TRANSMISSIONTOMORROW

Keeping the energy flowing

TRANSPOWER

CONTENTS

ELECTRICITY IS A MAJOR PART OF OUR SOCIETY AND ECONOMY. HOW WE GENERATE, TRANSPORT AND CONSUME IT WILL BE CRITICAL TO NEW ZEALAND AS WE GO FORWARD.

Transmission Tomorrow describes our look forward at the generation and use of electricity in New Zealand and how the transmission service must develop to meet the needs of consumers. This will shape our decisions and plans out to 20 years and beyond.

Just as Transpower's two roles of grid owner and system operator are interdependent for their successful operation, transmission is interlinked with a diverse range of stakeholders in the wider electricity system, including customers, landowners, distribution networks, retailers, generators and others. We have actively sought and listened to their input in preparing this document, and we thank those of you who worked with us in our focus groups, helped us in discussions and seminars, and contributed to our thinking over the past two years.

Our thinking has evolved since 2008 when we first started on Transmission Tomorrow – as Transmission 2040. We have realised investing in long-term strategies and technologies Is crucial both to defer the need for some new lines and substations and to create better options for when new build is required. This will ensure we limit, to the extent possible, the cost and footprint of the grid for future generations, while ensuring it is fit for purpose.

This document provides our view of transmission tomorrow – the actual development of the physical grid will continue to be found in our Annual Planning Report, which we are expanding.

We aspire to be recognised internationally as a leading transmission company for the way we plan, build, maintain and operate the grid. Above all, we want to make the most of New Zealand's investment in the grid to provide a better future for New Zealand. This document is one step towards that vision.

PATRICK STRANGE
CHIEF EXECUTIVE

TRANSPOWER HAS A KEY ROLE IN THE ELECTRICITY SYSTEM AS THE TRANSMISSION GRID OWNER AND SYSTEM OPERATOR.

Our national grid is the physical highway enabling consumers and generators to interact in an efficient, integrated electricity system. Meanwhile, our system operator controls and co-ordinates electricity generation and transmission minute by minute to maximise the efficiency and reliability of the system.

IN THINKING ABOUT THE FUTURE NEEDS FOR ELECTRICITY TRANSMISSION, WE SEE:

- an economy becoming increasingly reliant on electricity, with increasing expectations of a reliable supply
- transmission technology changing, enabling us to utilise our existing assets better
- technology enabling far more interaction with and by consumers
- increasing amounts of remote and intermittent generation being built.

THE IMPACT OF THIS ON TRANSMISSION TOMORROW – IN 20 OR 30 YEARS – WILL BE:

- while there is some uncertainty about where new generation will be built, today's transmission grid will endure, but carry higher loads
- we will deploy new technologies to get much greater cost-effective capacity out of our existing grid before we build more
- where we are more certain of future needs and to ensure the grid remains resilient and robust in a more dynamic future, we will need to expand the grid
- technology will also help integrate the electricity system to better manage supply and demand across the entire chain between generator and consumer
- greater deployment of technology across our assets and systems and greater integration of the industry will change the skills needed from our workforce.

THIS, IN SUMMARY, IS TRANSMISSION TOMORROW.

Electricity accounts for about one-quarter of our energy use today. In **PART 1**, we discuss how, in the future, electricity will supply an increasing part of that energy. Electricity will power our future – our homes, our businesses, our industries and, increasingly, our transport.

We can never be sure exactly how and where electricity generation and demand will expand in the long term. New technologies will develop, and we will continue to be more efficient in our use of electricity – but under most future scenarios in New Zealand, our growing dependence on electricity will continue to be met from large-scale generation located distant from where we use it.

In **PART 2**, we analyse what this will mean for the transmission grid and its core backbone links. The key outcomes are that, while the existing configuration of the backbone grid is appropriate, the electricity transported will increase markedly under almost all scenarios. The cost of meeting this challenge by simply scaling up the current grid using new lines, substations and equipment would be very high. Further, this would increase the impact of the grid's footprint significantly.

Electricity will power our future – our homes, our businesses, our industries and, increasingly, our transport.

It is a future with inherent uncertainty – there is no single end point. Our planning must reflect this and, above all, place Transpower in a position to meet all possible eventualities, however unlikely they may seem today.

In **PART 3**, we describe the three key strategies we will apply to provide the increasing services the grid must provide. The first two strategies focus on using technology to increase the utilisation both of individual elements of the grid and of the electricity system as a whole. The third strategy outlines the steps we will take to ensure that the grid's reliability and resilience is maintained, despite the increasing use of technology to load the grid more highly.

From these three strategies, a number of initiatives are identified.

In **PART 4**, we outline the platforms we will develop to ensure that Transpower is in a position to deliver the complex technological solutions required and to meet the challenges imposed by load growth.

We must have real-time access to high volumes of condition data about our assets and real-time information about the status of the wider electricity system...

Two of the platforms address information and data, recognising the importance intelligence has in operating tomorrow's grid. We must have real-time access to high volumes of condition data about our assets and real-time information about the status of the wider electricity system, including utilisation by consumers, distribution networks and generators (our network platform). Additionally, the data needs to be accessible consistently and comprehensively to our engineers, so that they can get optimum performance from the grid and electricity system (our asset information platform).

In the field, for example, laptops will be as important as screwdrivers and multimeters, requiring technicians with new skills.

The third platform delivers the people with the skills to apply and maintain the new technologies (our people platform). In the field, for example, laptops will be as important as screwdrivers and multimeters, requiring technicians with new skills.

Even with new technology, new lines and cables will be needed to improve the capacity, reliability and resilience of the grid. The fourth platform is focused on ensuring we have the access necessary to upgrade our existing lines to develop their full capacity and to build new lines when they are required (our corridor platform).

Transmission and the supply side of the electricity system cannot be considered in isolation. The needs of consumers and our transmission customers, particularly, must be to the forefront and must drive our actions. However, there are other important stakeholders – our landowners, the government as both shareholder and custodian of the New Zealand economy, the regulators and our service providers are all key stakeholders, as summarised in **PART 5**.

Finally, in **PART 6**, we summarise what Transmission Tomorrow has told us about the future. It is a future with inherent uncertainty – there is no single end point. Our planning must reflect this and, above all, place Transpower in a position to meet all possible eventualities, however unlikely they may seem today.

PART

1 ELECTRICITY IN OUR FUTURE

ELECTRICITY LIGHTS, HEATS AND POWERS OUR HOMES, WORKPLACES, FARMS, FACTORIES, HOSPITALS, SCHOOLS, TOWNS AND CITIES. A RELIABLE ELECTRICITY SUPPLY IS VITAL, AND THE TRANSMISSION GRID IS ESSENTIAL INFRASTRUCTURE.

As noted by Treasury in their recently released National Infrastructure Plan:[1]

> "Infrastructure is an enabler of economic growth and social cohesion. The Government's vision is that New Zealand's infrastructure will be of a quality, reliability and resilience sufficient to support our aspiration to become a competitive, high productive, high wage and sustainable economy with good living standards enjoyed by all."

Worldwide, there is strong belief that electricity demand will continue to expand despite improved technology that allows us to use it more efficiently. Growing household use of appliances, emerging use of electric vehicles, industrial fuel switching, higher commercial use and more intensive production on and from the land are all driving our electricity usage higher. Technological advances will change the way we generate and consume this electricity, and this change is occurring more quickly than in the past. These advances will significantly impact both the physical transmission grid and its operation.

Today, over two-thirds of New Zealand's electricity generation uses renewable fuels[2] – hydro, geothermal and wind – and much of it is distant from where we live and work. The grid was originally built to connect this remote renewable generation with our towns and cities, and this role looks set to continue.

Increasing electricity dependence

Electricity today accounts for about 26 percent of the total energy used in New Zealand – second only to oil (47 percent).[3] Nearly all our activity, whether at home or at work, is made possible by electricity – it is an intrinsic part of living and working in the 21st century.

Our electricity consumption is largely driven by GDP and population growth, and while it has slowed in the last two years due to the recession, consumption has grown 1.6 percent per year since 1990. In our homes, we continue to purchase electrical consumer goods and appliances to make our lives easier, warmer and more comfortable. The reducing cost of consumer electronics is turning the out-of-reach into the affordable – whether heat pumps, televisions or computers.

Nearly all our activity, whether at home or at work, is made possible by electricity – it is an intrinsic part of living and working in the 21st century.

Today's consumer electronics are more efficient than their forebears, but they are being used more widely and more often. In some cases, electricity-based options are displacing non-electricity options – heat pumps for fireplaces, portable phones for wired phones, rechargeable batteries for disposables.

1 National Infrastructure Plan, available from http://www.infrastructure.govt.nz/plan/mar2010.

2 Energy Data File 2010, Table G3b: Estimated Generating Capacity by Fuel Type December 2009 (MW), available from http://www.med.govt.nz/upload/73585/EDF%202010.pdf.

3 Energy Data File 2010 (Figures for calendar year 2009), Table A.5a: Total Consumer Energy by Fuel (Gross PJ), available from http://www.med.govt.nz/upload/73585/EDF%202010

FIGURE 1

REAL GDP/ELECTRICITY CONSUMPTION COMPARISON

SOURCE: STATISTICS NEW ZEALAND (COLLATED)

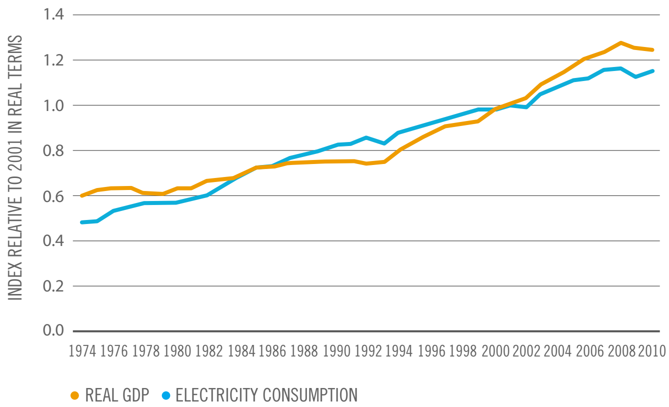
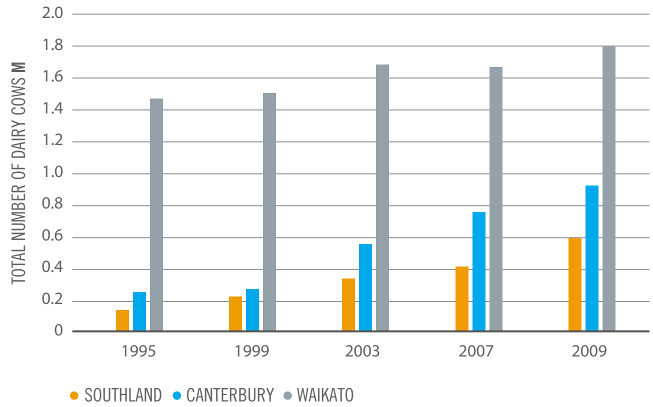


FIGURE 2

GROWTH OF DAIRYING

SOURCE: STATISTICS NEW ZEALAND AGRICULTURAL PRODUCTION STATISTICS 1995–2009



Electricity has the potential to displace significant quantities of fossil fuels where these are used as a primary energy source. We are seeing this already in towns and cities where controls on open fires are leading to more conventional electric heating or to heat pumps. Concerns over climate change and sustainability, coupled with the increasing cost of fossil fuels (including carbon taxing), will influence our future choices.

Greater intensity of production on the land is also increasing electricity demand. Mining, dairying and other energy-intensive processing are causing step load increases in electricity demand in certain regions of New Zealand. In parts of the South Island, dairying conversions, with the associated need to irrigate, are leading to step change increases in load of 6 percent per year as land use changes.

