrical power engineers.

Abstracts

EEA/CAENZ Workshop on Security of Supply, 14 June 2007

Orion's Security of Supply Standards

Glenn Coates (Orion)

Orion's existing 'Security of Supply' standard (SSS) was adopted by Orion's board in October 1998. Since 1998 there have been a number of changes to the technical and regulatory environment and Orion has gained experience in the application of the present SSS. Hence, Orion decided to review its SSS during 2006. The review found that the present SSS should be modified slightly to better reflect an optimum balance between the cost of the network and the value of "lost load" to our customers.

The review was extensive and included a review of the 'Value of lost load', network architecture, capacity and security thresholds. An external review of the findings was undertaken by SKM and following customer agreement during late 2006 the new SSS is to be implemented in Orion's asset management plan and practices this year.

The new SSS remains as a deterministic standard and is applied as a tool for identifying potential network constraints. Network upgrade proposals are subject to probabilistic analysis and if economically appropriate will be implemented. If a network constraint cannot be resolved economically, then a security gap is published in our Asset Management Plan.

The new SSS will generate savings to future network capital investment but will slightly reduce our reliability performance. Relative to all other major NZ line companies Orion will maintain a high standard of security and reliability performance. Savings on capital investment will reduce upward pressure on price and/or provide opportunities to invest in maintenance or operations which may provide a better reliability return to our customers.

Regulating Grid Reliability

John Gleadow (Electricity Commission)

This presentation provides an overview of the Grid Reliability Standards, how they came about, what they are and how they are given effect. An explanation of the regulatory framework is provided including the relationship between the Grid Investment Test, the Grid Reliability Standards, the Interconnection Rules and the Benchmark [Transmission] Agreement.

Security Supply Standards

Greg Salmon (Meridian Energy)

When the security margin in a particular region is tight, prices tend to be more volatile and retailers reflect this in the price they offer to customers. This situation can lead to regional markets where one retailer may have a significant competitive advantage over other retailers (or even areas where all retailers believe there is an unacceptable risk). This means that timely investment not only improves security of supply but can create additional competition and downward pressure on electricity prices.

Security of supply is assumed by electricity consumers and price is normally the most important consideration when consumers choose their retailer. Retailers are not able to differentiate their product in terms of reliability as they are dependent on the same providers of transmission and distribution. However there are a number of key outcomes in the delivery of security of supply; for example the retailer needs information when something does go wrong, and where demand management is used to manage security of supply that it has minimal impact on the customer.

Retailers currently attempt to differentiate their products on price and other services. However under the current market structure they only have direct control over part of the supply chain. Vertically integrated generator/retailers can manage their generation to help control supply risk (volatility due to energy availability) however they are exposed to price risk in the transmission and distribution of electricity over which they have very little control. There is significant price volatility, because of the state of the New Zealand transmission grid and nodal pricing. This potentially makes retailing electricity a risky business!

All commercial companies make price risk trade offs. Electricity retailers are no different and will set prices based on their risk return appetite. This should have some important consequences for how the industry addresses security of supply.

Generator/Retailers will tend to prefer large transmission options as it allows the greatest efficiencies in generation build and reduces nodal risk. The current market structure doesn't encourage generators to site their generation to meet security of supply requirements. There are a number of alternatives for delivering improvements to security of supply but how they impact on price risk varies between the different solutions. The net result is that some options can increase the price risk that retailers face and customers in this situation can expect to pay not only for the security of supply improvement through Part F of the rules but also an additional risk premium (unless the provider of the option is prepared to hedge the retailers risk).

Part of the reason for this situation is that there is currently no financial product that allows retailers to manage nodal risk. This is partly because the current distribution of rentals is unfair and this creates investment distortions. Other countries have introduced financial transmission rights (FTR) to address this concern however they still remain controversial in New Zealand and Locational Rental Allocation (LRA) has been proposed as an alternative. In either case, development is urgently required.

Network Security of Supply – an Ofgem perspective

John Scott (Ofgem)

John Scott's talk will be both an update on issues from the UK and a regulator's view of the challenges faced by the electricity networks sector.

He will be addressing the following topics:

The British context

- Quality Performance across Europe

Ofgem Quality of Service measures

- Guaranteed standards (GOSP) and Output Incentives (IIP)
- Quality of Supply performance data to 2005/06
- The structure and rationale of the GB model
- Revenue incentives and their values

GB Planning Standards

- Distribution standard recent update
- Next steps: KEMA/IC recent report
- Transmission standards and live issues
- The challenge of wind generation for network planning

Value to Customers

- Accent Customer attitudes survey (DPCR4)
- Implied IIP valuation of VOLL

Some Live Issues

- Recent European disruption – a serious incident
- Emergency Planning in Britain and recent lessons learned
- Black Start review and the priority actions

John's talk will present an overview of the issues and review whether the developments are simply business as usual, or is there yet greater change on the horizon to which the sector will need to respond ?

International Trends in Network Security of Supply

Phil Southwell (Western Power)

Network security of supply is of critical importance to all developed countries. As deregulation of the electricity industry has occurred across the world, the various aspects that contribute to this security have become clearer. However, this has presented new technical challenges, particularly in relation to interconnection between power systems. The resolution of these aspects has required greater oversight of the overall power systems supported by more rules and governing bodies.

As occurred in Auckland in 1998, there have been major loss-of-supply events across the world such as in North East America and Italy, both in 2003. These events have highlighted the critical importance of ensuring an adequate security of supply.

A further major issue relates to the impact of the use of significant quantities of renewable energy, particularly in Europe. This has gained even greater focus in recent times with the announcements in England and Europe to commit to very significant reductions in greenhouse gases.

CIGRE is an international organisation that researches, by means of working groups, technical issues in relation to transmission and subtransmission across the world. Study Committee C1 deals with asset management, power system planning and economics. This paper will draw on work carried out by recent working groups within C1 that is relevant to the above topic and covers the issues discussed above.

In addition, there will be a brief overview of the current Australian regulatory requirements for network security together with an outline of methods used to ensure customers are consulted in relation to the trade offs between price and reliability.

Presentations

Future Network Security of Supply Requirements for NZ

The US Perspective

Dr. Mohammad Shahidehpour, Fellow IEEE
Carl Bodine Distinguished Professor and Chairman
Electrical and Computer Engineering Department
Illinois Institute of Technology
Chicago, Illinois, USA

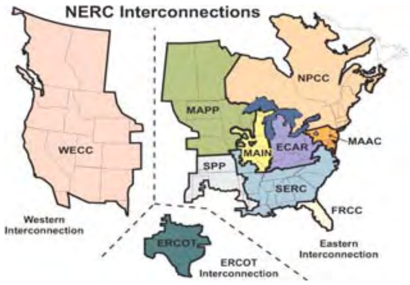
The Interconnection

- Edison designed the entire electrical system down to the wall outlet and in 1881 established the first power company.
- In the 1930s, isolated power systems melded into interconnected systems.
- In the 1950s and 1960s, isolated systems were converted to large regional pools.
  - bulk delivery over long distances
  - originated at large generating plants
- With economies of scale, prices declined and demands increased.

Electricity Facts

- Electricity is a cornerstone of any industrialized nation.
  - 4% of GDP in the U.S.
  - In terms of revenue, it surpasses telecommunications, airline, and gas industries.
    - $1 trillion total asset value, $360 billion annual revenue
    - 950,000 megawatts of generating capability and nearly 3,500 utility organizations.
- Electricity is an essential commodity that has no substitute.
  - Unlike most commodities, electricity cannot be stored easily
  - It must be produced at the same instant it is consumed.

3 Interconnections / 10 NERC Regions



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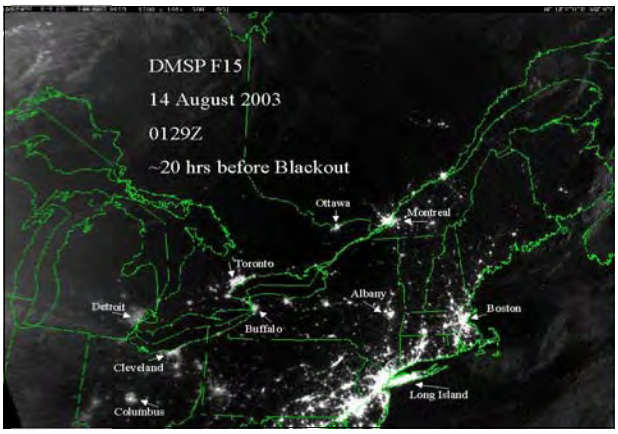
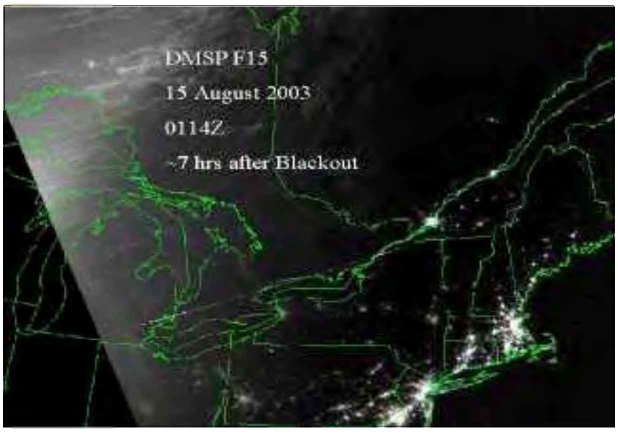
Invisible Asset

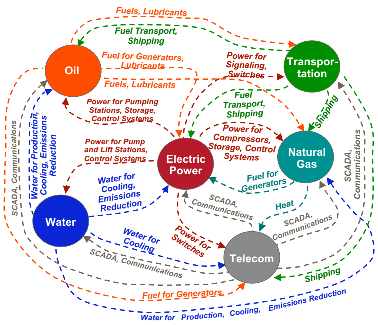
- High reliability has rendered electricity grid nearly invisible, at least until the lights go out.
- Blackout of 14 August 2003 raised questions about how a power grid works and why it fails.
- Many people asked: How could a small local problem bring the lives of 50 million people to a standstill in a few minutes?

5





Interdependent Infrastructures



Reliability Terms

- Reliability of the electric grid has been defined by NERC in terms of two functional aspects. These include:
- Adequacy — the ability of the electric system to supply the aggregate electrical demand and energy requirements of the customers at all times, taking into account scheduled and reasonably expected unscheduled outages.
- Security — the ability of the electric system to withstand sudden disturbances such as electric short circuits or unanticipated loss of system elements.

Improving Reliability

- There are two basic options for improving reliability.
- The first option is to construct the bulk power system with a high level of "adequacy" using large generation and transmission capability.
- Under this scenario, risk and uncertainty are minimized because the bulk power system is constructed to handle stresses well beyond what are predicted to occur.
- Unfortunately, the cost of this option is high and the redundancy in the infrastructure does not contribute to increased electricity production.

10

Improving Reliability

- The second reliability improvement option is to improve the operational methods or efficiency of the power system.
- Demand management (load shedding) is an example of operational methods that limit or interrupt loads when necessary to improve reliability.
- Another example of the efficiency improvement option is to provide quick recovery methodologies when outages occur or the training of operators in procedures to avoid outages.
- Risk and uncertainty are overcome by operating the existing bulk power system in an efficient way.
- Cost is reduced by using the second option, but reliability is not assured.

11

Minimizing Risks

- Realistically, some combination of the above two options probably is needed to reduce risk and uncertainty and ultimately improve reliability.
- In both cases, the uncertainty and risks to the bulk power system must be identified and then eliminated.
- As the risk level rises, the potential for problems increases and reliability degrades. Ideally, the added risks are identified and addressed before actual problems occur.
- As the risks are eliminated, the potential for problems decreases and reliability is improved.

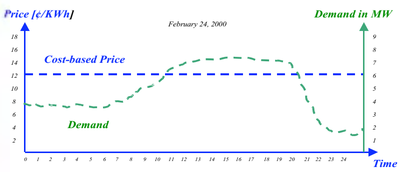
12

Electricity Restructuring

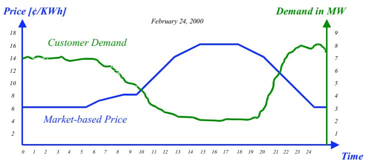
- Many attribute the utility industry problems as a loss in reliability brought on by electric utility restructuring.
- Restructuring advocates assert that functional changes in the electric utility industry resulting from restructuring are designed to add certainty and therefore improve reliability while providing lower prices to consumers.
- Functional changes such as improved planning and coordination, the ability to attract new market participants, increased redundancy, and the development of ancillary service markets all tend to lower risk and ultimately improve reliability.