In the future, as battery technologies improve and costs reduce, a high rate of conversion to rechargeable electric cars is possible. Should it eventuate, any significant growth in electric cars is likely to predominantly occur in our metropolitan centres, and we expect continued reliance on the grid to charge them.

As our dependence on electricity rises, so do our expectations of a reliable supply. The commercial sector's tolerance of even short outages is ever-diminishing, for example, where retailers could once continue cash register transactions during a power cut, now everything from the high street fashion store to the corner dairy stops as point-of-sale electronic transactions freeze. In our homes, loss of power increasingly removes our ability to light, heat, cook, communicate and entertain.

Our ever-growing cities have become very dependent on electricity. Commerce stops, traffic grinds to a halt and security becomes an issue when we experience an electricity outage. This comes at major cost. The 31-hour blackout in the north-eastern United States in 2003, affecting 50 million people, was estimated to have cost $9 billion. The smaller, six-hour Auckland outage of 2006, affecting 700,000 people, was estimated to have cost $70 million. These are large numbers – reflecting lost production that can never be recovered.

Beyond the economic cost is the reputational cost of major outages, which, if they occur frequently, may reduce confidence in the robustness of the power supply and hamper the investment that drives New Zealand's economic growth and competitiveness.

Central role of the grid

The backbone of New Zealand's electricity system is the transmission grid stretching the length and breadth of the country.

Today, it allows almost all New Zealanders to access the most efficient and least expensive generation – irrespective of location. Typically, that generation is renewable (hydro, wind, geothermal) and distant from where we live and work. The grid also plays a critical role in providing reliable supply, 24 hours a day, 365 days a year. The average reliability of our supply at our customer service points is 99.99 percent[4] – much higher than individual generators can attain. Without the grid, we would each be reliant on locally based generation, and our electricity would be more expensive and its supply less reliable.

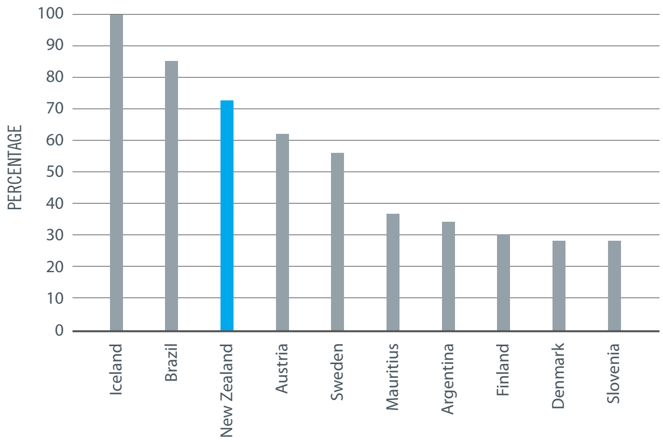
4 Transpower Quality Performance Report 2009/10, available from http://www.transpower.co.nz/f4266,39901750/quality-performance-report-2009-10.pdf.

FIGURE 3

TOP 10 RENEWABLE ELECTRICITY COUNTRIES

(AS A % OF TOTAL ELECTRICITY)

SOURCE: RENEWABLES 2010 GLOBAL STATUS REPORT[5]



Barring the discovery and development of large-scale gas fields or a step change in generation technology, economies of scale and environmental considerations are likely to drive the development of renewable plants remote from our load centres well into the future.

Our ability to tap into renewable sources of energy is the envy of many countries and an advantage in a carbon-sensitive world. Today, over two-thirds of our electricity comes from renewable generation, and the amount of renewable generation being installed is increasing.

In the last five years, geothermal and wind generation have increased significantly – now contributing up to 14 percent and 4 percent respectively of New Zealand's installed generation capacity. By contrast, we have seen the decommissioning of 300 MW of oil-fuelled generation at New Plymouth recently, and we expect the 1000 MW of coal-fired units at Huntly (now getting on for 30 years old) to be decommissioned progressively within the next 20 years.

Barring the discovery and development of large-scale gas fields or a step change in generation technology, economies of scale and environmental considerations are likely to drive the development of renewable plants remote from our load centres well into the future. We will also continue to benefit from last century's investment in the large hydro stations (Waitaki Valley, Manapouri, Clutha, Waikato River) for many decades into the future.

A future dominated by geographically diverse generation will demand more from our transmission grid. However, while this is the most probable outcome, the future is always uncertain. A future where we move away from renewable generation is also possible – it should be remembered that one event in the late 1960s, the discovery of the Maui gas field, set in train three decades of thermal generation development in New Zealand. Thus, there must be a balance struck between expanding the transmission grid, to enable new generation development, and avoiding early investment, which can be stranded if the generation does not eventuate.[6]

A future dominated by geographically diverse generation will demand more from our transmission grid.

To deal with this uncertainty, we have used scenarios to develop strategies that cater to a wide range of futures so that the risk to New Zealand of getting it wrong is minimised. This is discussed further in Part 2.

The changing role of the grid

The electricity system will change over the next 20 years. The underlying flows from generators to customers will continue, but the variability and volatility of these flows may rise significantly.

The fundamental role of the grid will remain – to transport large quantities of electrical energy from generators to diverse customers and to interconnect the system participants.

However, changes will occur in how generation and transmission interact to connect remote renewable generation. We will rely more on automated systems to manage output from renewable generation to control flows on the grid, reducing our reliance on additional grid capacity to prevent overloading after asset failures.

Change will also occur, perhaps more gradually, in the way customers meet their demand for electricity.

Historically, customers have enjoyed reliable electricity supply at a given price. Customers have limited ability to make active trade-offs between reliable network supply and price – it is a 'one size fits all' approach.

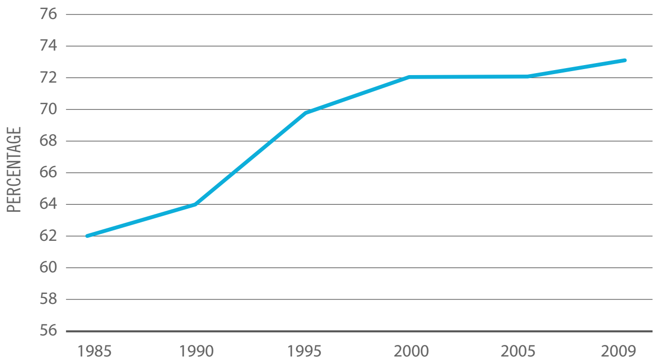
5 Note that New Zealand's entry is updated from 65 percent to 73 percent based on latest (2009) figures. Available from http://www.ren21.net/REN21Activities/Publications/GlobalStatusReport/tabid/5434/Default.aspx.

6 In recent years, two significant upgrades – the new Wairakei to Whakamaru 220 kV line, and a major duplexing project in the lower South Island – have been committed to facilitate the building of renewable generation.

FIGURE 4

PERCENTAGE OF INSTALLED GENERATION CLASSIFIED AS RENEWABLE
(EXCLUDING CO-GENERATION)

SOURCE: MINISTRY OF ECONOMIC DEVELOPMENT ENERGY DATA FILE 2010, FOR 2009 CALENDAR YEAR



We will rely more on automated systems to manage output from renewable generation to control flows on the grid, reducing our reliance on additional grid capacity to prevent overloading after asset failures.

Tomorrow's electricity system will allow for a far higher level of customer interaction. As active participants, customers will be able to differentiate the service they receive. One customer may require very high reliability at a price, while their neighbour may choose a lower level of service from the network and pay less.[7]

There will be a completely new set of active participants, including distributed generators, local storage devices and customers.

The transition to a far more sophisticated interaction between supplier and consumer requires both a capable grid and an effective system operator.

Sharing the load

Not all our future electrical energy needs will be met by distant generation. Beyond the grid, as customers become active participants, we expect to see greater distributed generation and increasing demand-side response.

Distributed generation – small locally based generation in homes or businesses (like solar heating or micro wind) – has yet to become mainstream. While it will play a more active part in the future, we expect it to remain secondary to large-scale remote generation for the foreseeable future, due to the significantly lower cost of that large-scale generation.

Demand-side technologies will couple electricity use to the economics of generation. Today, the system must have sufficient capacity to meet the largest peaks, no matter how infrequently they occur. That extra capacity then lies idle when usage drops in the early hours of the morning and at weekends.

For over 40 years, domestic customers have had the option of ripple control of their water heating at a reduced cost to them. This allows the network owners to reduce the demand peaks. This solution was pioneered in New Zealand. As system integration improves, we anticipate a wider co-ordination of supply and demand – principally through shifting other non-essential intermittent demand (like refrigeration) to off-peak times, when less costly generation can meet the need.

While this will not, by itself, reduce our total energy use, it will slow growth in peak demand. In turn, this will offer exciting opportunities to reduce the need for new peaking generation and some transmission investment. The change will take time, however, particularly as we, in New Zealand, already control the largest component – water heating.

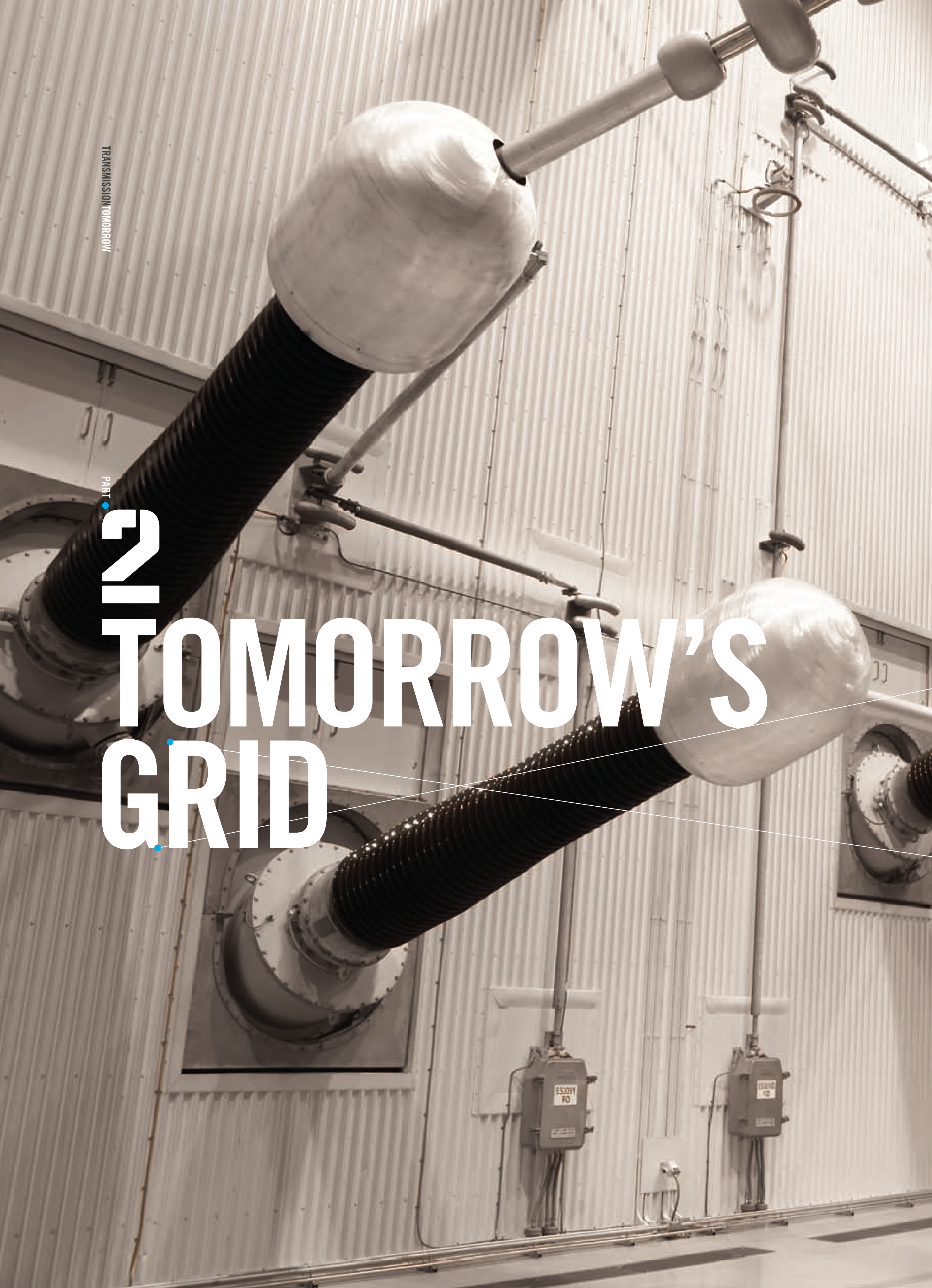
Demand-side response will also present challenges to maintaining and operating the grid, as a much flatter load curve[8] will limit our ability to perform maintenance and recover from failures. For both, we rely on lower demand periods through the rest of the day. To counter this, we will need to develop technology to use demand-side response as a tool for responding to system outages. Currently, we build the grid to have sufficient reserve to maintain full supply to customers in the seconds and minutes after transmission or generation outages occur. In the future, we will be able to incentivise customers to automatically reduce non-essential load.[9]

In Part 2, we examine what the future described so far will mean for the grid, by considering the impact of nine scenarios covering a broad range of possible developments.