Restructuring: What & Why

- What is restructuring?
  - Unbundling of vertically-integrated monopolies into separate generation, transmission and distribution entities.
  - Increased competition through open access.
- What are restructuring goals?
  - Reduce energy charges through competition.
  - Customer choices of providers by creating open access.
  - Level of service reliability can be priced for customers.
  - Business opportunities for new products and services.



Behavior of a Demand in a Vertically integrated Power Market

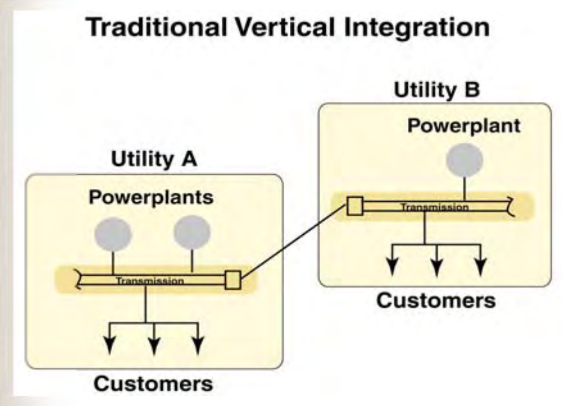


Response of a Demand to Price Signals

Electricity Restructuring

- Restructuring opponents argue that resulting functional changes in the industry tend to increase uncertainty.
- These changes include added complexity, added risk for investors, unclear responsibilities for reliability, and the potential to manipulate markets in ways that may cause power supply instability.

16



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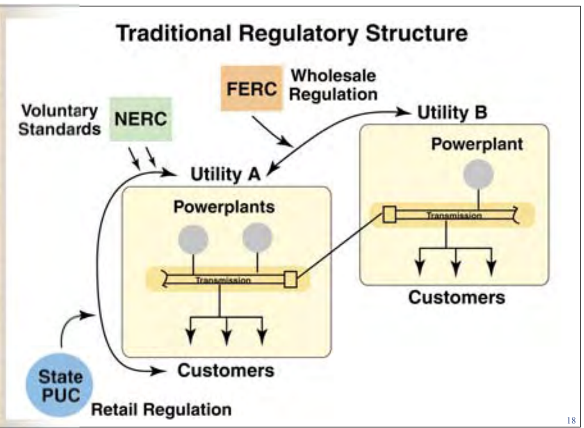

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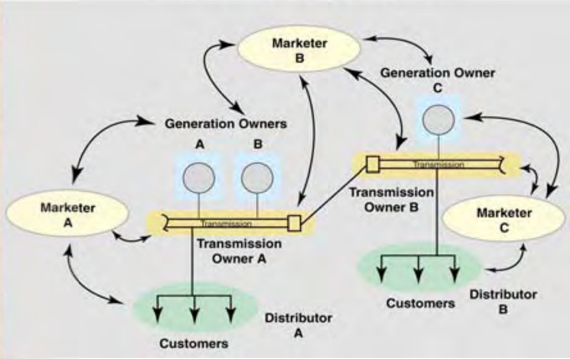
Restructuring - Main Participants



19

Industry Challenges

- Challenges facing the electricity industry restructuring:
  - rapid increase in wholesale transactions between independent power producers and distribution utilities;
  - increasing grid congestion;
  - continuing low levels of infrastructure investment;
  - technology which allows more options for consumers;
  - growing need for better grid security;
  - Investment decisions made by market forces rather than by a centralized decision process.

20

North American Electric Reliability Council

- NERC was formed after the 1965 blackout in the Unites States.
- NERC's mission is to improve the reliability of the bulk power system in North America.
- To achieve that, NERC develops and enforces reliability standards; monitors the bulk power system; evaluates adequacy annually via a 10-year forecast and winter and summer forecasts; audits users, owners and operators for preparedness; and educates, certifies and trains industry personnel.
- NERC is a non-profit organization subject to oversight by the U.S. Federal Energy Regulatory (FERC) and governmental authorities in Canada.

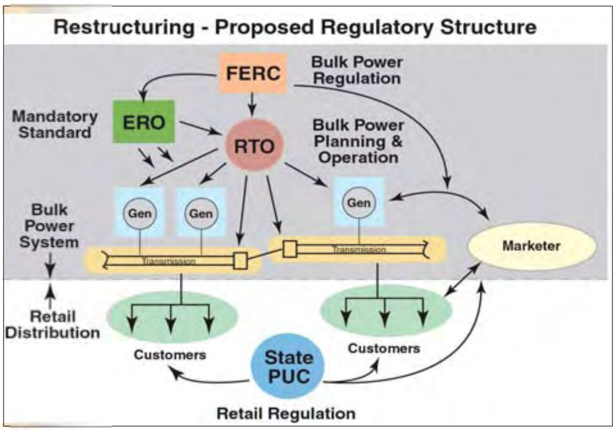
21

Reliability Guidelines

- North American electricity industry has operated one of the world's most reliable electricity networks under voluntary guidelines for decades.
- Voluntary guidelines worked very well to a point, but they were not enough.
- The electricity industry is no stronger than its weakest link, and a mistake by one entity can affect customers hundreds of miles away.
- To avoid future blackouts, everyone must follow all the rules, all the time. Mandatory standards are the next logical step toward achieving that.

Organizations

- The August 2003 blackout that affected 50 million people in the northeastern and midwestern U.S. and Canada prompted U.S. legislators to make standards mandatory and enforceable via the Energy Policy Act of 2005, which also authorized the creation of a self-regulatory Electric Reliability Organization (ERO) to develop and enforce the standards.
- FERC approved NERC's functions as ERO on July 20, 2006.
- ERO would develop mandatory standards for all activities on the bulk power system.



Energy Policy Act

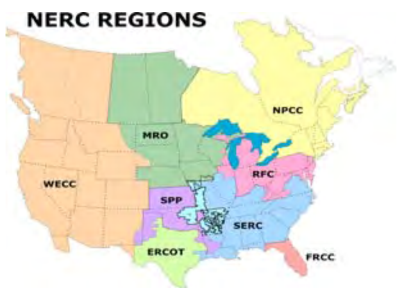
- The Energy Policy Act of 2005 did not outlaw blackouts. It did not grant the FERC plenary power to take any action it saw fit to prevent blackouts.
- What it did do was to provide for mandatory reliability standards, backed by new enforcement powers granted to FERC.
- As of June 18, 2007, U.S. utilities and other bulk power industry participants that violate any requirements of 83 reliability standards will face enforcement actions by ERO under federal law.

25

Mandatory Compliance

- Standards relate to the planning and operation of the bulk power system which cover areas such as balancing customer demand with generation supplies, emergency operations, cyber security, vegetation management, and disturbance reporting.
- More than 1,400 entities that carry out functions necessary to ensure a reliable bulk power system must comply with the NERC Reliability Standards.
- NERC, working with eight regional entities under delegation agreements approved by FERC, will monitor compliance with the standards and impose enforcement actions when violations are identified.

26



27

Current Reliability Regions

- ERCOT - Electric Reliability Council of Texas
- FRCC - Florida Reliability Coordinating Council
- MRO - Midwest Reliability Organization
- NPCC - Northeast Power Coordinating Council
- RFC - ReliabilityFirst Corporation (under construction)
- SERC - Southeast Electric Reliability Council
- SPP - Southwest Power Pool
- WECC - Western Electricity Coordinating Council

28

NERC Control Areas

29

Violations of Mandatory Compliance

- Violation of mandatory standards would result in penalties, and the threat of penalties might encourage participants to maintain reliability features even when the standards were not perceived as economically beneficial to the transmission owner.
- The electricity industry has spent years preparing for this new era in which compliance with reliability standards is mandatory, corrective measures can be ordered, and fines of up to $1 million a day can be imposed.

30

Reliability Standards Index

Standard Number	Title
	Resource and Demand Balancing
BAL-001-0	Real Power Balancing Control Performance
BAL-002-0	Disturbance Control Performance
BAL-003-0	Frequency Response and Bias
BAL-004-0	Time Error Correction
BAL-005-1	Automatic Generation Control
BAL-006-1	Inadvertent Interchange
	Critical Infrastructure Protection
CIP-001-1	Sabotage Reporting
CIP-002-1	Critical Cyber Asset Identification
CIP-003-1	Security Management Controls
CIP-004-1	Personnel & Training
CIP-005-1	Electronic Security Perimeter(s)
CIP-006-1	Physical Security of Critical Cyber Assets
CIP-007-1	Systems Security Management
CIP-008-1	Incident Reporting and Response Planning
CIP-009-1	Recovery Plans for Critical Cyber Assets

	Communications
COM-001-1	Telecommunications
COM-002-2	Communications and Coordination
	Emergency Preparedness and Operations
EOP-001-0	Emergency Operations Planning
EOP-002-2	Capacity and Energy Emergencies
EOP-003-1	Load Shedding Plans
EOP-004-1	Disturbance Reporting
EOP-005-1	System Restoration Plans
EOP-006-1	Reliability Coordination – System Restoration
EOP-007-0	Establish, Maintain, and Document a Regional Blackstart Capability Plan
EOP-008-0	Plans for Loss of Control Center Functionality
EOP-009-0	Documentation of Blackstart Generating Unit Test Results
	Facilities Design, Connections and Maintenance
FAC-001-0	Facility Connection Requirements
FAC-002-0	Coordination of Plans for New Facilities
FAC-003-1	Vegetation Management Program
FAC-008-1	Facility Ratings Methodology
FAC-009-1	Establish and Communicate Facility Ratings (Future Effective Date)
FAC-010-1	System Operating Limits Methodology for the Planning Horizon (Future Effective Date)
FAC-011-1	System Operating Limits Methodology for the Operations Horizon (Future Effective Date)
FAC-012-1	Transfer Capabilities Methodology
FAC-013-1	Establish and Communicate Transfer Capabilities
FAC-014-1	Establish and Communicate System Operating Limits (Future Effective Date)

	Interchange Scheduling and Coordination
INT-001-2	Interchange Transaction Tagging
INT-003-2	Interchange Transaction Implementation
INT-004-0	Interchange Transaction Modifications
INT-004-1	Interchange Transaction Modifications
INT-005-2	Interchange Authority Distributes Arranged Interchange
INT-006-2	Response to Interchange Authority
INT-007-1	Interchange Confirmation
INT-008-2	Interchange Authority Distributes Status
INT-009-1	Implementation of Interchange
INT-010-1	Interchange Coordination Exemptions
	Interconnection Reliability Operations and Coordination
IRO-001-1	Reliability Coordination – Responsibilities and Authorities
IRO-002-1	Reliability Coordination – Facilities
IRO-003-2	Reliability Coordination – Wide Area View
IRO-004-1	Reliability Coordination – Operations Planning
IRO-005-2	Reliability Coordination – Current-Day Operations
IRO-006-3	Reliability Coordination – Transmission Loading Relief
IRO-014-1	Procedures to Support Coordination Between Reliability Coordinators
IRO-015-1	Notifications and Information Exchange Between Reliability Coordinators
IRO-016-1	Coordination of Real-time Activities Between Reliability Coordinators