7 New Zealand's ripple control water heating is a simple example. Customers can choose to have their water heating periodically turned off in return for a lower tariff.

8 A typical daily load profile shows peaks in the morning and evening, with lower usage between times.

9 Some modern refrigerators include under-frequency relays that could be enabled in the future to aid the grid to recover from a major failure or outage.



PART 2

TOMORROW'S GRID

NEW ZEALAND IS A LONG, NARROW COUNTRY, WITH OUR ELECTRICITY GENERATION OFTEN LOCATED FAR FROM THE LARGE CITIES WHERE DEMAND IS HIGHEST.

As a result, our grid is long and stringy and features a high voltage backbone spanning the length of the country (some 2000 kilometres) that links distant generation to major loads. Connected to this backbone are a series of regional grids that serve regional loads and generation.

Our major long-term planning concerns lie with this high voltage backbone grid.[10]

Today, the backbone grid predominantly carries energy from south to north. This often reverses overnight, as South Island hydro generators conserve water, and periodically reverses in dry winters, when the southern hydro lakes run low.

To determine the shape of tomorrow's grid, we need to understand the impact of changing demand and emerging generation options on the grid. To do this, we have developed four scenarios of electricity generation and demand development in New Zealand, which look forward 30 years.[11]

> To determine the shape of tomorrow's grid, we need to understand the impact of changing demand and emerging generation options on the grid.

While it is impossible to predict the future with any certainty, we must continue to plan for it. The scenarios we have developed, along with those developed by the Electricity Commission in its 2008 Statement of Opportunities,[12] allow us to explore the impact of different futures on the grid. The scenarios themselves do not reduce the uncertainty, but act as a tool with which to develop strategic initiatives that are robust to a range of future outcomes.

The scenarios are based on the two key elements that most affect the size and capacity of the grid – demand for electricity and the nature and location of generation.

Future demand and generation

The scenarios use a range of peak demand growth as follows:

- Increases from today's level by the year 2040, ranging from 30 to 80 percent in the North Island.
- Changes from today's level by the year 2040, ranging from -5 to 60 percent in the South Island. Negative growth only occurs in one scenario – where the Tiwai Point aluminium smelter closes.

These are not extreme limits – a 30 percent increase by 2040 is equivalent to an average annual growth rate of about 1 percent per year; a 100 percent increase by 2040 is equivalent to a growth rate of 2 percent per year. Actual growth could be lower or higher.[13]

New generation[14] modelled in our scenarios is based on known and possible resources of hydro, wind, geothermal, gas or oil, coal and, to a lesser extent, marine generation.[15] These resource areas and their spatial relationship to the major load centres will, to a large extent, dictate the future size and capacity of our grid.

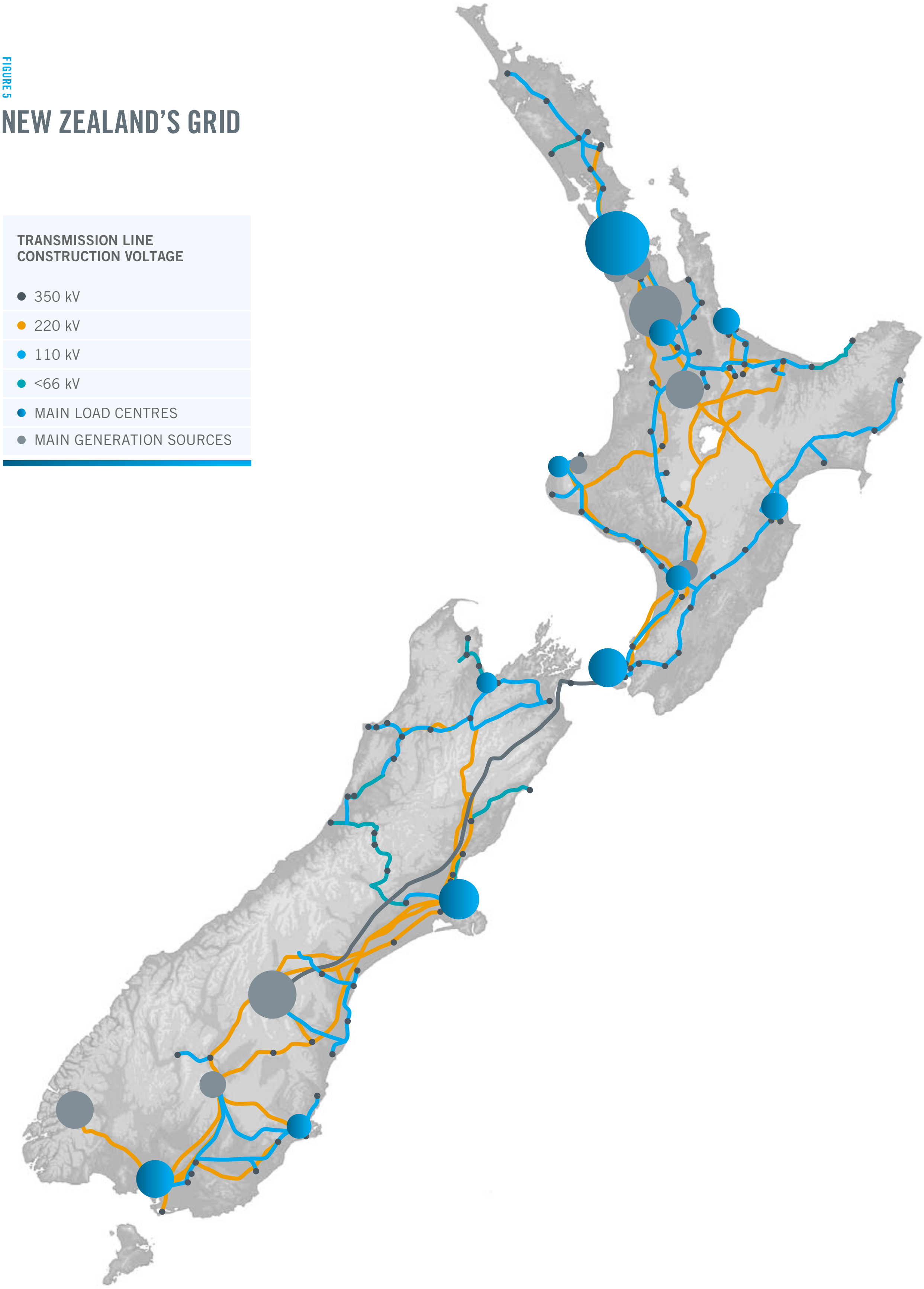
10 Future electricity flows across the smaller regional grids are sensitive to regional growth and the location of new generation plant. Both are more difficult to forecast and outside the scope of this report.

11 Refer to our companion paper *The Enduring Grid*.

12 The Electricity Commission's recently published 2010 scenarios are similar.

FIGURE 5

NEW ZEALAND'S GRID



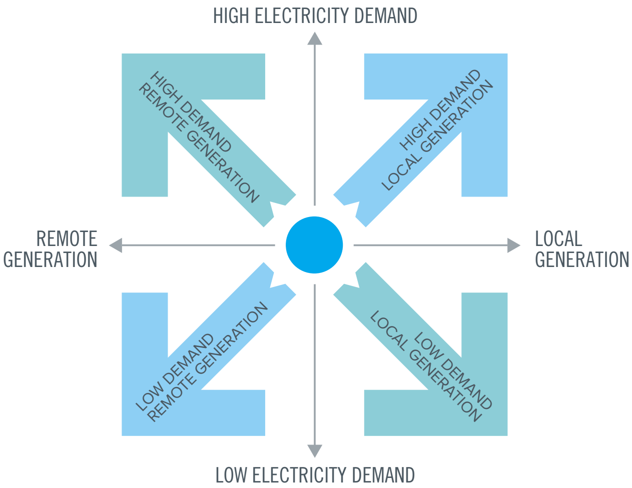
13 As noted earlier, New Zealand's consumption grew at 1.7 percent per year from 2000 to 2008.

14 The scenarios include both baseload generation and peaking plant and the use of demand-side response as an alternative to peaking plant.

15 Other technologies, such as solar, may well become relevant in New Zealand. Their impact would be similar to that of the technologies considered.

FIGURE 6

FOUR TRANSPOWER SCENARIOS



While long-term energy flows are one driver of grid expansion, peak flows are the major factor in sizing the grid – the higher the peak flow, the more capacity is required to prevent bottlenecks in the transport of electricity between regions.

Scenarios

Four scenarios have been developed covering the extremes of high and low demand and remote and local generation.

To these, we added the five scenarios developed by the Electricity Commission in its 2008 Statement of Opportunities. These nine scenarios cover a broad range of possible future developments.

Modelling future grid flows

For each scenario, we used computer modelling to determine what the electricity flows would be over the next 30 years under dry, wet and average hydro inflow years.

To determine the requirements for a backbone grid under each of these scenarios, we need to look at both the energy and peak flows across the grid.

While long-term energy flows are one driver of grid expansion, peak flows are the major factor in sizing the grid – the higher the peak flow, the more capacity is required to prevent bottlenecks in the transport of electricity between regions. Such bottlenecks result in a higher overall cost to New Zealand as more expensive generation is required to meet the demand.

The long-term trend in energy flows from the scenarios is as follows:

- Along the grid backbone from Roxburgh in the lower South Island to Auckland, northward flows range from about today's levels under the low demand scenario to up to three times as much under the other scenarios.
- Under all scenarios, the predominant flows remain from south to north.
- The south to north flow trend is driven by the continued growth of Auckland's demand, relative to that for the rest of the country. While the scenarios have assumed significant amounts of new generation is built in the Auckland region, it is not expected to be enough to counterbalance its growing demand for electricity, requiring more electricity to be imported from the south.

Grid future

The scenario analysis demonstrates that:

- grid flows will continue to be dominated by the large load in the upper North Island region – electricity will continue to predominantly flow south to north
- a strong grid will continue to be required and its capacity increased over time to support geographically diverse generation and deliver electricity to where it is needed.

The scenario modelling has confirmed that, while the configuration of the existing backbone is fit for purpose, its capacity will need to increase significantly over time.

The analysis also shows that the existing grid will, in most parts, accommodate the increased volatility associated with more intermittent renewable generation.

The scenario modelling has confirmed that, while the configuration of the existing backbone is fit for purpose, its capacity will need to increase significantly over time.[16] Identifying this now gives us the opportunity to plan additional capacity and to manage the increase in the footprint of the grid, by using existing lines and routes where possible.

The aim of our strategies in Part 3 is to use technology to better utilise the grid, particularly where the need for significant additional capacity is uncertain, while securing options to enhance the capacity of existing lines and routes. This is essential if Transpower is to deliver the grid performance required by our customers at the least cost over time.

16 The exact timing and magnitude is dependent upon the rate of demand growth as well as the location, size and timing of new generation.

PART 3

OUR STRATEGIES


LIFTING GRID PERFORMANCE
LIFTING SYSTEM PERFORMANCE
IMPROVING RELIABILITY AND RESILIENCE

PART 3 DESCRIBES OUR STRATEGIES TO DELIVER THE GRID OF TOMORROW AND OUR CURRENT INITIATIVES TO ACHIEVE THESE STRATEGIES.

THE THREE STRATEGIES ARE:

LIFTING GRID PERFORMANCE | LIFTING SYSTEM PERFORMANCE | IMPROVING RELIABILITY AND RESILIENCE

The first two – lifting grid performance and lifting system performance – are technology-focused, to deliver more from the grid cost-effectively and limit expansion of its footprint. Reliability and resilience is the counterbalance to ensure the grid is robust and reliable.

STRATEGY 1: LIFTING GRID PERFORMANCE

We will lift the performance of New Zealand's grid and transmission assets by:

COMPLETING our life cycle-based asset fleet renewal and refurbishment programmes

EXTENDING our condition and risk-based approach to asset management

OPERATING key assets to ratings that reflect the actual conditions at the time

MAXIMISING the capability of transmission routes using new approaches.

Our transmission lines, cables, transformers, circuit breakers and other substation equipment – the physical assets – are the building blocks of the grid. Grid performance is driven by the performance we can obtain from them, their failure rate and their service requirements.

Today

We operate a large number of assets. For example, our 41,500 towers and poles support many individual assets, such as more than 190,000 insulator strings, each of which is separately monitored, maintained and periodically replaced.

We also operate a wide range of AC voltages – 11 kV, 22 kV, 33 kV, 50 kV, 66 kV, 110 kV, 220 kV and 400 kV. National Grid (UK), with a system peak 10 times greater, runs only 132 kV, 275 kV and 400 kV AC assets.[17]

Our key assets are older than those of comparable transmission companies, due to the very low replacement investment in the decade to 2007.

Maintenance is based on regular field-based condition assessment. Older equipment requires more frequent maintenance and more servicing downtime compared to modern equipment.[18] Our diverse range of asset types and manufacturers compounds that issue. More frequent maintenance downtime, coupled with age-related deterioration, has led to lower grid reliability and increased cost.

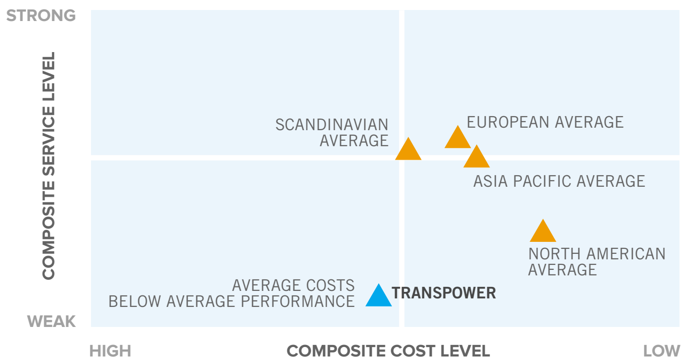
This performance is reflected in international transmission company comparisons. Figure 7 compares our asset operating and maintenance performance against that of worldwide transmission utilities. Best performers are in the upper right quadrant. As our key equipment has aged, our reliability has fallen behind that of our peers, while the costs have increased.

17 Transpower has a programme to rationalise voltages, including divestment of non-core low voltage assets.

18 Typical 20-year-old circuit breakers are serviced every four years – the equivalent modern unit is serviced every 12 years.

FIGURE 7

TRANSPOWER OPERATIONAL AND ASSET MAINTENANCE PERFORMANCE INTERNATIONAL COMPARISON



Our key assets are older than those of comparable transmission companies, due to the very low replacement investment in the decade to 2007…. As our key equipment has aged, our reliability has fallen behind that of our peers while the costs have increased.

In addition, many of our older sites need upgrading to meet modern workplace safety standards.

Current operation is based on a static view of the asset, with limited ability to adjust its capability in real time in response to the needs of customers or unplanned unavailability of other assets.

Because we must transport electricity over long distances, often we cannot access the full thermal capacity of lines due to limits such as voltage instability. Further, unequal sharing between different lines on a common transmission route constrains our ability to fully utilise them.

The future

Tomorrow's grid will feature more volatile flows from intermittent renewable generation, demand response and distributed generation. This could erode grid utilisation. Our challenge is to instead increase utilisation of our asset fleet while optimising new capital outlay. Increasing utilisation is the most effective means of minimising cost to our customers.[19]

As we move to a more highly utilised grid, individual asset availability and reliability will need to improve markedly. The frequency and duration of outages will reduce due to improved management together with the replacement of aged or poorly performing assets. Analysis of rich information on asset condition will optimise maintenance programmes and initiate early action to avoid failures.

Operating the grid will incorporate real-time asset management, with use of predictive models to provide variable and dynamic major asset ratings based on actual conditions. The utilisation of long transmission routes will be enhanced by using technology to allow the lines to be run at close to thermal limits safely, deferring the timing of new lines.

Initiatives

We will lift the performance of New Zealand's grid and transmission assets by:

- completing our life cycle-based asset fleet renewal and refurbishment programme
- extending our condition and risk-based approach to asset management
- operating key assets to ratings that reflect the actual conditions at the time
- maximising the capability of transmission routes using new approaches.

Renewal and refurbishment programme

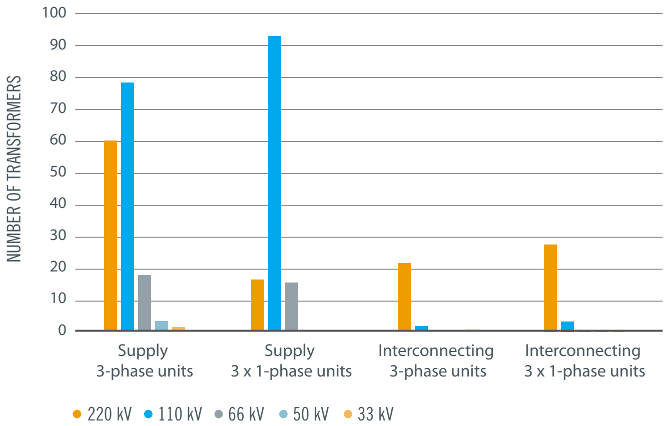
In 2008, we launched a major 30-year asset renewal programme based on a full life cycle assessment of each asset type.

As we move to a less redundant, more loaded grid, the impact of poorly performing assets increases markedly. The life cycle economic assessment includes comparison of the capital cost of replacement against the reduced life cycle costs of maintenance, spares, interruptions (measured by the cost of non-supply to the customer) and electrical losses. Other factors considered include safety and environmental benefits, for example, the societal benefit of undergrounding overhead lines or reducing greenhouse gas (SF_6) releases.

19 A 10 percent increase in utilisation over the next 20 years would save hundreds of millions of dollars in capital assets that would otherwise need to be installed.

FIGURE 8

INTERCONNECTING AND SUPPLY TRANSFORMERS
(3-PHASE AND EQUIVALENT)



An outcome of (our) renewal programme will be greater asset standardisation (such as fewer AC voltage levels and fewer transformer types), which will reduce costs through common maintenance, reduced spare inventories and greater interchangeability.

Development of new life cycle strategies for all major asset fleets was completed in 2009/2010.

An outcome of this renewal programme will be greater asset standardisation (such as fewer AC voltage levels and fewer transformer types), which will reduce costs through common maintenance, reduced spare inventories and greater interchangeability.

A further outcome is better serviceability. The assessments have demonstrated the benefits of designing to minimise maintenance, including enabling work to be performed on inservice (live) assets.[20]

Given the long asset life of heavy power equipment and the current age of our fleet, the renewal programme will take a long time to reach a 'steady state' – at least 15 to 20 years.[21]

However, as the replacement and refurbishment is being prioritised to address the poorest performing and more critical assets first, our asset performance will move within the mid range of our peers within the first seven years.

Condition and risk-based asset management

Condition monitoring is non-invasive ongoing testing of an asset – what we can learn of its condition without taking it out of service.

Transpower's condition monitoring for mechanical and conductive assets (towers, conductors and joints, cables, busbar elements and the like) is relatively sophisticated.[22] In contrast, current maintenance practice for key power transforming and switching equipment is less so, and we are reliant on risk assessment instead. Maintenance is largely specification-based, modified by periodic infield condition assessment (such as oil or electrical testing).

The present international state of the art is that monitoring is not relied upon to identify all incipient failures in power transforming and switching equipment – it cannot yet replace the need for redundancy and risk-based maintenance or replacement.

However, monitoring can increase reliability by preventing some early failures. Further, we believe there will be continued advances in the use of condition monitoring to extend asset life, and we will progressively install active monitoring on key assets.

Real-time asset management

Most of our assets are operated to pre-calculated ratings. These ratings can vary by season, load type and load duration.

In most cases, asset ratings are set to limit temperatures in key elements of the asset – for transmission lines, it is the line conductors; for transformers, it is winding temperatures.

Pre-calculated line ratings reflect the least favourable combination of temperature, wind and sunshine expected during that rating period. The actual load-carrying capacity of the line at any given time is often higher. Like transmission lines, actual underground cable and transformer capacities vary with ambient conditions and are higher for short-term loadings due to thermal lag.

Variable asset rating aims to make available this 'unused' capacity.

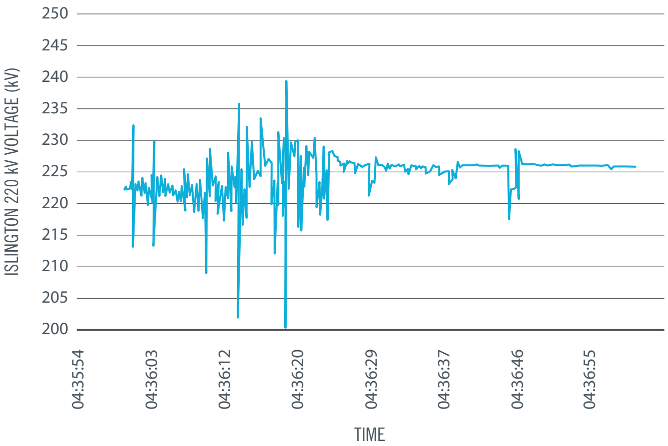
20 Transpower is already a world leader in inservice (live-line) work on high voltage transmission lines.

21 As an example, the power transformer replacement programme is costing $20–30 million per year for 20 years, at which time we will have an asset fleet equivalent to that of our peers.

22 For example, ground and helicopter-based thermal surveying is used widely, and new monitoring techniques to address emerging issues are developed quickly.

FIGURE 9

ISLINGTON 220 KV VOLTAGE, 4 SEPTEMBER 2010 – CANTERBURY EARTHQUAKE



The carrying capacity of our existing lines is being progressively lifted by thermally uprating (retensioning) existing conductors or by installing larger or duplexed conductors. A next step with long lines supplying major load centres is to allow them to operate closer to their thermal limits by extending our use of reactive compensation.