Modeling, Data, and Analysis	
MOD-001-0	Documentation of TTC and ATC Calculation Methodologies
MOD-002-0	Review of TTC and ATC Calculations and Results
MOD-003-0	Procedure for Input on TTC and ATC Methodologies and Values
MOD-004-0	Documentation of Regional CBM Methodologies
MOD-005-0	Procedure for Verifying CBM Values
MOD-006-0	Procedures for Use of CBM Values
MOD-007-0	Documentation of the Use of CBM
MOD-008-0	Documentation and Content of Each Regional TRM Methodology
MOD-009-0	Procedure for Verifying TRM Values
MOD-010-0	Steady-State Data for Transmission System Modeling and Simulation
MOD-011-0	Regional Steady-State Data Requirements and Reporting Procedures
MOD-012-0	Dynamics Data for Transmission System Modeling and Simulation
MOD-013-1	RRO Dynamics Data Requirements and Reporting Procedures
MOD-014-0	Development of Interconnection-Specific Steady State System Models
MOD-015-0	Development of Interconnection-Specific Dynamics System Models
MOD-017-0	Aggregated Actual and Forecast Demands and Net Energy for Load
MOD-016-1	Documentation of Data Reporting Requirements for Actual and Forecast Demands, Net Energy for Load, and Controllable Demand-Side Management
MOD-018-0	Reports of Actual and Forecast Demand Data
MOD-019-0	Forecasts of Interruptible Demands and DCLM Data
MOD-020-0	Providing Interruptible Demands and DCLM Data
MOD-021-0	Accounting Methodology for Effects of Controllable DSM in Forecasts
MOD-024-1	Verification of Generator Gross and Net Real Power Capability
MOD-025-1	Verification of Reactive Power Capability

34

NUC-001-1	Nuclear Plant Interface Coordination
Personnel Performance, Training, and Qualifications	
PER-001-0	Operating Personnel Responsibility and Authority
PER-002-0	Operating Personnel Training
PER-003-0	Operating Personnel Credentials
PER-004-0	Reliability Coordination – Staffing
PER-004-1	Reliability Coordination – Staffing
Protection and Control	
PRC-001-1	System Protection Coordination
PRC-002-1	Define Regional Disturbance Monitoring and Reporting Requirements
PRC-003-1	Regional Requirements for Transmission and Generation Protection System Misoperations
PRC-004-1	Analysis and Mitigation of Transmission and Generation Protection System Misoperations
PRC-005-1	Transmission and Generation Protection System Maintenance and Testing
PRC-006-0	Development and Documentation of Regional UFLS Programs
PRC-007-0	Assuring Consistency with Regional UFLS Programs
PRC-008-0	Underfrequency Load Shedding Equipment Maintenance Programs
PRC-009-0	UFLS Performance Following an Underfrequency Event
PRC-010-0	Assessment of the Design and Effectiveness of UVLS Program
PRC-011-0	UVLS System Maintenance and Testing
PRC-012-0	Special Protection System Review Procedure
PRC-013-0	Special Protection System Database
PRC-014-0	Special Protection System Assessment
PRC-015-0	Special Protection System Data and Documentation
PRC-016-0	Special Protection System Misoperations
PRC-017-0	Special Protection System Maintenance and Testing
PRC-018-1	Disturbance Monitoring Equipment Installation and Data Reporting
PRC-020-1	Under-Voltage Load Shedding Program Database
PRC-021-1	Under-Voltage Load Shedding Program Data
PRC-022-1	Under-Voltage Load Shedding Program Performance

35

Transmission Operations	
TOP-001-1	Reliability Responsibilities and Authorities
TOP-002-0	Normal Operations Planning
TOP-002-2	Normal Operations Planning (Future Effective Date)
TOP-003-0	Planned Outage Coordination
TOP-004-1	Transmission Operations
TOP-005-1	Operational Reliability Information
TOP-006-1	Monitoring System Conditions
TOP-007-0	Reporting SOL and IROL Violations
TOP-008-1	Response to Transmission Limit Violations
Transmission Planning	
TPL-001-0	System Performance Under Normal Conditions
TPL-002-0	System Performance Following Loss of a Single BES Element
TPL-003-0	System Performance Following Loss of Two or More BES Elements
TPL-004-0	System Performance Following Extreme BES Events
TPL-005-0	Regional and Interregional Self-Assessment Reliability Reports

Voltage and Reactive	
VAR-001-0	Voltage and Reactive Control
VAR-001-1	Voltage and Reactive Control
VAR-002-1	Generator Operation for Maintaining Network voltage Schedules (Future Effective Date)

36

Interchange Scheduling and Coordination	
INT-001-2	Interchange Transaction Tagging
INT-003-2	Interchange Transaction Implementation
INT-004-0	Interchange Transaction Modifications
INT-004-1	Interchange Transaction Modifications
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Conclusions

- Whether the proposed legislation can provide the desired reliability has yet to be seen.
- The details of the implementation by FERC, NERC, and the industry participants would be the key.
- The answer to the question of whether reliability can be maintained while restructuring the electric utility industry is difficult to predict.
- There has been much concern about the topic; however, the proposals remain, for the most part, untested and unproven.
- Proposed legislative remedies will be successful only if and when they result in the necessary capability, flexibility, and efficiency in the existing system required to overcome the added risks.

EEA Annual Conference in Auckland, June 15 – 16, 2007

International Trends in Network Security of Supply

Phil Southwell; General Manager Strategy and Corporate Affairs, Western Power; Australian Panel Convenor of CIGRE Study Committee C1.

Zoran Božić, Access Development Engineer, Western Power

1. POWER SUPPLIES AROUND THE WORLD

In 1893 Tesla's polyphase alternating current was chosen for Niagara Falls power plant on the basis of its undeniable merits. Harnessing of Niagara in 1895 gave birth to the great power systems of the world that now supply electricity to our homes. That system stretched for just 35km and supplied the nearby town of Bufallo by one 11kV line.

Since then, the world has embraced rapid electrification and electricity has reached the furthest corners of our planet. Heavy power lines became a synonym for progress of our civilisation.

The dissemination of Tesla's invention planted many seeds of electrification around the world. Out of each power station a power system grew, gradually extending its geographical reach. When two such isolated power systems reach one another and merge they form an interconnected system or interconnection. Two large interconnections in Europe and North America spread like a gigantic web across the whole continent. Despite physical boundaries that constrain their geographical expansion, power systems are continuously evolving, mainly following the pace of population and industrial development. In that respect one can differentiate today between power systems which are highly industrialized in some parts, highly interconnected, isolated or developing. Different characteristics of these power systems require different approaches to security.

Three major changes over the past two decades include changes in fuel for power generation, increased uncertainty due to deregulation of the electricity supply industry and the changed role of the transmission system. These will be briefly described here and discussed in terms of their impact on power system security. A brief review of recent blackouts will focus on their early warning signs and how to avoid them in operational timeframes and by regulatory means. The paper will draw on work carried out by recent CIGRE working groups.

2. FUEL

2.1 Traditional Fuels

The first power stations utilised hydro energy potential for the generation of electricity. For over half of the 20th century, coal and hydro electric plants were the dominant source of electric energy. The use of nuclear power for commercial electricity generation began in the sixties and was given a boost in the aftermath of the oil crisis in the seventies. The enthusiasm for nuclear power was shaken after a few incidents and unresolved concerns for safe long-term storage of the nuclear waste. A number of European countries renounced nuclear power and devised a program to accelerate phasing out their existing nuclear power plants.

The use of natural gas for electricity generation is largely constrained by the availability of gas and open cycle gas turbines have been traditionally used for peaking plant. Use of gas became extremely popular around the world in the nineties with the mass proliferation of gas turbines operating in the combined cycle mode as base load units. Today combined cycle plant is the dominant type of new generation in Europe and North America, and probably in most of the world where gas is available.

Common for all these traditional types of power plant (hydro, coal, nuclear and gas) is that they use synchronous generators to generate electricity and connect to the grid. Together, they have dominated the industry for over a century. Synchronous generators are robust, reliable and extremely suitable devices to ride through disturbances and provide continuity of supply to customers.

2.2 Wind Power

The unchallenged dominance of the traditional power generation plant started to change in the past decade. Initiatives in various countries to reduce dependence on imported fuels, and perhaps climate change, have led to a global wind power boom. An unprecedented market growth of 32% was recorded in 2006 [Modern Power Systems, March 2007, p-3, article "Global windpower boom"], when about 16,000MW of new wind capacity was installed, bringing the total installed wind energy capacity worldwide to about 75,000MW.

Countries with the highest total installed capacity are Germany with 20,900MW, Spain with 11,600MW, the USA with 11,600MW, India with 6,300MW and Denmark with 3,100MW.

Europe is still leading the trend with 49,000MW of installed capacity at the end of 2006, representing 65% of the global total. European wind generation produced about 100TWh of electricity in 2006, or about 3.3% of total EU electricity consumption. The wind power was second only to gas-fired capacity in terms of new installations in the EU and the USA.

Newer players gaining ground are China with 1,347MW and France with 810MW. The installed capacity of wind turbines in Australia reached 870MW in 2006 with a further 150MW under construction. In New Zealand, the current figure of 170MW will nearly double to 321MW after completion of projects under construction.

There is a world-wide trend toward an increasing proportion of the aggregate generation coming from wind power. Two characteristics of wind power plant have important consequences for security: the output of wind turbines can only be scheduled to the extent wind conditions can be predicted, and; wind turbines are not connected to the grid via synchronous machines. Both these characteristics adversely impact power system security and may require remedial measures.

Wind generation has been shown to integrate better with hydro or some other flexible source of generation, for example in Brazil, Europe, Australia and New Zealand.

2.3 Link Between Fuel and Generation

Deregulation in the USA has established a regulatory link between fuel and generation. Of concern are transport prices for gas and electricity and their impact on the location of generation and stress of the transmission system.

In the early years of deregulation there was pancaking of electricity tariffs and postage stamp prices for gas transport. Pancaking of electricity tariffs meant that each utility along the trading path was entitled to charge a fee for transporting electricity across their own power lines, so the overall charge was the sum of individual charges. Postage stamp prices for gas transport was a fixed price structure which did not take consideration of the distance over which the gas was transported. This price structure for transport of electricity and gas discouraged long distance electricity trading and ensured that new generators are located in the close proximity of major load centres, which was beneficial for power system security.

Deregulation reversed the situation. Pancake electricity tariffs were replaced by postage stamp tariffs, while, at about the same time, postage stamp gas transport prices were replaced by those based on the distance from the source. The new electricity and gas tariffs effectively shifted new generators away from load centres towards gas sources. Local and regional government initiatives accelerated this trend by offering various incentives to attract developers of new generation in areas that were typically located far away from major load centres.

No new transmission lines were built to accommodate such long distance trading, and it did not take long before it was not possible to transport electricity to major load centres due to the congestion of the transmission grid. This example demonstrates the need to coordinate the regulatory regimes, particularly when they potentially have a major impact on the power systems.

3. UNCERTAINTY

The deregulation and creation of electricity markets over the past decade or two has led to disaggregation of utilities and decentralised decision making. Different and sometimes conflicting short-term commercial interests have often precluded information sharing, and even, in some cases, led to information manipulation through gaming. The net effect has been increased overall uncertainty in the industry, which also adversely impacts security.

For example, it is difficult to plan network expansion when the location, size and timing of new generation sources are not known. The broad-brush approach of investigating all possible combinations of options is not possible because their number grows exponentially with system size.

While many countries are trying to develop competition in electricity, they are still exercising some level of overall control of pricing, planning and operations, and countries such as Spain and Portugal have adopted a new proactive approach for extending their transmission networks towards selected geographical regions abundant in wind energy to attract and speed up new developments in the area. The traditional approach has been to wait for wind applications and then construct lines.

Recent concerns with energy dependency and climate change are also making it more difficult to predict future developments, because of uncertainty over potential interventions of the governments in various countries.

For example, in 2004, Tony Blair announced a major stimulus for the development of renewable energy, by setting a target to achieve a 15% contribution from renewables to Great Britain's electricity needs by 2015, on a path to achieving a 20% overall contribution by 2020 [http://www.number-10.gov.uk/output/page6333.asp]. Wind energy, expected to be increasingly offshore, was expected to be the primary source of renewable power.

In 2005, a target was set to supply 10 percent of electricity from renewable sources by 2010 in Great Britain. [http://www.nao.org.uk/pn/04-05/0405210.htm].

In March 2007, the 27 EU countries agreed to a target of a 20% overall boost in renewable fuel use by 2020, and will each decide how to contribute to meeting that target. However, in what is viewed as a concession to France, they recognised the contribution of nuclear energy in "meeting the growing concerns about safety of energy supply and carbon dioxide emission reductions".

On 23 May 2007, Tony Blair reiterated his backing for nuclear power as his government prepared to unveil their energy strategy, and first reactions indicate that a fresh nuclear row is set to erupt in Great Britain. It is clear that any support for nuclear will come at a cost of damaging the fledgling renewables industry.

Regardless of the actual outcome in each EU country, any aggressive focus on a target to supply a certain percentage of electricity from renewable sources is likely to lead to a concentrated effort to improve renewable generation technology – embedded and distributed generation, supply and demand management and energy control are likely to evolve rapidly.

Mass proliferation of renewable and other generation connected to the distribution system, if it eventuates, may also provide a limited relief for the transmission system. Historically, this has not been feasible because economies of scale made generation plant of higher ratings more economical. Time will show whether the perceived benefits of such generation, aided by electricity pricing, government initiatives and improved technology, will influence, and by how much, the established economic framework in favour of mass proliferation of distributed generation and various load management solutions.

3.1 Wind Uncertainty

Unpredictability of wind as the primary source of energy, compounded by that of a relatively high ratio of installed wind power capacity and the capacity of the local transmission system in the vicinity of newly installed wind turbines, creates numerous operating problems, ranging from local power quality problems to those that may impact the whole power system.

For example, the amount of generation reserve in the system, that would be sufficient otherwise, may not be sufficient if the wind penetration exceeds a certain threshold. In the isolated system of Western Australia, with respective minimum and maximum loads of 2,400MW and 4,500MW, that threshold was found to be about 15% of the total load connected at the time. Ireland has similar limitations.

A recent German study [Modern Power Systems, March 2007, p-25-28, 'Living with wind power in Germany'] reports that 36GW of installed wind turbine capacity in Germany in 2015 would provide the firm capacity of only 5-6 percent of that value. Clearly, the impact of unpredictability of such a large magnitude on transmission capacity and its utilisation, power flows across the system, unit commitment and system operation is hard to comprehend.

4. CHANGING FUNCTION OF THE TRANSMISSION GRID

Probably one of the main causes of a number of recent major unreliability events lies in the changing function of the transmission grid and delays in adapting to change.

For over 50 years before the deregulation and development of electricity markets, a single vertically integrated utility controlled generation, transmission and distribution of electrical energy in a given geographical area and such a utility generally maintained sufficient generation capacity to meet the needs of its customers. Interconnections with neighbours and long distance power transfers were generally used for emergencies.

Such practices contributed to system reliability aided by the laws of physics that govern the flow of electricity. To avoid line overload and tripping, the amount of power flow across each line must be kept below its capacity at all times. The difficulty in controlling individual power flows rises rapidly with the distance and complexity of the network (for example, the number of lines) along the path of an interconnection. Any change in generation or topology of the transmission network will change loads on all other generators and transmission lines in a manner that may not be anticipated or that is difficult to control.

The development of electricity markets over the past decade or two brought a fundamental change to that paradigm. Major transmission infrastructure has become no longer just a tool for mutual assistance, but a platform for shifting ever growing power volumes across the entirety of interconnected networks. Deregulation has resulted in higher cross-border and long distance energy exchanges, which are driven by short-term objectives of individual market participants. Other across-interconnection power flows result from an increasing number of major wind energy generation sources. These flows were usually not anticipated in the original designs of power systems, and difficulties now arise each time they reach and potentially exceed transmission capacity. The likelihood of this is compounded by delays in obtaining new transmission corridors, market-driven load and generation patterns, volatile wind generation infeeds and unusual network topologies.

Due to increased long distance and cross border trading across most national systems, individual Transmission System Operators (TSO) are becoming increasingly interdependent. Interconnected power systems are operated ever closer to their limits for increasingly longer times. Operation under higher stress for longer periods of time will inevitably result in more severe and more frequent incidents.

4.1 Impact on System Control

The changing functions of the transmission system, higher system stress, volatility of wind generation, and trading volumes changing hourly by thousands of megawatts, make daily operation of power systems much more challenging today.

At the same time as these challenges have been increasing, the range of actions available to system operators has become generally constrained by short term electricity market rules and it was noted [UCTE, "Final Report: System Disturbance on 4 November 2006", 2007] that "The need for more complex management of interconnected grids is obvious, but has so far not always been supported by regulators and main stakeholders when TSO operators have requested more generation data and intervention rights, particularly in emergency situations."

5. BLACKOUTS

Customer expectations have risen significantly as the reliability and quality of supply has improved, together with the proliferation of products that rely on electricity. Major loss of supply event are not viewed kindly by customers and governments are well aware of the pressures they face if one occurs.

Thirteen major blackouts spanning the last eight years were studied in [CIGRE WG C1.2 report] and were examined in the context of the growing complexity of power system operations and electricity trading arrangements, with a view to understand their mechanisms and identify early warning signs.

The blackouts were found to be exceptionally complex phenomena, because their causes extend well beyond technical considerations and include regulatory, economic, planning, operational and social factors.

Some of the early warning signs of susceptibility of a power system to blackouts include the number, magnitude, frequency, duration or cumulative time of events when the:

- Area Control Error (regulating error or the system frequency error) is outside the permitted dead band
- Voltages at key locations were outside their normal band
- The system is in an insecure state (risk of overload/instability following the next contingency)
- The system is in an 'unusual' state
- The number of incidents (near misses) is high
- The number of transmission load relief procedures, as a proxy for 'near miss' situations are significant
- Bulk transmission system utilisation change (%) increases over the past few years defined as the ratio between yearly electricity load demand [TWh] and equivalent EHV transmission grid extension [km]
- Percentage of time near critical transfer limits increases
- Maximum loading of key interconnectors (transmission corridors), particularly relative to the load growth, and their load duration curve is approached
- The maximum number of generating and other plant in the system that went on maintenance simultaneously is significant
- Use of equipment for duties beyond their assigned short circuit level occurs
- Percentage of disconnected load increases
- The number of projects delayed, perhaps weighted by the delay time increases, and
- Lack of clear responsibility for power system security occurs.

Additional trend information can be obtained by monitoring how these indicators change over time.

5.1 Avoiding Blackouts

Central to avoiding blackouts in operational time frames is to operate power systems securely, which means within the security limits defined by the list of credible contingencies for which the system was designed. That may be a problem in very large interconnections where there is no 'overall picture' due to poor visibility beyond own borders. In many cases, power systems were operated beyond their security limits when the incident occurred and this contributed significantly to system unreliability.

A practical question for avoiding blackouts is therefore how to identify states of non-secure operation of the power system. This is important as they usually precede blackouts, and, in many cases, system operators were not aware of them because 'nothing had happened'.

The National Electricity Market (NEM) in Australia sets a good example on how to effectively operate a large interconnected system with long distance trading. Two key success factors, in our opinion, are computerised dynamic on-line power system security assessment, that covers the whole interconnection and is based on the constantly evolving power system specific constraint equations, and the IT platform which provides the overall picture of the state of the interconnection to all participants and system operators. Europe and the USA, who recently experienced major incidents, have not yet achieved this milestone. To a significant degree they have been handicapped by the greater size of their power systems and the relative autonomy within each country or state.

High quality real-time assessment of the state of the interconnection with respect to the security limits, together with the power of the operators to expand the list of credible contingencies, in response to adverse weather and bushfire conditions, enables reliable, adaptive and effective management of the NEM interconnection.

For disturbances more severe than those a system has been designed to withstand, the correct operation of protection and robustness of generators to remain connected is essential to contain the spread of the disturbance and minimally interrupt the supply to customers.

A number of incidents were caused by protection problems that were present but only triggered when a particular set of circumstances occurred (London, Helsinki). It is important to have commissioning and testing procedures that minimize the risk of such "booby traps".

An alternative approach to enhance power system security is to design the system to a higher standard by expanding the list of credible contingencies. This was done in Iran in 2003, after a widespread blackout, by including in planning criteria circuit breaker fail faults on critical transmission installations and subsequently retrofitting the additional protection.

6. CIGRE AND IEEE ACTIVITIES

CIGRE (International Council on Large Electric Systems) is one of the leading worldwide organizations that encompass technical, economic, environmental, organisational and regulatory aspects of power systems and their management. Presently 16 study committees are active, each dealing with a technical field of the power industry. Their work, carried out by working groups and task forces, is coordinated by the Technical Committee of CIGRE. Altogether more than 1000 experts are involved in these working bodies and some 50 reports are issued every year.

IEEE is a similar non-profit organisation with a broader focus on the general advancement of technology.

CIGRE and IEEE coordinate activities to address contemporary challenges to the electricity supply industry, including joint working groups. Recent examples include two joint working groups assigned to develop respective dynamic models of gas plant operating in combined cycle and wind power plants.

Surveys are usually used to quickly gather information on a specific topic. Two recent CIGRE surveys related to power system security include “A survey of requirements for generator data and the need for confidentiality” and “Survey of planning standards in major cities”.

CIGRE Committee C1 facilitates and promotes the progress of engineering and the international exchange of information and knowledge in the field of system development and economics. The Committee adds value to this information and knowledge by synthesizing state-of-the-art practices and developing recommendations. The Committee has ten active working groups, covering specific topics in the areas of economic and technical regulation, asset and risk management, dynamic performance and the impact of uncertainty.

In the aftermath of two major blackouts in 2003 in the USA and Italy, blackouts have been studied by two separate working groups: CIGRE C1.2 Review of Real System Unreliability Events – What Factors Signalled a Lack of Transmission Capacity, and IEEE Working Group on Blackout Experience, Mitigation and Role of New Technologies. This work is nearing completion and final reports will be published shortly.

7. REGULATORY REQUIREMENTS & RESPONSE

The analysis of recent blackouts shows that they are usually caused by a complex sequence of cascading events that were not effectively managed in the required operational time-frames.

Underlying causes, in many occasions, originated in rules and regulations governing electricity markets and power system operations and in delays in adapting to the changes in the generation mix and to industry deregulation.

The link between fuel and generation, established in section 2, leads to a conclusion that regulatory or legal solutions may require simultaneous consideration of both the energy market and supply.

The following three regulatory approaches concerning planning factors were recommended in [CIGRE C1.2 report]:

- The regulatory or legal framework and various incentives should take closer consideration of the impact they create on the grid and infrastructure, and should be directed towards alleviating congestion and stress of the electricity grid.
- Promote the placement of new generation in close proximity to load centres thereby eliminating the need for long power transfers, and
- Rather than confining to a particular jurisdiction, conduct planning and real-time contingency assessment studies to encompass the entire paths of major normal and emergency power flows. This requires close TSO and DSO cooperation and transparency and data sharing among all participants.

The regulatory challenges concerning operational factors include finding the right balance between 'purity' of the electricity market and power system security.

Namely, the creation of electricity markets has increased complexity of system operation, while the ability of TSO's to manage critical events has become, constrained by short-term market rules. This was recognised as one of the root causes of the largest blackout in history in Europe, which occurred on 3 November 2006, and similar considerations apply to two other major blackouts in 2003 in the USA and Italy.

In response to that finding, the working group that investigated the 2006 incident recommended EU countries adapt the regulatory or legal framework that would give system operators more control over the generator output to manage grid congestions. Coincidently, an operational power quality problem in Western Australia, caused by wind generation, identified the need for a similar change.

In addition, technical issues concerning plant performance requirements have emerged as regulatory issues.

7.1 Plant Performance Requirements – Non-synchronous Generation

It was reported in [Modern Power Systems, March 2007, p-25-28, 'Living with wind power in Germany'] that characteristics of the current technology of non-synchronous generators in Germany, through which wind generators are connected to the grid, introduce additional problems for maintaining the existing level of security of electricity supply. These problems include generator fault-ride through capability and the duration and magnitude of the generator fault current contributions that are insufficient for protections to see the fault and provide adequate voltage support.

Similar shortcomings were associated with early designs of combined cycle plant, resulting in improved design, which now permits them to meet their share of the control duty requirements imposed on the aggregate generation for the operation of the power system. This required mandating certain plant performance requirements as a condition for connection to the network. These typically include voltage and frequency fault ride through capability, reactive power capability and control duties.

Wind technology is no different and, for example, one wind farm in Western Australia improved the original design by installing discharge resistors and can now ride through zero volts for one second.