For transmission lines, variable ratings can allow greater energy transfer over what might otherwise be a constrained line.[23] Of even more value to the system operator is being able to allow a temporary higher loading on assets (particularly transformers and cables) after a failure of another asset.

Variable and dynamic asset ratings require a real-time asset management capability. At a minimum, our regional operating centres (ROCs) will become asset management centres – able to use the rich data increasingly available from our assets to initiate proactive action to prevent asset problems and provide real-time ratings at critical times. The ability to accurately estimate and monitor key temperatures within equipment in real time will greatly increase our ability to react to an asset failure without disconnecting customers.

Real-time asset management will also require a more dynamic and interactive relationship between the system operator and the grid owner. Transpower's dual role is a key advantage for this, versus other regimes where the system operator is in separate ownership.

Maximising the capability of transmission routes

The carrying capacity of our existing lines is being progressively lifted by thermally uprating (retensioning) existing conductors or by installing larger or duplexed conductors.

A next step with long lines supplying major load centres is to allow them to operate closer to their thermal limits by extending our use of reactive compensation. This is not straightforward: the compensation changes the response characteristics of the system, and this must be managed safely.

Compensation can take the form of fixed capacitors, SVCs and STATCOMs. We have used fixed capacitors extensively and now have SVCs at Islington and Albany. Last year, we installed two of the world's first grid-connected STATCOMs – fast-acting state-of-the-art power electronics devices – at Kikiwa substation, south of Nelson. Figure 9 shows how our new SVC and STATCOMs rapidly stabilised upper South Island grid voltage in the seconds following the Canterbury earthquake.

Management of many reactive support devices requires the installation of area-wide automated management systems in the form of regional reactive power controllers (RPCs) in both Christchurch and Auckland.[24] These will help the system operator to better manage regional voltage, eliminating the need for manual switching and thus enabling more use of compensation devices.

The configuration of individual transmission lines that make up a common transmission route can result in an uneven distribution of electricity flow between them. For instance, in Southland, the two shorter direct lines between Invercargill and Roxburgh reach their limit when the longer double circuit that also connects Roxburgh and Invercargill via Dunedin is only at 60 percent of its capacity.

We will be installing a technology already used outside New Zealand – series compensation[25] – to better utilise the longer lines. This is a quarter of the cost of a new additional line, with capital cost savings in the order of $80 million.

Series compensation technology will also be used, possibly as early as 2015–2020, to make better use of the new high capacity Brownhill to Whakamaru line and increase overall capacity across all the lines that supply Auckland from the south.

23 For example, the normal rating of the spur transmission line by which a wind farm is connected to the core grid may limit the wind farm's peak output, which occurs when the wind is high, but if the allowable capacity of the line is linked to the actual wind speed (higher winds cool the conductor), the constraint can be relieved, as the line's rating will rise as the wind farm's output increases.

24 The Christchurch RPC will be commissioned for winter 2011, and the Auckland regional RPC will be commissioned within the next five years.

25 A capacitor in series with the line to improve its electrical characteristics.

TIMING: LIFTING GRID PERFORMANCE

DATE/INITIATIVE	NEXT 5 YEARS	WITHIN 10 YEARS	WITHIN 20 YEARS	20+ YEARS
RENEWAL AND REFURBISHMENT	Strategic replacement programme for major plant continued	Asset performance comparable to that of our international peers	Complete strategic replacement programme	Assets designed to maximise availability – little offline maintenance required over lifetime of asset
CONDITION-BASED ASSET MANAGEMENT	Extend monitoring on key or at-risk assets	Roll out of SMS to deliver rich asset data (see Part 4)	Major substation equipment only serviced if identified by condition-based information	
OPERATING ASSETS TO RATINGS	Variable line ratings across New Zealand	Dynamic cable rating for Auckland upgrades		Asset capability dynamically optimised in dispatch of the electricity system
	Dynamic line rating for specific lines	Dynamic transformer rating and cycling		
REAL-TIME ASSET MANAGEMENT	Introduce real-time asset management in grid operation	Proactive maintenance and outage scheduling using rich asset data		
MAXIMISING CAPABILITY OF TRANSMISSION ROUTES	Area wide RPCs in main centres	Use of series compensation	Major transmission routes can operate close to thermal limits	Conversion of key AC lines to higher capacity DC (due to technology advances)
	Use of STATCOMS in Auckland			

- COMMITTED INITIATIVE
- POTENTIAL OUTCOME
- POSSIBLE TECHNOLOGY TREND

STRATEGY 2:
LIFTING SYSTEM PERFORMANCE

We will improve the efficiency of the New Zealand electricity system and the utilisation of the grid by:

IMPROVING the interaction between generation and transmission

INCREASING our ability to use consumer response

DEVELOPING the operational capability to dispatch a highly utilised electricity system.

The grid is just one element of a wider electricity system that includes generators, large grid-connected customers, and distribution networks and their end users.

The laws of physics require that the system must be run as one integrated whole at all times. Generation must balance demand at all times – if one more electric toaster is switched on, generation must increase to match the increased demand.

Today

System co-ordinators dispatch sufficient generation to meet the changing, but largely predictable, demand for electricity and to ensure sufficient reserves (generation and interruptible load) are available to respond to any sudden outage.[26]

At times, grid limits are reached, requiring a more expensive generator to run or load to reduce to maintain system security. This can cause higher energy prices and lead to higher overall consumer costs.

The variability of new generation technologies, such as wind, is providing challenges to the advance scheduling and dispatch of generation. Further, generation embedded within distribution networks is increasing the proportion of consumer demand 'invisible' to – and thus unable to be forecast by – the system operator.

The future

Operating the electricity system will become more dynamic and complex, with more intermittent renewable generation, variable asset ratings, distributed generation, energy storage and consumer response.

The transmission and distribution grids will become interactive (two-way) with a flow-on effect of more variability on the grid. Load forecasting will better reflect local conditions (such as temperature, wind and cloud cover). Dispatch of generation will be dynamic. Switching of controllable loads and demand-side response by consumers will become part of the load-balancing mix.

The ability to reliably switch off non-essential demand when the electricity system is under stress will reduce the need for spare generation and grid capacity.

Electricity system operators will have sophisticated applications and displays to operate and dispatch a complex, highly utilised grid, while maintaining a strong awareness of electricity system performance.

Use of wide-area controls to integrate and automate the operation of generators, grid devices and load to respond to grid contingencies will be an alternative to providing grid redundancy through new grid assets.

Initiatives

We will improve the efficiency of the New Zealand electricity system and the utilisation of the grid by:

- improving the interaction between generation and transmission
- increasing our ability to use consumer response
- developing the operational capability to dispatch a highly utilised electricity system.

26 The transmission grid is designed to carry the resulting changed energy flows by providing additional capacity to ensure no overloading after sudden generator or transmission circuit tripping.

Longer term, we will integrate the operation of generation and transmission to cover contingencies and better utilise the available transmission capacity. Achieving this will reduce the need for new lines on the backbone grid.

Integrating generation and transmission

Two major system management technology upgrades – enabling automatic control of generation (AGC) and the use of new control technologies on the HVDC system – will combine to provide major customer benefits in the next decade.

Currently, one generator in each island is dedicated to load-following – adjusting output to meet short-term load changes. Within the next few years, we expect AGC to manage the dispatch of generation. Our new market systems software can already run the generation dispatch automatically, while our network platform investment (see Part 5) will provide the high speed communications platform to enable wide use of AGC.

The upgraded HVDC bipole control system (to be commissioned in 2013) will enable a single national frequency-keeping market. The net present value of savings from a single market to maintain frequency at a stable 50 Hz in each island is estimated at between $25 and $107 million per year.[27]

Longer term, we will integrate the operation of generation and transmission to cover contingencies and better utilise the available transmission capacity. Achieving this will reduce the need for new lines on the backbone grid. This can be achieved through combining the automatic dispatch of generation using AGC with the use of variable ratings and the automated operation of the grid to manage asset failures.

A first step will be the integrated management of the upgraded HVDC bipole control system and the backbone grid north of Wellington, to be implemented in 2015. This will avoid a line upgrade to these lines, which may have otherwise been required for infrequent dry years.

Enabling consumer response

Demand-side response in managing the electricity system will play an increasing role in improving electricity system utilisation – be it off-peak charging of electric cars, traditional ripple controlled water heating, managing when we heat or cool our homes and offices or the direct control of appliances to cover for the loss of grid capacity from a failure of generation or grid equipment.

There are major investments internationally in 'smart grid' technologies (see sidebar), which will make demand-side participation more relevant in the medium term.[28]

Over time, demand-side response will see more 'load smoothing' as loads are managed effectively to lower expensive demand peaks.

Upper South Island distribution companies are already collaboratively managing regional demand to reduce system peaks. Wider adoption of this approach will reduce growth in transmission peaks, delaying upgrades as a consequence. The South Island initiative has reduced the peak demand in the region by 3 percent, deferring investment of $10 million by at least two years. Transpower worked with the distribution companies to enable this scheme, and we will continue to promote similar schemes.

27 Electricity Authority Frequency Regulation Market Development – Discussion Paper, available from http://www.ea.govt.nz/our-work/consultations/pso-cq/frequency-regulation-market-development-discussion-paper.

28 For example, the United States is expected to spend $5.4 billion on smart grid technologies in the medium term.

GETTING MORE FROM OUR GRID WITH POWER ELECTRONICS

Forty-five years ago, New Zealand was a leader in introducing high voltage direct current (HVDC) technology as a response to the special challenges of our long, stringy and islanded grid.

Pole 1, commissioned in 1965, was one of the first long distance HVDC bulk power transmission systems in the world and was built to bring electricity north from the new Waitaki Valley hydro generation stations.

In the mid 1970s, the link was modified to work bidirectionally, enabling electricity transfer into the South Island. This gave added flexibility to manage the overall generation mix, allowing thermal generation in the North Island to be sent south overnight and in dry years.

In 1992, Pole 1 was joined by Pole 2, a modern thyristor-based[29] DC link. This also featured our first use of distributed microprocessor devices to control the flows across the link. Pole 3, a modern thyristor-based replacement for Pole 1, will extend this capability.

We believe power electronics and HVDC technologies have huge potential to get the most out of our grid.

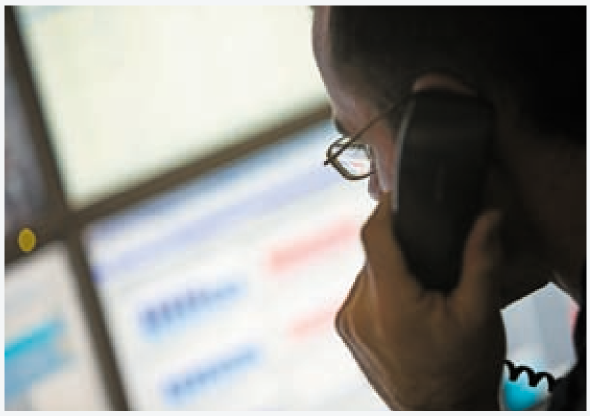
We have just installed our first static synchronous compensator (STATCOM), one of the first grid-connected applications of this technology in the world. Until now, their use in electricity systems has been limited to providing reactive support and fault ride through capability for wind generation.

STATCOMs are now an effective option to increase the capacity of the existing grids into Auckland, Wellington and Christchurch – our major load centres most dependent on distant generation. We will be installing three more STATCOMs by 2015 – two in the Auckland area and one as part of Pole 3 in Wellington.