Non-synchronous generation is acknowledged now in many countries. The approaches taken vary. For example, while many have the same requirements for all types of generation, non-synchronous generators are given concessional treatment in Western Australia in terms of technology and specific plant performance requirements for reactive power. The rationale was a decision to help to facilitate the initial proliferation of renewable generation in Western Australia.

7.2 Plant Performance Requirements – Distributed Generation

The generators connected to the distribution system in the EU are now required to have the same fault ride through capability as large generators connected to the transmission system. The recommendation retrospectively applies to units already in service. This was deemed necessary because, in a few incidents, the large amount of distribution connected generation (up to 3,400MW) disconnected at about 49Hz, which made the under frequency load shedding ineffective.

Another technical recommendation for the EU, concerning generators connected to the distribution system, is the requirement for TSOs to have on-line access to their status, schedules and changes to the schedules, at least as one-minute data. This will probably take the form of aggregate generation data provided by individual DSOs.

Different characteristics of individual power systems should be accommodated through appropriate system performance requirements allowing for identified credible contingencies and specific requirements for connection to the network through the relevant transmission and distribution rules or codes.

8. CUSTOMER CONSULTATION IN AUSTRALIA

This section discusses the extent to which the customers in Australia are consulted in relation to the trade offs between the price, power quality and reliability of the system to which they connect.

The National Electricity Rules (NER) apply in the National Electricity Market (NEM), which is the largest interconnection in Australia that connects Queensland, New South Wales, Victoria, South Australia and Tasmania. In addition to the NER, the states have some further specific requirements.

Generally, there is limited scope for customers to negotiate power quality and reliability and the resulting connection cost. The NSPs provide the same level of reliability to all customers in an area, and if a particular customer wants a higher one, it has to pay for it.

The concept of minimum and maximum access standards is employed in the NER. The idea is to provide certainty, in the form of ‘no questions asked’ to access applicants who meet the maximum access standards, and ‘no connection permitted’ to those who do not meet the minimum access standard. The area in between is the subject of negotiation.

The implementation of this concept is not always easy, as those responsible for power system security believe that the maximum access standard applies generally, unless the applicant can demonstrate that the application and location specific conditions permit a lower level. The developers have the opposite view and believe that the minimum access standards should apply generally, unless the NSP can demonstrate that the higher (up to the maximum access) standard is needed. The decision by the South Australian Electricity Supply Industry Planning Commission (ESIPC) to mandate maximum access standard performance for windfarms connecting in South Australia caused a controversy at the time but has not been disputed since.

Technical Rules for connection in Western Australia (South West and North West of the state) and the Northern Territory specify one set of connection requirements. The Rules permit applicants to apply for an exemption from a certain clause. In that respect the connection requirements in WA and NT can be considered to correspond to the maximum access standard in the NER and are consistent with the ESIPC interpretation.

With respect to power quality, the NSPs are responsible to keep the overall distortion levels in the system below certain thresholds and disputes may arise about the amount of that allowance allocated to individual access applicants, typically about harmonics levels. The responsibility for fault level upgrades is another issue often debated, together with a range of issues associated with the rights to use spare system capacity.

Operational experience, including blackouts, indicates the need for ongoing compliance with the rules or codes and its enforcement through regular testing of plant performance characteristics and protection schemes. The implementation of these tests requires widespread customer consultation and coordination of activities.

9. CONCLUSION

Network security of supply is of critical importance to all developed countries. As deregulation of the electricity industry has occurred across the world, the various aspects that contribute to this security have become clearer.

Three major changes over the past two decades include changes in fuel for power generation, increased uncertainty due to deregulation of the electricity supply industry and the changed role of the transmission system.

Greater interconnection has presented new technical challenges and complicated oversight of the overall power systems. This has led to imposition of more rules and governing bodies.

A brief review of recent blackouts focused on their early warning signs and how to avoid them within operational timeframes and by regulatory means. It was found that the underlying causes, in many cases, originated in rules and regulations governing electricity markets and power system operations and in delays in adapting to the changes in the generation mix and industry deregulation.

Some of the recent activities of CIGRE and IEEE relevant to power system security were reported. CIGRE is an international organisation that researches, by means of working groups, technical issues in relation to transmission and subtransmission across the world. Within CIGRE, Study Committee C1 deals with asset management, power system planning and economics. This paper largely drew on work carried out by recent working groups within C1 that is relevant to the above topic and covers the issues discussed above.

A brief overview of current Australian regulatory requirements for network security together with an outline of methods used to ensure that customers are consulted in relation to the trade offs between price, quality and reliability concludes the paper.

Technology Operations

Electricity is Telecom Networks Fuel

By Colin Foster

Telecom

Technology Operations

12th largest electricity user
- annual consumption 215 GWHr

Has 8120 connections
- 126 TOU
- 2400 Metered
- 5594 Un-metered
  - 3223 Road side cabinets
  - 2371 Phone boxes

Make connections to every lines company

Reliance on Power Supply

Technology Operations

>80% of energy to operate the network

Most electricity converted to heat
- then rejected

Robustness of Telecom’s power and air conditioning infrastructure is matched to the power supply reliability

Telecom uses nationally applying standards

Security of supply to higher priority sites

Quality of power

Need to engineer for
Sags / Brown outs

Low individual phase voltages

Spikes

Lightning

Earth Potential Rise

Telecom operates remote earthing

Power Outages

Two factors for Telecom in power failure
- length of outage (affects battery reserve time)
- time between outages (time to recharge)

Statistics over last five years
11 Lines Companies > 10 per year per site
(Mainly rural)

There does not appear to be a direct correlation between number of outages and length of outages

Exporting Opportunities

Not to forget what the prime purpose of Telecom generators are

Approximately 45 Mw of generation capacity available
Present loading approximately 20 Mw

Considering safety allowances about 10 Mw spare capacity

Need to consider prime purpose of the generation infrastructure

Electricity Profiling

Telecom sites have constant demand

Developing a profile for approval to apply in lieu of peaky profile used presently

Expected to save 5% energy costs and possibly some line charges

Line Ownership

Inconsistent national application of ownership responsibilities

In general Telecom has constructed 11 Kv lines to remotes sites

Exercise being undertaken with each company to determine policy

Have implications on H&S and stability of supply

Line Charges

Differing standards for each company

Segregation between load and fuse size is difficult to minimise high volume and costs

The Future – Telecom Wish List

Technology Operations

1. Minimise outages
2. Improved communication with Lines Companies
3. Line ownership clarified – more consistency
4. Higher security of supply to some sites

Security of Supply for the Domestic Consumer

Peter Rutledge
Grey Power Energy Committee

14 June 2007

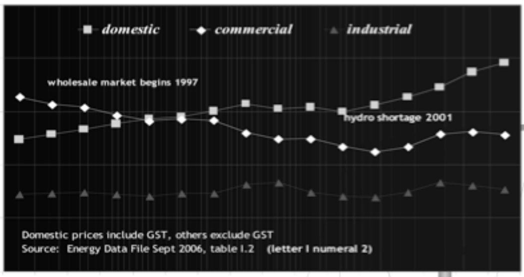
Domestic Consumers are about 32% of the market…

- Therefore collectively are a substantial stakeholder in the industry
- But they do not have adequate representation at the bargaining table
- Electricity Commission advisory groups are not allowed to discuss price levels

Small Consumer's interests are largely ignored

- Business and supply-side interests dominate the lobbying scene
- Security involves affordability as well as continuity
- How they are currently being exploited is shown in the next slide

Real Electricity Prices

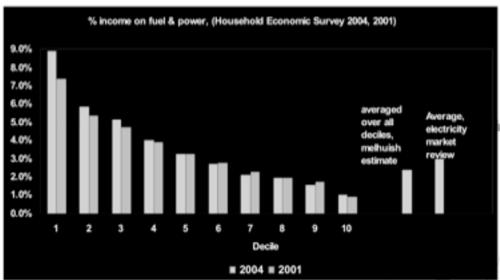


Price increases

... from that data the average annual price change from 2000 to 2005 was:

- Residential +5.5%
- Commercial +1.8%
- Industrial +1.9%

HOUSEHOLD EXPENDITURE



Domestic Consumers create security for all consumers

- In times of crisis Domestic consumers are pressured to reduce consumption
- Generally they have responded well in the past
- Concept Consulting “Tendering for Reserve Energy” say the domestic sector can reduce consumption at the lowest cost
- But they usually do not received any compensation for this inconvenience

The Evolving Domestic Market

- For over 50 years NZers were encouraged to build all electric homes
- Many do not have alternatives for cooking, space heating and hot water, the basics for survival
- The all electric trend is increasing as heat pumps replace log burners etc

More changes…

- Those who use alternative heating at peak times get no reward for doing so
- Many are now dependent on supply for home computing which can also involve their livelihood
- It certainly involves their children’s education

21^{st} Century Needs

- So many houses in NZ are inadequately heated by WHO standards
- The average temperature requirement is 18 degrees and 21 degrees if babies or elderly are involved
- Electrically heated houses are on average 2 degrees colder than wood heated houses *(Heep Year 9 report)*

Responsibilities of Electricity Suppliers

- Today's electricity suppliers effectively bought the former supply organisations
- Buying a business means taking over the liabilities as well as the assets

Obligations

- Therefore the current suppliers have an obligation to those who were (and are still) exhorted to be all electric
- The suppliers must ensure that the Domestic consumers interests are looked after as much as any other sector of the market

Provision of security as it is now

- The suppliers have the obligation to ensure that capacity is adequate to meet demand
- Present situation of providing the back-up by a highly inefficient generating plant in the wrong place is ridiculous

Provision of security as it is now

- Consumers are paying for it by a levy otherwise it could not possibly generate at 20c/kWh
- Without the levy capital cost has been estimated to add $1/kWh to its output
- Since it was installed it has been lying idle probably 99% of the time eating its head off in capital charges

The Future

- Increased energy efficiency may lead to increased consumption of electricity
- Electric vehicles, electrified rail and electricity substituting for thermal fuel consumption
- Therefore we can expect electricity demand to accelerate

Wind Generation

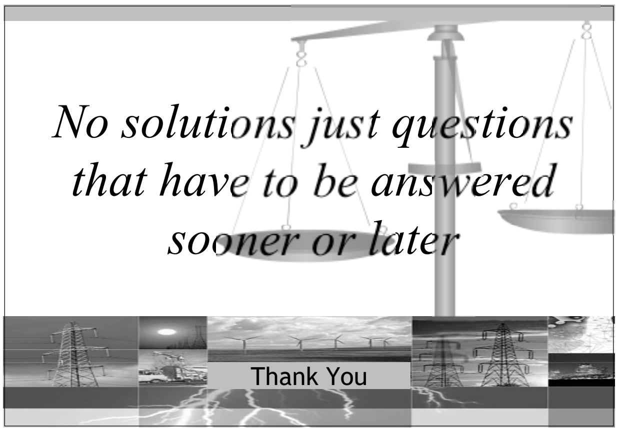
- The present system of tinkering with capacity by installing subsidised wind generators can only suffice for a very limited time
- It is well known that wind generation needs spinning reserve for wind failure
- Given that the capacity factor of wind plant is normally only 45-50% what is the cost of the back-up

Wind Generators?