We expect power electronics technologies to evolve, reduce in cost and provide enhanced capabilities to enable control of electricity flow over circuits. This would allow full use of the capacities of individual, parallel transmission lines along the backbone grid.[30]

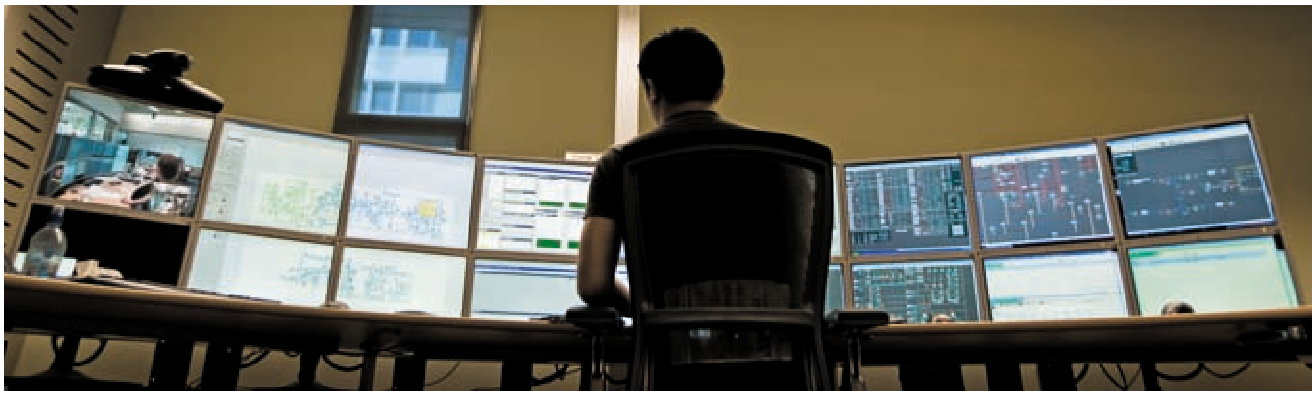
We also believe multi-terminal HVDC links will eventually become economic – allowing an intermediate take-off from an existing HVDC transmission line. For example, this may eventually allow Christchurch to be fed from the existing interisland HVDC line, should further capacity be required.

Today, these technologies are still developing and are expensive. As in the past, we will be early adopters, given their value to us in the context of our long, unmeshed grid and relatively low population and resource base. To better support this, we are establishing a new group of specialist engineers and technicians within Transpower as a centre of excellence in the development and delivery of power electronics technologies into the New Zealand electricity system. The inaugural members are now being trained to take an active part in commissioning the advanced electronics of Pole 3.



29 Thyristors are solid state semiconductor devices capable of switching very high voltages and currents.

30 Existing AC lines can also be converted to DC, increasing our long-term options to increase their capacity in the event of high load growth.



An important opportunity for the electricity system over the next 20 years will be the wider ability to control non-essential consumer loads to respond to unplanned outages or near-term issues on the grid.[31] We have trialled such an approach in the South Island using commercial loads.[32] Longer term, the ability to secure a predictable response from many smaller consumers through control of individual appliances and devices in homes and businesses offers significant benefits and will ultimately provide the grid with a self-healing capability.

An important opportunity for the electricity system over the next 20 years will be the wider ability to control non-essential consumer loads to respond to unplanned outages or near-term issues on the grid.

There is an ongoing need for transmission investment into the upper North and upper South Islands. Our demand-side initiatives to date have focused on short-term needs, principally to buy time until we can commission these grid upgrades. However, we are now investing over $10 million to procure 60 MW of permanent demand-side response in the upper North Island. One aim of this initiative is to build the capacity for demand-side response within the electricity sector by utilising the smart metering and consumer technologies currently being installed by retailers and distribution companies.

One aim of this initiative is to build the capacity for demand-side response within the electricity sector by utilising the smart metering and consumer technologies currently being installed by retailers and distribution companies.

Developing operational capability

The way we operate the grid must evolve to accommodate a more dynamic grid with real-time ratings, automated dispatch and demand-side response. We also need to enable a reduced market gate closure – the lead time by which generator offers must be set. Today, the need for electricity system operators to assess and review the resulting dispatch conditions results in dispatch – including the capability of the grid – being finalised two hours ahead of real time.

To reduce market gate closure, we are automating how the necessary constraints on generation dispatch are formulated to ensure the grid remains secure and within limits. Automated constraint design is a new capability developed in our market systems software, and we will be introducing it during 2011.

Lower voltage distribution networks that Transpower serves will gradually become 'two-way' with the growth of demand-side response and smaller scale embedded generation

31 Technology to interrupt a limited number of discrete large loads – non-essential processes in our steel mills, wood processing plants and aluminium smelting – already exists and is in use in New Zealand.

32 In 2007 and 2008, we funded major demand-side trials in the upper South Island to test aggregators' ability to deliver up to 27 MW of reliable interruptible load from smaller businesses.

Over the next year, we will be prototyping a new controller-centric display that will complement our system management applications. This important initiative to develop new display technologies will support reduced market gate closure times to make available the full benefits of variable and dynamic ratings by 2013.

(such as solar). The actual flows across the grid will be less predictable as a result. This will challenge the traditional approach to managing the connection between the grid and its consumers.

However, operators must clearly understand the status of the grid. Past improvements to our market systems have been driven by the introduction of specific new capabilities, including assessment of voltage stability, standby reserve forecasts and reserve adjustment factors. This has placed more information in front of the operators, and focus is now turning to assisting operators to maintain an overall awareness of the state of the electricity system in a control room with multiple displays and information sources.

A number of future trends will increase the demand on operators to be able to quickly understand the true state of the electricity system. These include variable and dynamic asset ratings, automated dispatch, the use of wide-area management control systems and the variability from a growing portfolio of renewable generation, demand-side response and smaller scale generation embedded within distribution networks.

In 2001, we were an early adopter of visualisation technology – the use of displays to identify discrepancies and trends in a user-friendly way. Our constraint visualisation package allows ready identification of discrepancies between what is happening on the actual grid and how it is represented in the market systems.

While our visualisation technology is still world-leading, system operators worldwide are now starting to develop and, in limited areas, introduce integrated applications to support operator decision-making for managing increasingly complex electricity systems.

Over the next year, we will be prototyping a new controller-centric display that will complement our system management applications. This important initiative to develop new display technologies will support reduced market gate closure times to make available the full benefits of variable and dynamic ratings by 2013.

We envisage we will introduce further controller-centric displays progressively over the next decade.

On a regular basis, we will also publish our roadmaps for continued development of the main market and SCADA and EMS systems.

THE SMART GRID (IN THE NEW ZEALAND CONTEXT)

What is a smart grid? The definition we like best is:

…an electricity network that can intelligently integrate the behaviour and actions of all users connected to it – generators, consumers and those that do both – in order to efficiently deliver sustainable, economic and secure electricity supplies.[33]

We have avoided using the term Smart Grid in Transmission Tomorrow because of the confusion it causes – it refers not to the grid as we know it, but to the wider electricity system. In fact, most of the technology under development is more applicable to distribution than transmission networks.

Are today's networks not smart? Yes and no. The transmission grid features two-way communications and controls and relatively sophisticated interactions with the larger generators and distribution networks we connect to. The lower voltage distribution networks, however, have been one-way to date, with little communication to or feedback from customers.

Digital communications now make the prospect of an end-to-end network feasible, with customers being active participants able to use intelligent devices to modify their electricity use in response to price or system conditions.[34] This offers major long-term benefits to all participants, including Transpower, by actively reducing demand peaks that drive the need for additional grid capacity. However, this does introduce another challenge for Transpower, as flatter load curves reduce our traditional maintenance windows.

Smart grids are not going to arrive overnight. They will evolve over many years and decades, as the gradual coalescence of many applications and developments.

Transpower technology strategies already involve the use of smart grid technologies, for example, wide-area automatic generator control (AGC). Also, through our upper North Island demand-side initiative, we will be seeking customer response as a dependable and guaranteed way to defer transmission investment into Auckland.

However, the major advantages for transmission will not flow until smart grid technologies gain momentum within the distribution networks, where there is a physical interface with most customers. This is some way off – we are beginning to see improved metering, and we will start to see the roll-out of smart appliances over the next few years.

In the longer term, we are counting on using widespread consumer response to offset the challenge higher generation variability will impose on the transmission system. Our platforms are designed to support this future.

The unique nature of our small, isolated and renewables-based electricity system means New Zealand's journey to smarter networks will not be the same as large interconnected networks.

An early opportunity for New Zealand is to achieve the benefit of a more intelligent and integrated grid. This requires the use of smart control technologies to support a growing portfolio of variable renewable generation without massive increases in grid capacity. Achieving this is more than a technical challenge – it will require close co-operation across the industry to realise its benefit to customers.

We are committed to leading the way here so that New Zealand makes smart choices.

33 European Technology Platform SmartGrids – see http://www.smartgrids.eu/.

34 For example, through intelligent appliances and devices automatically modifying their usage to respond to system conditions or prices.

TIMING:
LIFTING SYSTEM PERFORMANCE

DATE/INITIATIVE	NEXT 5 YEARS	WITHIN 10 YEARS	WITHIN 20 YEARS	20+ YEARS
INTEGRATING GENERATION AND TRANSMISSION	Introduction of AGC New HVDC controls manage transmission north of Wellington	Integrated control of generation and transmission for contingencies to enable renewables	Automated dispatch of generation and transmission (self-healing grid stage 1)	
ENABLING CONSUMER RESPONSE	Secure up to 60 MW of demand-side response in upper North Island Initiatives in upper South Island and upper North Island to test use of mass consumer response	Use of wide-area response from smaller consumers defers timing of additional grid capacity		Demand-side response automatically covers short-term grid failures (self-healing grid stage 2)
DEVELOPING OPERATIONAL CAPABILITY	Automated design of dispatch constraints Operator displays to provide situational awareness	Automatic dispatch of generation integrated with dispatch of transmission		Operators able to 'pilot' a fly-by-wire self-healing grid with automated dispatch and dynamic systems to ensure stability

COMMITTED INITIATIVE
POTENTIAL OUTCOME
POSSIBLE TECHNOLOGY TREND

STRATEGY 3:
IMPROVING RELIABILITY AND RESILIENCE

We will improve the resilience and reliability of the grid by:

MAINTAINING key strategic spares and resource to ensure we can restore security after a major event

DESIGNING AND CONFIGURING substations to reduce the risk of long-duration failures

ENSURING the grid remains reliable and resilient against failures of key substations

DEPLOYING modern grid monitoring technologies to prevent instability on a more highly utilised grid.

Reliability and resilience describe how robust the grid is to both expected and unexpected events that can cause loss of supply to end consumers.

Reliability refers to the day-to-day ability of the grid to provide continuity of service. The difference between 100 percent continual service and the grid's actual performance is its reliability. In broad terms, we measure reliability in system minutes lost – one system minute is equivalent to turning the whole system off for one minute or turning one-sixtieth of the total load on the system off for one hour.[35]

In 2009/2010, Transpower had 22 system minutes of unavailability, made up of 44 individual outages ranging from fractions of a system minute to one of eight system minutes.[36]

Unexpected failures of Transpower assets represent about 10 percent of all consumer interruptions – most come from within the distribution networks that connect the grid to New Zealand consumers.

No grid can guarantee 100 percent continuity of service. Investment to eliminate every possible outage is uneconomic. It is often more cost-effective for the customer to bear the cost of very infrequent outages or take other measures to compensate for the grid's temporary unavailability.

Resilience refers to the ability of the grid to withstand and recover from major unplanned events.

We expect the grid will suffer damage from extreme weather or very large earthquakes. Over the years, our experience with earthquakes and other events has led to improved design standards, substation retrofitting and a more resilient grid. Reinforcements made after earlier events (such as the 1987 Edgecumbe earthquake and the 1989 San Francisco earthquake) helped us to be able to restore power very quickly after the 2010 Christchurch earthquake.