- Repeated attempts to get an indication of the cost of the back-up have only elicited evasive answers
- If hydro is used for the back-up water will get progressively run down as the proportion of wind power increases
- This will lead to problems in dry years

Conclusion

- Domestic consumers need an advocacy organisation to protect and bargain for their security of supply among other things
- Central planning is essential for the development of future generating requirements


No solutions just questions that have to be answered sooner or later
Thank You

Reliability of Electricity Distribution Networks

An overview of performance over 12 years and some suggestions for improved reporting

Brian McGlinchy
Consultant

Historical perspective

- CAE study in1993 suggested that industry adopt the concepts of reliability reporting developed by Billinton and others
- These were:
  - SAIDI
  - SAIFI
  - CAIDI
- Data to be collected and published by ESANZ and EEA

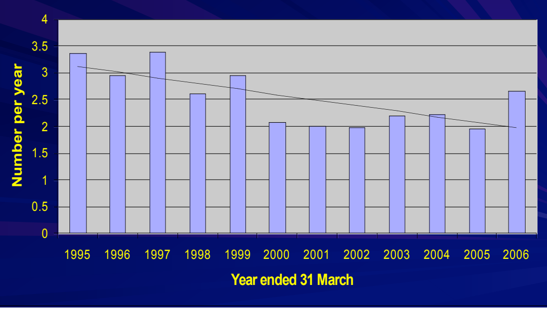
Government regulations

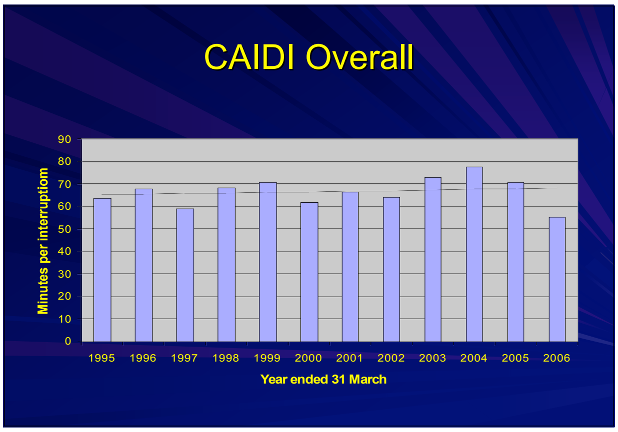
- Information Disclosure Regulations came into force on 1 April 1994.
- Some changes since then, but principles have been the same
- Annual reports published for year ended:
  - ESANZ, 1995 to 1997
  - Brian McGlinchy 1998 to 2004
  - EEA 2005 & 2006

Some results and trends from 12 years of data

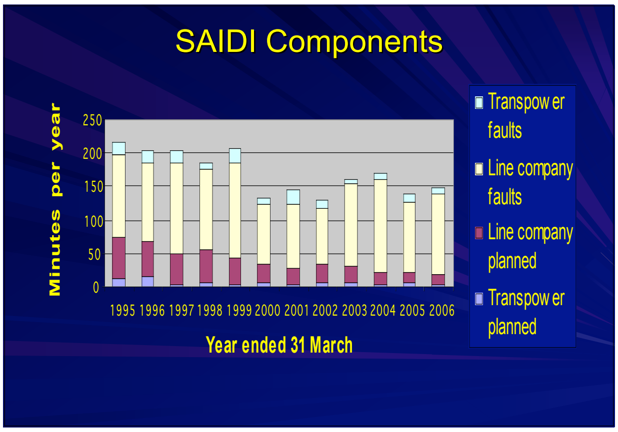
SAIDI Overall

SAIFI Overall

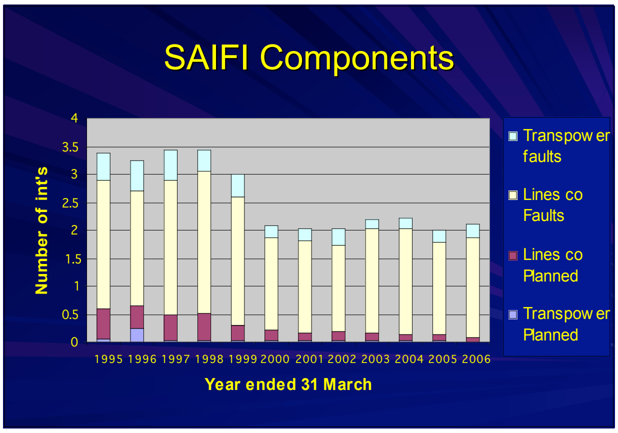




CAIDI Overall
Minutes per interruption
90
80
70
60
50
40
30
20
10
0
1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006
Year ended 31 March



SAIDI Components
Minutes per year
250
200
150
100
50
0
1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006
Year ended 31 March
Transpower faults
Line company faults
Line company planned
Transpower planned

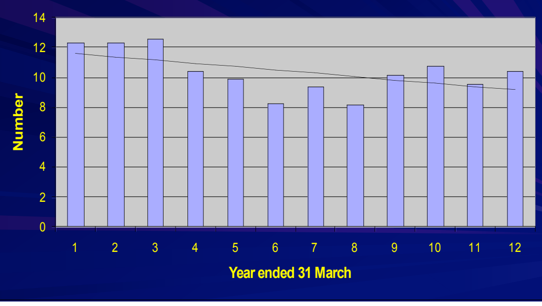


SAIFI Components
Number of int's
4
3.5
3
2.5
2
1.5
1
0.5
0
1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006
Year ended 31 March
Transpower faults
Lines co Faults
Lines co Planned
Transpower Planned

11kV Lines and cables

Faults per 100km

11kV lines: faults per 100km



11kV Cables: faults per 100km

Suggested improvements

Lines business or regulator?

Improvements (1)

- Reports should be by smaller geographic areas

Improvements (2)

- Start reporting short interruptions less than 1 minute SAIDI (M)

Improvements (3)

- Report performance by type of customer:
  - CBD
  - Urban
  - Rural
- If the security of supply guide specifies these areas, then lines business has obligation to report back on performance

Improvements (4)

- Data shows only a small improvement in lines business faults.
- Anecdotally this seems wrong given the attention being given to trees and general maintenance.
- Better analysis could be achieved if lines businesses reported incidents by cause. Eg weather, equipment failure, human interference, grid failure etc

Deficiencies in Regulations

- Time weighting of merged companies needs revision. Particularly as it loses data from original company pre-merger.
- Reporting of predictions of faults in lines and cables needs to be divided into two separate categories.

As it was in the beginning…

Lines businesses and their associations should take the lead

Discussion

Transmission – reliability of supply to major centres

Presentation to EEA
June 2007

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Why reliability is important ….

- Supply reliability is regarded as a given
  - Expectation of a high reliability
  - Some degree of acceptance for acts of God but not design / process
    - Recent Mercury issue could have been caused by
      - Distribution failure
      - Transmission failure
- Reliability has always been an economic trade-off
  - Judgement about critical and non-critical loads
  - Operational flexibility
  - High impact low probability events
  - Business confidence in reliability

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Terminology

- Supply adequacy
  - Enough accessible generation to meet the demand
- Security
  - Ability of the power system to survive a credible contingency
  - System Operator always maintains security
- Reliability
  - Ability to meet (forecast) demand without interruptions even with a credible contingency
- For transmission planning
  - Need to plan to meet all three

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Transmission issues

- Legacy issues
  - Lack of investment in recent past
  - Power system has grown incrementally
  - Design and/or technology not appropriate
- Aging assets
  - Lines, substations, equipment, technology
    - continue resuscitation; or
    - upgrade?
- Diversity
  - Points of concentration

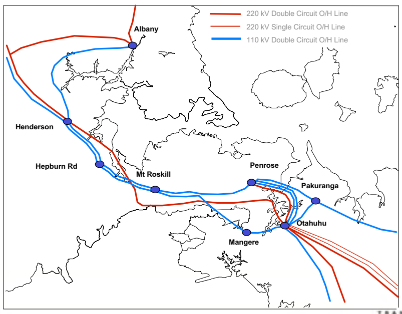
Supplies to major cities

- Look at
  - Auckland
  - Christchurch
- Factors
  - Diversity
  - Legacy issues
  - HILP events
  - Incremental development
  - Design and technology
  - Aging assets

High Impact Low Probability events

- Low probability of occurrence
  - Natural events - Earthquakes
  - Area events – bushfires, storms
  - Collateral events – gas leaks, fires, people related
- High impact
  - Shutting down a substation
  - Voltage collapse
  - Many consumers affected for a long time
- Exposure
  - High load concentrations
  - High asset concentrations

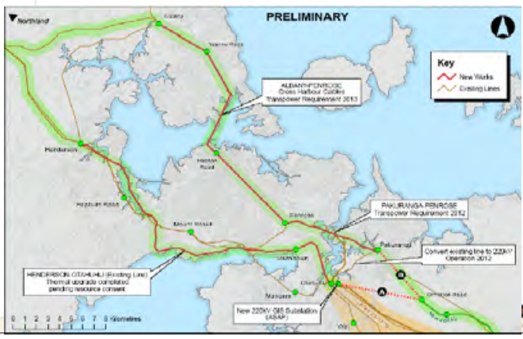
Existing Transmission Lines



Auckland strategy

- Improve supply capability from South
  - North Island Grid Upgrade
  - Cross harbour cables
- Deliver diversity
  - Pakuranga as opposed to Otahuhu
  - Reinforce North Auckland and Northland via eastern corridor
- Address legacy issues
  - Otahuhu Substation diversity
  - Technology / design / aging assets

Auckland supplies



Otahuhu substation

- Single supply point for bulk of Auckland
- Concentration of lines into / out of Otahuhu
  - Auckland
  - North Auckland and Northland
- Problems
  - Diversity
  - Legacy - technology / design
  - HILP events
  - Aging assets

Otahuhu – investment plan

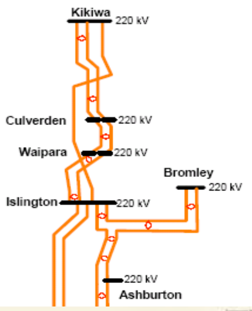
- Create a new substation at the same site
  - Too costly to provide greater physical separation
- Create some diversity
  - Share feeders between two electrically separate substations
- Improve technology / design
  - 1.5 cb arrangement as opposed to SBDB
  - GIS instead of AIS (3 time more reliable)
- Redevelop existing substation (future)

Aerial view – Otahuhu development

North Auckland and Northland

- Investment plan
  - Cables to Albany via CBD
- Diversity
  - Creates eastern corridor
  - Reduces dependency on existing OTA-HEN lines
- HILP event mitigation
  - Loss of OTA-HEN line
  - One cable or two?????

Christchurch and USI



Christchurch and the Upper SI

- Diversity of incoming supplies
  - Better than AKL
  - Four 220 kV circuits geographically separated
- Two major substations
  - Islington
  - Bromley
- Technology / design
  - SBDB throughout
  - Incremental growth

Christchurch and USI strategy

- Grid upgrades
  - Kikiwa third circuit - completed
  - ROX-ISL duplexing – underway
  - Bussing at Ashburton - underway
- Further upgrades
  - Reactive support at ISL and KIK – applied for
  - Possible:
    - Bussing 4 incoming feeders at Geraldine
    - Series compensation of all 4 feeders
- New line???
  - Voltage stability rather than thermal
  - How hard can you push the existing system?

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Christchurch issues

- Substation reliability at Islington
  - Need to secure feeders to north
    - Bus section breakers
    - Incrementalism ??
    - Technology – 1.5 cb vs SBDB ??
- HILP events
  - Already lost USI during bus maintenance
  - Cost of separate substation justified?
    - Lower load exposure
    - Some resilience through Bromley

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Justifying upgrades / investments

- GIT requires 20 year view
  - This is improvement
  - Attempts to avoid incrementalism
  - Not well understood by proponents of 'JIT and keep it cheap'
- Probabilities and failure modes
  - Data is not freely available
  - Seldom in form needed
  - HILP events very difficult to classify and estimate
  - Benefits of diversity
    - Largely HILP event mitigation

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Grid Reliability Standards

- Two components:
  - Deterministic for some parts of the network
  - Probabilistic for:
    - Non-core assets
    - Any level of reliability above safety net
- Probabilistic planning:

  ‘cost’ = P(event) * VoLL

  This is the average cost, not the event cost

Other factors

- Lead times
  - Lines – 5-7 years
    - Dominated by designation, consenting and easements
  - Substations
    - Generally 2 years
      - Consenting
      - Supply lead times for small projects
- Managing uncertainty
  - Risk averse?
  - Favouring staged options?
  - Getting easements in advance of need?