Resilience also refers to the ability of the grid to withstand extreme failures, such as concurrent outages of several lines, which are thought so improbable as to be disregarded for design. However, these high impact, low probability (HILP) events do happen, and they can have a very high impact on society and the economy.[37]

> Over the years, our experience with earthquakes and other events has led to improved design standards, substation retrofitting and a more resilient grid.

They often cannot be predicted from past asset performance. The long thin nature of the New Zealand grid with limited asset redundancy increases our exposure to HILP events.

HILP events are often triggered by a simple event or failure that is not contained, with subsequent failures leading to extended outages. This vulnerability can be due to the grid being configured differently at the time, other equipment failing to perform as expected or a lack of operator information on true grid status. For example, in the north-eastern United States, a monitoring system failure deprived operators of important information that would have allowed them to respond to a fault, and this was a contributing event in the 2003 blackout that affected over 50 million consumers.

35 Losing supply to Hamilton for 40 minutes would produce one system minute of unavailability.

36 The eight system minutes involved a total of 280,000 consumers being without supply for up to five hours.

37 Major failures on grids around the world (such as the north-eastern United States blackout of 2003, which left 50 million United States and Canadian customers without power for up to two days and contributed to at least 11 deaths) have demonstrated their impact – and shown that they occur more frequently than our models predict.

CAPTION: HVDC TOWER IN THE SOUTH ISLAND HIGH COUNTRY FOLLOWING A SEVERE WEATHER EVENT.

Today's New Zealand grid, with its long main backbone grid and few alternative routes, is less resilient than the highly meshed networks of Europe and North America, so we must be able to apply uniquely New Zealand solutions.

With increasing loading on grids and wider use of automated controls, the inherent stability of traditional grids is being eroded, and exposure to sudden wide-area collapses or cascading failures due to mal-operation of automated or complex systems must be considered. Adoption of automated controllers therefore requires careful and precise engineering and exhaustive testing.

Today

The New Zealand grid was built to a simple N-1 standard. This approach (deterministic planning) provides redundant assets to cover for a single expected failure of substation equipment or a transmission circuit.[38]

Most grids around the world have been built to similar standards. A lesser number, such as the UK's National Grid, have been built to an N-2 standard – two assets can fail concurrently without loss of supply. Many grids (but not New Zealand's) have been built to N-2 for large load centres (major cities) and N-1 elsewhere.

Reliability is inherently higher for redundant systems; however, an N-1 grid is still exposed when an asset is out for maintenance or repair. As discussed earlier, our grid reliability has been falling below that of our peers, due in part to asset age and in part to outage exposure during repair or replacement activities.

Resilience is inherent in a system with redundancy. Pragmatic design and operating practices increase resilience further. For example, many transmission companies limited how much load could be transmitted through a single substation (although New Zealand did not). Further, all companies carry certain spares to allow rapid restoration after a catastrophic failure.

Today's New Zealand grid, with its long main backbone grid and few alternative routes, is less resilient than the highly meshed networks of Europe and North America, so we must be able to apply uniquely New Zealand solutions.

The grid connection to each of our three largest urban centres has been highly reliant on a single substation – Otahuhu for Auckland and Northland, Islington for Christchurch and Haywards for Wellington. There has also been limited diversity of transmission routes for lines between Whakamaru and Auckland.

Our current investment in the new Brownhill to Whakamaru 400 kV-capable line, the duplication of Otahuhu substation and the 220 kV cross-harbour Auckland cable all significantly improve reliability, resilience and diversity to Auckland. They provide alternative feeds to the 220 kV grid within the Auckland urban area, reducing reliance on the Otahuhu substation and creating a 220 kV ring around the city (Figure 10).

Further, the higher loading and length of key transmission routes into Auckland and Christchurch lends them a 'brittle' characteristic for the operators,[39] making measures to prevent system collapses more challenging.

38 Today, Transpower uses more complex probabilistic techniques for grid planning where possible.

39 When secure capacity limits are exceeded, the system can collapse with little warning, like a brittle stick, rather than providing warnings to which the system operator can respond.

FIGURE 10

EFFECT OF CURRENT PROJECTS ON AUCKLAND'S HIGH CAPACITY TRANSMISSION LINKS

PRESENT

BY 2015

The future

Reliability: Consumers will demand increasing reliability from key electricity-powered services. This does not necessarily mean a matching increase in grid reliability. Local storage (as from electric cars or battery-type devices) to maintain some services may well become more economic.

In the next 10–20 years, we believe that technology will emerge to allow many consumers to 'ride through' relatively short interruptions, using local storage and the ability to turn off non-essential load (such as refrigeration). This may be effective for short duration grid outages of, say, an hour or two (depending on the time of day), but this will be of limited use for longer outages such as major equipment failure or HILP events.

Resilience: Consumer requirements for grid resilience will increase, and tolerance for extended outages will continue to decrease. Further, demand-side responses will be less effective in mitigating longer outages.

The greater reliance on 'active systems' (such as special protection schemes) to provide reliability, together with a more highly utilised grid, could reduce the inherent resilience of the grid and thus its ability to cope with extreme or unforeseen events.

Accordingly, we will need to take specific design, reinforcement and operating measures to reduce both the probability and consequences of HILP events, so that resilience is maintained.

Resilience initiatives

Reliability is inherent in many of our initiatives; however, maintaining resilience in a less redundant, more highly loaded grid requires special attention.

We will improve the resilience of the grid by:

- maintaining key strategic spares and resource to ensure we can restore security after a major event
- designing and configuring substations to reduce the risk of long-duration outages, with a focus on diversity
- ensuring the grid remains reliable and resilient against failures of key substations
- deploying modern grid monitoring and control technologies to prevent instability on a more highly utilised grid.

MAINTAINING SPARES TO RESTORE SECURITY QUICKLY

We maintain temporary transmission towers and key cable components to allow rapid restoration after a line or cable failure. This is supported by mutual support agreements with the Australian transmission companies and arrangements with manufacturers.

We also maintain key substation equipment spares. Over the last two years, we have augmented this by procuring spare transformers at a cost of approximately $30 million to ensure a failed transformer can be replaced inside one month.[40] This practice will continue.

MAJOR SUBSTATION DIVERSITY

The linear nature of our grid leaves us materially exposed to loss of service at certain key nodes, due to the concentration of power flows through them.

40 Tranformers can take 18 months to two years to procure or repair.

We have initiated a programme of developing long-term site strategies, with pilots for two critical sites – Penrose in Auckland and Central Park in Wellington – to be completed by the end of 2011. These strategies will drive future development of these two sites. Similar plans will be developed for all major substations over the next five years.

Commissioning of a new gas-insulated substation in 2010 addressed our highest risk, at Otahuhu. Further south, a new substation as part of the North Island Grid Upgrade will provide similar diversity at Whakamaru by 2013.

We are currently carrying out a HILP review of the Bunnythorpe node. Similar reviews will target Wellington and Christchurch to ensure these cities have increased diversity commissioned within 10 years.

KEY SUBSTATION SITE STRATEGIES

We have initiated a programme of developing long-term site strategies, with pilots for two critical sites – Penrose in Auckland and Central Park in Wellington – to be completed by the end of 2011. These strategies will drive future development of these two sites. Similar plans will be developed for all major substations over the next five years.

In 2009, we initiated two nationwide site risk management programmes. One is focused at eliminating high impact common cause failures (such as a transformer fire leading to failure of neighbouring transformers). The second is a review with connected customers of individual substations, to optimise resilience across the combined systems.

DEPLOYING MONITORING TECHNOLOGY TO PREVENT INSTABILITY

The dynamic way the electricity system responds to unexpected failures is changing with new generation and grid technologies, greater use of industrial and agricultural motor controls and new consumer technologies such as heat pumps.

Monitoring systems that can provide early warning of emerging stability issues are required as we increase the utilisation of the grid (see page 34).

Today, the increasing dependence on wind and geothermal generation has changed the nature of the North Island electricity system, and a new control – over-frequency arming – will be advanced to avoid electricity system failure if a large section of the grid shuts down unexpectedly.

A review of our ultimate backstop against grid collapse – automatic under-frequency load shedding (AUFLS) – is under way.

RUNNING TO THE TRUE LIMITS WITH WIDE-AREA MONITORING SYSTEMS (PHASORS)

Until recently, engineers had only limited ability to monitor the detailed millisecond-by-millisecond behaviour of an electricity system. As a result, grid limits were established from predetermined studies that were deliberately conservative to ensure the electricity system remained stable when major assets failed.

Wide-area monitoring systems (WAMS) using a network of phasor measurement units (PMUs) are now starting to deliver high resolution information on the dynamic behaviour of electricity systems. Engineers can now assess the true dynamics of the electricity system closer to real time.

In the past, we have relied on SCADA to understand the status of the grid – this is analogous to an X-ray of human tissue, where only the hard bones are visible. Now, just as a CT scan reveals the soft tissue as well as bone, a network of PMUs can reveal more details of the true dynamics of the electricity system.

WAMS are becoming an important tool to validate the models used to set limits on the grid, detect abnormal behaviour and keep operators situationally aware. They can play an important role in New Zealand with our growing reliance on electricity transfer over long distances, increasing utilisation of the grid and changes in the technologies used to generate electricity.

In 2007, we installed our first PMUs along with a system to monitor small disturbances on the grid (Psymetrix). We currently have 11 PMUs and will progressively roll out additional units each year. The PMUs take their data from the modern intelligent electronic devices (IEDs) already installed in many of our substations and rely on our new high capacity fibre-based broadband network to make the information available.

Already our network of PMUs has identified unexpected oscillations among generators in the central South Island and confirmed that our new SVCs and STATCOMs responded as modelled in the upper South Island during the Canterbury earthquake. They will be invaluable to the tuning of the upgraded HVDC link control systems during commissioning.

WAMS are not yet widely used internationally, although they are being introduced in large and interconnected electricity systems in Europe, China and North America. We expect WAMS will deliver major benefits for our long stringy grid. Here, the benefits will be in managing a highly utilised grid as well as verifying the stable performance of generators and power electronics devices such as HVDC links and STATCOMs.

Ultimately, we expect a transition for this technology from a monitoring role to one of actively managing and protecting the grid. Here, PMU data, along with the integrated control of generation stations and our substations as a wide-area protection system, will enable immediate action to be taken to keep a highly utilised grid operating within its true limits.

TIMING:
IMPROVING RELIABILITY AND RESILIENCE

DATE/INITIATIVE	NEXT 5 YEARS	WITHIN 10 YEARS	WITHIN 20 YEARS	20+ YEARS
RESTORING SECURITY QUICKLY	Complete strategic transformer spares programme	Automatic under-frequency load shedding improvements		Automatic rerouting of power flows using power electronics
RESILIENCE OF MAJOR SUBSTATIONS	Complete HILP reviews for Bunnythorpe substation and Wellington and Christchurch	Diversity into Wellington and Christchurch	Further diversity to wider Auckland	Major substations become modular and compact
SITE RISK MANAGEMENT	Site strategies for Penrose and Central Park	Site strategies for all major sites		Greater standardisation of equipment and layouts – enables hot swapping of failed assets
MONITORING TECHNOLOGY DEPLOYMENT TO PREVENT INSTABILITY	Complete installation of systems to monitor electricity system dynamics	Improved dynamic response information extends operating envelope of existing grid	Dynamic systems used to contain and limit widespread failures	

COMMITTED INITIATIVE
POTENTIAL OUTCOME
POSSIBLE TECHNOLOGY TREND

PART

4 OUR NEW PLATFORMS

OUR ABILITY TO IMPLEMENT OUR STRATEGIES AND RESPOND EFFECTIVELY TO FUTURE NEEDS WILL BE GOVERNED BY THE CAPABILITIES AND RESOURCES WE HAVE AT THE TIME – OUR PLATFORMS.