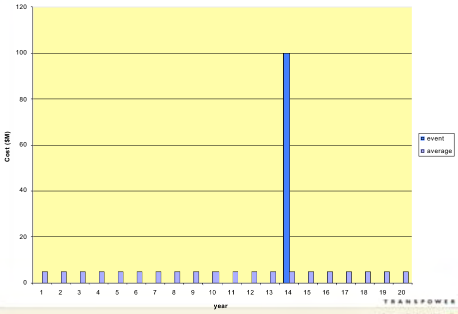
Summary

- Many legacy issues on transmission system
- Reliability is expected
  - Acts of God tolerated
- UNI and USI issues being progressively addressed
  - Planned investments will deliver reliability in timely manner
- Investments driven by strong economic approach
  - Costing of ‘unreliability’ through probabilistic methods
  - Data issues and:

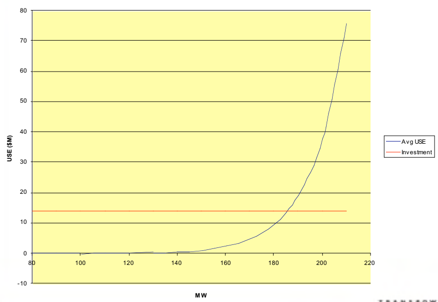
    Precision vs accuracy ?

Questions ……?

Probabilistic events



Timing a new investment



Pricing the Risk of Security of Supply

Greg Salmon

Outline

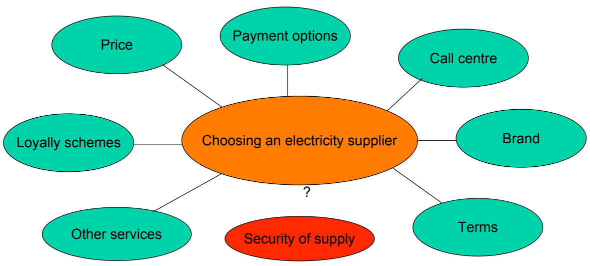
Choosing an electricity supplier

The importance of risk - Today's risks are tomorrows prices

Improving security of supply and risk

Managing the risk

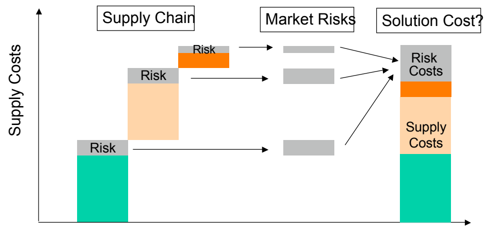
Choosing a Retailer



Key concern is PRICE and SERVICE!!!
Security of supply is assumed

Supply Chain Costs and Risks

Risks created by one part of the delivery system, but sitting with another part, will ultimately cost the consumer – with/without a solution.

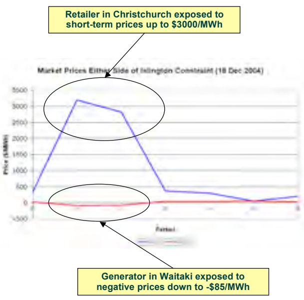


Solutions should remove market risks – or will fail consumers!

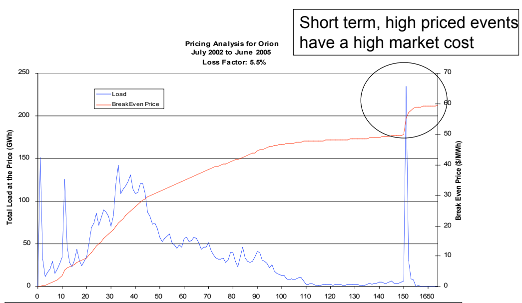
Security of Supply and its effect on Prices

Market Impacts

- Generation cut off from load
  - Short-term market high spot prices far in excess of the generator bids (Spring-washer effect)
  - Exposed retailers in constrained regions get burnt
  - Inability to significantly reduce load as mass-market customers are not exposed to spot
- Resulting increased volatility and risk leads to
  - Regionalised "gentailers" – reduce exposure by only retailing in areas where generation located e.g. MRP, Genesis
  - National retailers pricing transmission risk into contracts
  - Less apparent competition for end-consumers

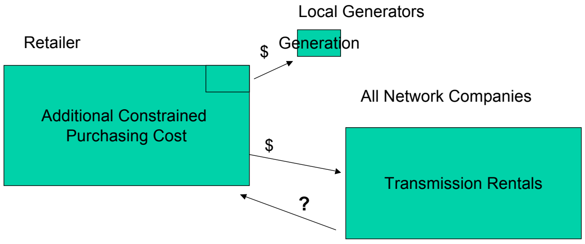


Break even pricing



Supply risk costs at least $10 in this case

Who benefits when a transmission contraint binds? -The money go round



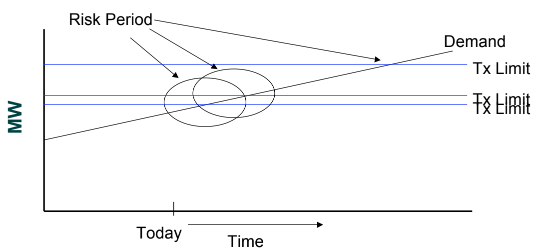
It is very rare for generators to be the major beneficiary of a transmission constraint

What do generator/retailers do to manage Security of Supply risk

- Participate in upgrade approval process
- There has been an increase in the number and skilled of staff in all the generator/retailers that manage this risk
- Industry working groups designed to manage security of supply have mushroomed
- Working with network companies to use water heating load
- Contracting embedded generation
- We can attempt to hedge our risk (discussed later)

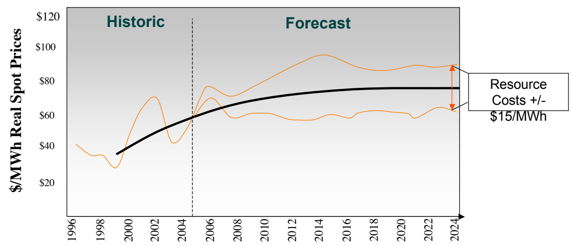
These tend to be low cost marginal options because of free rider issues

What about the investment options?



Incremental improvement doesn't change the risk

What really matters….



Upper bound with higher priced coal/LNG assumptions and C-tax
Lower bound with large new indigenous gas discoveries and good infrastructure
Middle ground is Renewable/Gas supported by solid transmission/networks

Financial Security of Supply Risk Management

It is almost impossible to buy a financial product to manage nodal risk:

- as the risk cost is uncapped
- The inability to manage the physical risk in that part of the supply chain

- Hedging tend to be backed by generation (so are more of a physical product)
- Vertical integration can also be another way of managing nodal risk

Near impossible to buy financial risk management products for nodal risk

What is the industry doing to manage the risk?

Now

- Rule changes to reduce the impact of spring washer pricing.

Future

- Reviewing what we do with rentals – two options
  - Financial Transmission Rights (FTR)
  - Locational Rental Allocation (LRA)

We need to develop away to manage the financial risk

Conclusion

- Investment in Security of supply that does not address supply risk will fail customers
- Focusing our attention on short term planning fixes perhaps distracts us from addressing the real long term cost-benefits and creating a more sustainable energy future.
- The current market structures don't necessarily support the most efficient outcomes.
- To change this we need to improve the market structure.

Investment in security of supply that does not address supply risk will fail customers!

END OF PRESENTATION

Transmission – reliability of supply to major centres

Presentation to EEA
June 2007

Why reliability is important ….

- Supply reliability is regarded as a given
  - Expectation of a high reliability
  - Some degree of acceptance for acts of God but not design / process
    - Recent Mercury issue could have been caused by
      - Distribution failure
      - Transmission failure
- Reliability has always been an economic trade-off
  - Judgement about critical and non-critical loads
  - Operational flexibility
  - High impact low probability events
  - Business confidence in reliability

Terminology

- Supply adequacy
  - Enough accessible generation to meet the demand
- Security
  - Ability of the power system to survive a credible contingency
  - System Operator always maintains security
- Reliability
  - Ability to meet (forecast) demand without interruptions even with a credible contingency
- For transmission planning
  - Need to plan to meet all three

Transmission issues

- Legacy issues
  - Lack of investment in recent past
  - Power system has grown incrementally
  - Design and/or technology not appropriate
- Aging assets
  - Lines, substations, equipment, technology
    - continue resuscitation; or
    - upgrade?
- Diversity
  - Points of concentration

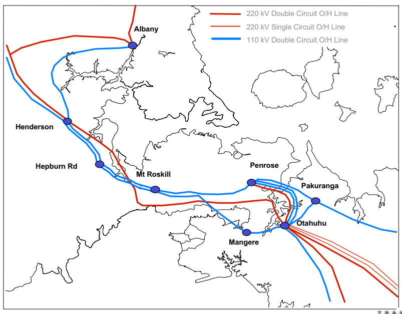
Supplies to major cities

- Look at
  - Auckland
  - Christchurch
- Factors
  - Diversity
  - Legacy issues
  - HILP events
  - Incremental development
  - Design and technology
  - Aging assets

High Impact Low Probability events

- Low probability of occurrence
  - Natural events - Earthquakes
  - Area events – bushfires, storms
  - Collateral events – gas leaks, fires, people related
- High impact
  - Shutting down a substation
  - Voltage collapse
  - Many consumers affected for a long time
- Exposure
  - High load concentrations
  - High asset concentrations

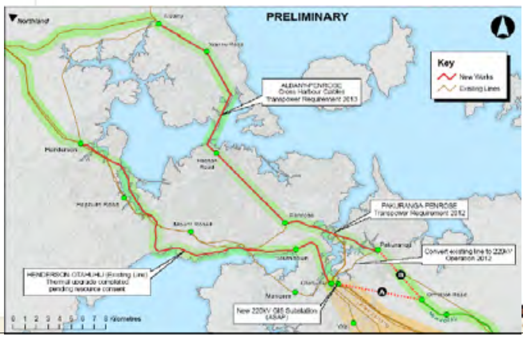
Existing Transmission Lines



Auckland strategy

- Improve supply capability from South
  - North Island Grid Upgrade
  - Cross harbour cables
- Deliver diversity
  - Pakuranga as opposed to Otahuhu
  - Reinforce North Auckland and Northland via eastern corridor
- Address legacy issues
  - Otahuhu Substation diversity
  - Technology / design / aging assets

Auckland supplies



Otahuhu substation

- Single supply point for bulk of Auckland
- Concentration of lines into / out of Otahuhu
  - Auckland
  - North Auckland and Northland
- Problems
  - Diversity
  - Legacy - technology / design
  - HILP events
  - Aging assets

Otahuhu – investment plan

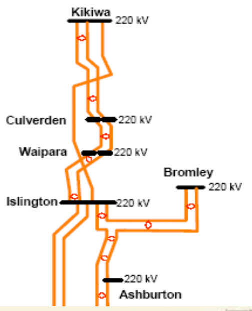
- Create a new substation at the same site
  - Too costly to provide greater physical separation
- Create some diversity
  - Share feeders between two electrically separate substations
- Improve technology / design
  - 1.5 cb arrangement as opposed to SBDB
  - GIS instead of AIS (3 time more reliable)
- Redevelop existing substation (future)

Aerial view – Otahuhu development

North Auckland and Northland

- Investment plan
  - Cables to Albany via CBD
- Diversity
  - Creates eastern corridor
  - Reduces dependency on existing OTA-HEN lines
- HILP event mitigation
  - Loss of OTA-HEN line
  - One cable or two?????

Christchurch and USI



Christchurch and the Upper SI

- Diversity of incoming supplies
  - Better than AKL
  - Four 220 kV circuits geographically separated
- Two major substations
  - Islington
  - Bromley
- Technology / design
  - SBDB throughout
  - Incremental growth

Christchurch and USI strategy

- Grid upgrades
  - Kikiwa third circuit - completed
  - ROX-ISL duplexing – underway
  - Bussing at Ashburton - underway
- Further upgrades
  - Reactive support at ISL and KIK – applied for
  - Possible:
    - Bussing 4 incoming feeders at Geraldine
    - Series compensation of all 4 feeders
- New line???
  - Voltage stability rather than thermal
  - How hard can you push the existing system?

TRANSPOWER

Christchurch issues

- Substation reliability at Islington
  - Need to secure feeders to north
    - Bus section breakers
    - Incrementalism ??
    - Technology – 1.5 cb vs SBDB ??
- HILP events
  - Already lost USI during bus maintenance
  - Cost of separate substation justified?
    - Lower load exposure
    - Some resilience through Bromley

TRANSPOWER

Justifying upgrades / investments

- GIT requires 20 year view
  - This is improvement
  - Attempts to avoid incrementalism
  - Not well understood by proponents of 'JIT and keep it cheap'
- Probabilities and failure modes
  - Data is not freely available
  - Seldom in form needed
  - HILP events very difficult to classify and estimate
  - Benefits of diversity
    - Largely HILP event mitigation

TRANSPOWER

Grid Reliability Standards

- Two components:
  - Deterministic for some parts of the network
  - Probabilistic for:
    - Non-core assets
    - Any level of reliability above safety net
- Probabilistic planning:

  ‘cost’ = P(event) * VoLL

  This is the average cost, not the event cost

Other factors

- Lead times
  - Lines – 5-7 years
    - Dominated by designation, consenting and easements
  - Substations
    - Generally 2 years
      - Consenting
      - Supply lead times for small projects
- Managing uncertainty
  - Risk averse?
  - Favouring staged options?
  - Getting easements in advance of need?

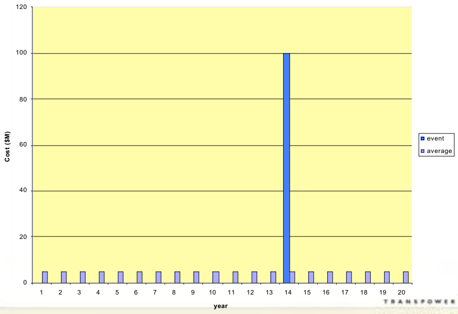
Summary

- Many legacy issues on transmission system
- Reliability is expected
  - Acts of God tolerated
- UNI and USI issues being progressively addressed
  - Planned investments will deliver reliability in timely manner
- Investments driven by strong economic approach
  - Costing of ‘unreliability’ through probabilistic methods
  - Data issues and:

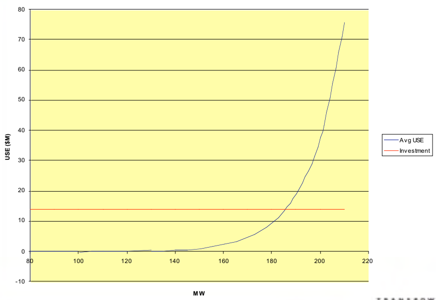
    Precision vs accuracy ?

Questions ......?

Probabilistic events



Timing a new investment



Security of supply – an Orion view

Contents

- **Orion today**
  - current security of supply standard
  - reliability performance
- **Orion security standard review**
  - VOLL review
  - definitions and model inputs
  - architecture review
  - customer consultation
  - new security of supply standard
  - application – deterministic or economic check
- **diversity of supply**
  - **M**ajor **O**utage **C**ausing **H**uge **E**conomic **D**isruption - MOCHED
  - GXPs and subtransmission architecture

Orion

Orion today

Orion today – security of supply in context

July 25, 07

- security of supply standards state the desired response of networks following defined contingencies
- reliability is a measure of network performance and is a result of:
  - the level of security of supply
  - network architecture
  - asset maintenance policies
  - asset replacement policies
  - operating practices, etc
- when developing security of supply standards or policies it is important to ensure that an economic balance occurs between investment in security of supply and all other factors leading to reliability performance

4 of 31

Orion today - current security of supply standard

July 25, 07

KEY.

1. Time allowed to restore supply after one interruption (n-1 event/contingency).

2. Time allowed to restore supply if a second interruption occurs in same area (n-2 event/contingency).

3. Time allowed to restore supply after single busbar fault.

CLASS. D Loads up to 200MW i.e. CBD or major sector of city.
1. Immediately restore 100%. 2. Immediately restore 50% and the rest within 1 hour. 3. Immediately restore 50% and the rest in the time taken to complete repairs.
CLASS. C2 Loads 10 to 60MW i.e. Special industrial/commercial load, CBD and Transpower GXPs.
1. Immediately restore 100%. 2. Within1/2 hour restore 95% and the rest in the time taken to complete repairs. 3. Within 2 hours restore 95% and the rest in the time taken to complete repairs.
CLASS. C1 Loads 10 to 60MW i.e. Primary urban network including district and network substations.
1. Immediately restore 100%. 2. Within 2 hours restore 95% and the rest in the time taken to complete repairs. 3. Within 2 hours restore 95% and the rest in the time taken to complete repairs.
CLASS. B Loads 2 to 10MW i.e. Major lines, single xformer district subs and large urban radial feeders.
1. Within 1« hours restore 50%, within 3 hours restore 95%, and the rest in the time taken to complete repairs. 2 & 3. Restore 100% in the time taken to complete repairs.
CLASS. A3 Loads 1 to 2MW i.e. Urban secondary feeder
1. Within 1 hour restore 50%, within 2 hours restore 95%, and the rest in the time taken to complete repairs. 2 & 3. Restore 100% in the time taken to complete repairs.
CLASS. A2 Loads 1 to 2MW i.e. Rural feeder
1. Within 2 hours restore 50%, within 6 hours restore 95%, and the rest in the time taken to complete repairs. 2 & 3. Restore 100% in the time taken to complete repairs.
CLASS. A1 Loads 0 to 1MW i.e Remote rural feeder & very small Transpower GXP.
1, 2 & 3. Restore 100% in the time taken to complete repairs or switching.

5 of 31

Orion today – how was our SS developed?

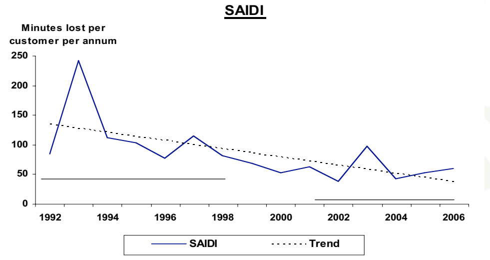
July 25, 07

- was developed in 1998 after the Auckland power crisis
- was the result of an EA technology detailed review of our system and our 10 year investment plan – reflected what we had?
- development included extensive consultation with local stakeholders to ensure that our existing network and proposed security standard reflected customer requirements
- no security of supply standard existed in NZ and we based the structure of our security of standard on the UK P2/5 standard (now P2/6)
- has guided Orion on network security investments by:
  - identifying security gaps
  - enabling prioritisation of improvements
  - ensuring consistency of solutions
- It has contributed towards improved levels of supply reliability for our customers...

6 of 31

Orion today - reliability has improved

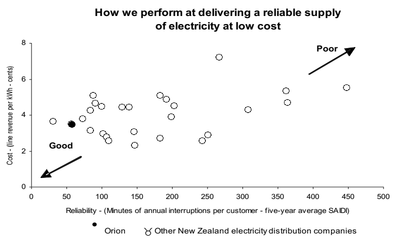
July 25, 07



Orion

Orion today – cost versus reliability good

July 25, 07



Orion

Security of Supply review

What level of security do customers require?

SS review – why do we need a review?

July 25, 07

We need to review our security standard because:

- 8 years have passed since our security standard was first developed
- construction labour, safety and compliance costs have increased
- new technology available at reasonable cost
- society/business is more dependent on electricity
- customer attitudes to electricity may have changed
- we need to ensure that investment undertaken by Orion in the next 5-10 years meets the majority of our customers needs/wants.

UK P2/5 underlying philosophy:

"The aim of the electricity industry should be to match its costs of preventing loss of supply to the benefit consequently obtained by customers."

10 of 31

Orion

SS review - the review process

July 25, 07

The review included the following phases:

1) *Estimate the value of lost load (VOLL)*
2) *Examine alternative network architectures and security standards*
3) *Examine previous customer consultation to determine the likely 'general public' price/reliability preference*
4) *Based on the results of 2) and 3), arrive at a 'most favourable security standard' (call this the 'preferred standard').*
5) Consult with key stakeholders on the preferred standard and variations to it
6) If necessary, modify the preferred standard to ensure the majority of key stakeholders agree (not necessary in the end)
7) Implement the new security of supply standard

11 of 31

Orion

SS review - value of lost load

July 25, 07

- how much does it cost customers when electricity supply is lost?
- how much would customers be willing to pay to ensure the power stays on?
- the value of lost load is difficult to calculate because of the wide range of variables; time of year, day or *night, customer type, etc*
- we have based our VOLL determination on an inflation adjusted review of CAE's 1992 report.
- we removed the agricultural sector and scaled up the industrial sector to reflect smaller scale Christchurch industry (CAE values for industrial were low because of the smelter and timber processing industries in NZ, so used Australian Vencorp study for industrials)

12 of 31

Orion

CAENZ

Recent Publications

NEW ZEALAND CENTRE FOR ADVANCED ENGINEERING

Challenging the Future: Connecting the Words in Risk Communication

Ed. Jim Tully, pub. Feb 2007, B5 format, softbound, 134 pp inc index, B&W illustrations.

Written to appeal to a range of risk and communications professionals, this book visits risk communication from the perspective of risk managers, analysts, communicators and academics. The intent is to provide a practical resource for developing risk communication strategies by drawing on the disciplines of risk management and communications management.Examples assist readers to challenge their own thinking and find innovative solutions to their risk communications needs.

ISBN 0-908993-45-5. Price: NZ$56.25 (includes GST, p&p)

Energy Supply in the post-Maui Era

CAE Comments Series - 4, pub. 2005, A4, softbound, 46 pp, colour/B&W illustrations.

This study is a continuation of earlier CAE analyses of the New Zealand energy situation, and the issues surrounding primary energy supply in particular. The study offers a comprehensive discussion of the risks New Zealand faces in the post-Maui era, especially with regards to the supply and consumption of gas. The report seeks to develop a clear understanding of the primary technical, economic and transactional requirements that might frame future decision-making and investment.

ISBN 0-908993-38-2. Price: NZ$35 (includes GST, p&p)

Planning for Natural Hazard Risk in the Built Environment

Pub June 2004, A4, softbound, 52 pp, B&W illustrations.

This report, while not intended to provide an exhaustive assessment of all aspects of the topic, does bring forward the key factors and considerations believed to be important to good decision-making. As such it is an overview assessment that trolls for issues that may or may not require further attention. The identification, acquisition, transfer and usage of knowledge is the key theme arising herein.

Price: NZ$30 (includes GST, p&p)

New Zealand's Energy Future: A Sustainable Energy Supply After Maui

CAE Comments Series - 3, pub. 2003, A4, softbound, 36 pp, 2-colour/B&W illustrations.

Depletion of the Maui gas field has quickly imposed a new framework for New Zealand's energy future, beginning with the immediate concerns of electricity supply but in the medium term moving to the much more fundamental concern of securing adequate primary energy sources to meet ongoing demands for essential energy services.

ISBN 0-908993-35-8. Price: NZ$30 (includes GST, p&p)

Distributed Generation: A Study of Opportunities

CAE Comments Series - 2, pub. 2003, A4, softbound, 36 pp, 2-colour/B&W illustrations.

Distributed Generation (DG) has emerged as both a potentially attractive means of providing new electricity generation capacity and an alternative to expanding the capacity of established electricity transmission and distribution networks. This situation has arisen because of the ongoing improvement in the technologies used in DG and also because of the changing structure of the electricity industry, which now encourages more innovative solutions to meet energy requirements involving a number of industry stakeholders .

ISBN 0-908993-33-1. Price: NZ$45 (includes GST, p&p)

Resource Stewardship: Waste Minimisation

Ed. Lesley Stone. Pub Dec. 2003. B5 format, softbound, 248 pp + index, B&W illustrations.

This book is about examining the life cycle of products and the development of waste minimisation programmes that will make progress towards the goal of achieving optimal 'resource stewardship'. The book aims to enhance readers' knowledge of resource stewardship and the role of waste minimisation, and provide decision-makers and practitioners with insights that will help them to change their thinking from waste minimisation to resource stewardship.

ISBN 0-908993-36-6. Price: NZ$75 (includes GST, p&p)

Sharing the Future: Risk Communication in Practice

Ed. Janet Gough. Pub. September 2003. B5 format, hardbound, 176pp, B&W illustrations.

While risk communication is sometimes thought of solely from the perspective of an organisation communicating with its external stakeholders, external risk communication is part of good practice and helps an organisation to fulfil its legislative responsibilities, provide due diligence and obtain necessary permits. This book addresses the theoretical foundations of risk communication, and includes a number of New Zealand and international examples of its application. It will provide you with an understanding how risk communication can practically be applied to improve your chances of meeting your organisation's risk management objectives.

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