Our existing platforms support planning, building, maintaining and operating the grid. We are establishing four new technology and capability platforms to underpin and enable the delivery of the strategies outlined in Part 3.

These new platforms cannot be developed in response to a particular project or as 'business as usual'. They can only be justified by considering the benefits across the breadth of our system.

Without these key platforms in place, Transpower will be forced into more expensive alternatives in the future.

The new platforms:

NETWORK PLATFORM – to deliver a secure digital data network linking our assets, control centres, offices and the wider electricity system.

ASSET INFORMATION PLATFORM – to deliver a step change in the way that we manage the grid.

PEOPLE PLATFORM – to ensure we have access to the skilled and experienced people required to operate and maintain the grid and to operate the electricity system.

CORRIDOR PLATFORM – to secure appropriate long-term access to transmission routes.

Platform 1: Network

A secure digital data network is a key enabler to many of our strategies and the smart grid vision that underpins them.

We must be able to access high volumes of data from the equipment in our diverse substations. Equally, we must be able to send high speed control instructions back, with certainty they are received securely and acted on without delay. We also need to have real-time access to information from the wider electricity system.

ACCESSING ASSET DATA TODAY

Much of Transpower's substation equipment incorporates intelligent electronic devices (IEDs) to enable continuous monitoring of their condition.[41]

However, access to them is limited. Only some are connected to SCADA (our current data gathering and control system), and these are hard-wired via a remote terminal device (RTU) in the substation. What limited capacity there is to transfer data to our engineering offices or control centres is via lower speed point-to-point telecommunications circuits.

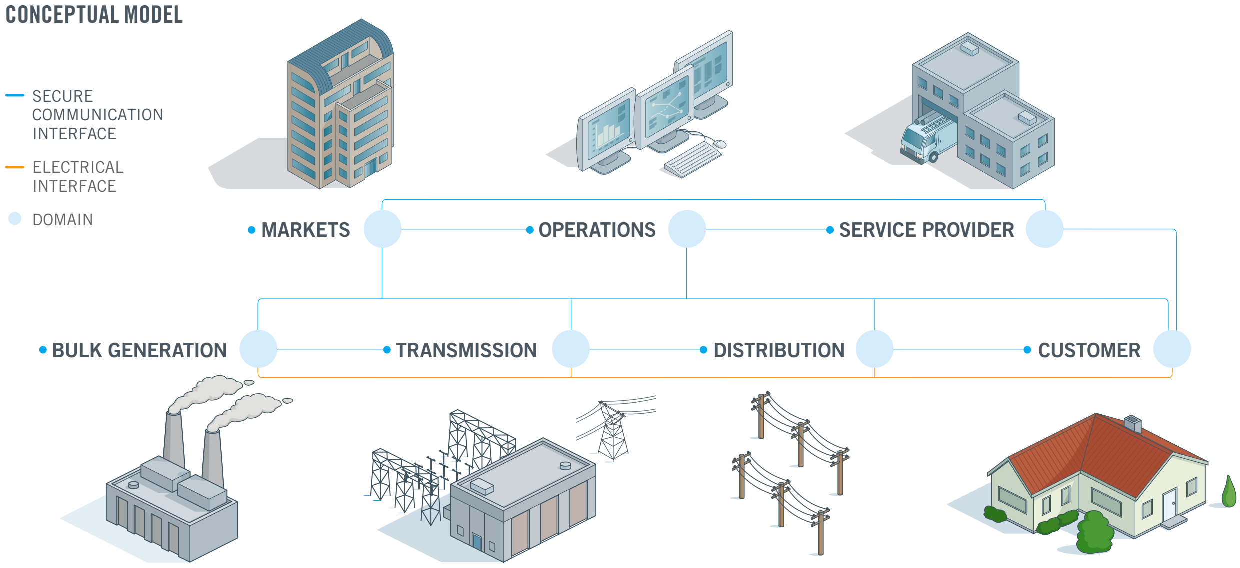
Much of our data can only be accessed by a technician going to the site and plugging in a laptop. During a fault, we often do not have key information until the site is visited, delaying restoration.

Wide-area control systems are difficult and expensive to implement and equally difficult to modify.

41 Over 70 percent of our key control equipment uses modern, multifunction computer-based relays. Transpower is one of the leading international utilities in their use.

FIGURE 11

CONCEPTUAL MODEL



The existing hard-wired point-to-point network of connections is not scalable to operate tomorrow's grid. Nor does this architecture have the flexibility to quickly and easily connect new internet-enabled internet-ready devices such as IP meters and phasor measurement units (PMUs), which will become essential to operating a more highly loaded grid securely.[42]

THE FUTURE

> Smart grids are digital. Computers speed the exchange of information, and gather a greater amount of data and act on it, to improve grid management and customer service.[43]

Substation devices, our engineering offices and control centres will be interconnected with dedicated networks. Monitoring and control devices will be linked to this network in the same plug and play way in which we add devices to our office computer networks today.

The time-critical but low-volume data required for real-time operation of the grid will, in the medium term, still use SCADA. Other data will be collected via a substation high speed local area network (LAN), aggregated and rationalised in a substation data hub and then made available across Transpower via a high speed wide area network (WAN).

The WAN will enable secure connection through standard protocols to generation stations, distribution company networks and customer sites and will serve as an integrated information highway for the smart grid.

DEVELOPING OUR NETWORK PLATFORM

Transpower is part way through a major transformational programme to establish the network platform. The benefits are high – the data network is fundamental to our asset and system strategies.

In 2007, we launched our Telecommunications Network Project, through which all key Transpower and generator sites will be connected by a wide area network (WAN) by 2012. This is a fully secure, dedicated network using predominantly leased dark fibre.

This year, we will start installing a pilot substation management system (SMS), which will replace the current hard-wired, proprietary connectivity in substations with a high speed local area network and data hub, to which monitoring and control devices can be linked.

SMSs will be installed in new substations and progressively retrofitted to existing substations. The speed at which this will be performed – between one and two decades – will be dictated by the development of applications that justify the outlay.

Direct access to system data for generators and distributors will be provided via the WAN with a secure internet protocol (ICCP), removing the current data exchange via hard-wired SCADA feeds.

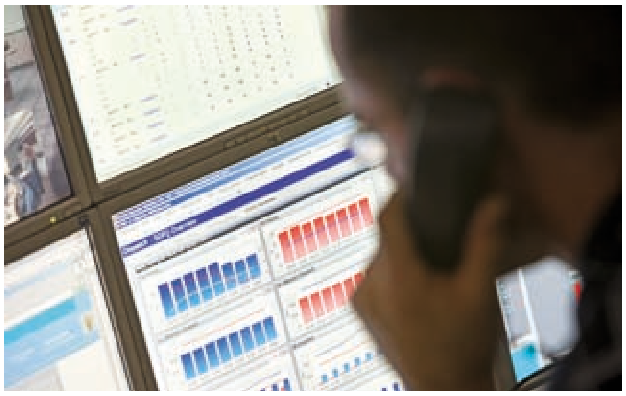
Eventually, the high speed WAN may become the platform for the operation of the grid itself, replacing the SCADA network. In the longer term, it would be the foundation for the fly-by-wire grid, which is retuned second by second to maximise power transfer across critical routes.

42 IED numbers are projected to grow from approximately 1400 per substation today to over 3000 in the next 10 years. Corresponding data points will grow from about 100,000 today to more than 300,000.

43 *The Guardian Weekly*, 20 August 2010.

A modern asset information system is a prerequisite for Transpower to effect a step change improvement in the way that we plan, manage and maintain the grid.

The objective is to have one database with all data in standard formats, which is accessible and updateable by multiple applications.



Platform 2: Asset information

To implement our asset management and system performance strategies (such as variable ratings), online access to accurate current and historical data for each asset is essential. Further, there are major operational and maintenance cost benefits in provision of online access to asset information to operating, engineering and field staff.

A modern asset information system is a prerequisite for Transpower to effect a step change improvement in the way that we plan, manage and maintain the grid.

TODAY'S INFORMATION CHALLENGES

We have disparate systems for managing asset data. The key is MMS (the maintenance management system), a 14-year-old computer application developed to schedule maintenance with our service providers.

Data is difficult to manage as it is duplicated across multiple applications. Some data is double handled – entered in one system then re-entered in another by hand. Some asset maintenance and performance data resides with our service providers and is inaccessible to our engineers.

Our grid engineers must undertake time-consuming analysis in order to assess the health of critical equipment, manually aggregating data from multiple sources. These sources are incomplete, making it difficult to undertake comprehensive analysis to enable predictive maintenance management.

Field access to asset and engineering data is largely through hard copy today.

INFORMATION SYSTEMS OF THE FUTURE

The objective is to have one database[44] with all data in standard formats, which is accessible and updateable by multiple applications.

Data will be accessible online to our field force – one-time automated data input will replace the largely manual and expensive practices employed today. Collection of asset condition inspection data (numerical, text, images and video) will be automatically tagged to specific assets and their location using wireless geospatial systems, entered directly via wireless data devices and automatically uploaded to the core asset management systems. This will allow for timely access by engineers and operational staff.

Data will be checked for consistency at source to eliminate errors.

DEVELOPING OUR ASSET INFORMATION PLATFORM

We face the major cost of updating our end-of-life applications such as MMS. We will use this opportunity to make the transition to an integrated asset information system.

The current core asset register and work order system will be replaced with a modern non-proprietary system that supports a standardised set of transmission company business processes. This system will replace several disparate existing systems over time.

The core asset register will use standard protocols to link with Transpower's financial, project management and procurement systems.

44 There may be multiple physical databases, but the objective is to have a single 'point of truth' – there is only one value to which all applications refer for each item.

A common hub or gateway will be established that securely controls and manages access between the corporate office data stores, and engineering and field staff. This gateway will support a variety of mobile and remote fixed terminals used by Transpower field staff and third-party service providers.

Platform 3: People

We will be dependent upon the skills and experience of our people in planning and operating tomorrow's grid. These engineering and technical people are spread across the industry – both in-house and within our close network of service providers and consultants. All are important for our future success.

The introduction of new grid assets, new asset management approaches and supporting systems and system management advances will require:

- retention of our experienced people
- ongoing recruitment of technical, engineering and business people
- development of new skills, both in-house and by our wider workforce.

TODAY'S CHALLENGES IN OBTAINING AND RETAINING SKILLED AND EXPERIENCED STAFF

Our engineering workforce is increasingly mobile and global. We compete with the rest of the world for our engineering and technical resources, and there is a worldwide shortage of skilled transmission people.

In the field, the major increase in our workload over the past two years is stretching our service providers' workforces. The availability of technicians capable of working with modern systems and equipment is a particular concern, given the relatively long lead time to train them.

Our engineering workforce is increasingly mobile and global. We compete with the rest of the world for our engineering and technical resources, and there is a worldwide shortage of skilled transmission people.

THE FUTURE

The stewardship of the electricity system and its assets will become more IT based. This will require a changed skill set from our people. At the engineering level, power systems engineers will require a greater understanding of the IT tools and systems that will maintain and monitor our assets in the future. At the field level, technicians will need to be as handy with a laptop as they are with a multimeter.

Without a special focus on developing and maintaining skills, we will not be able to implement the strategies outlined in Part 3 for the grid of the future.

DEVELOPING OUR PEOPLE PLATFORM

We have four programmes focused on building our people platform.

In 2001, Transpower initiated a programme to recruit New Zealand graduate engineers. The graduates are placed on a two-year rotation to gain experience in various aspects of our business. This includes periods working in the field with our service providers and with generators. Altogether,

CAPTION: FIRST STATCOMS TO BE INSTALLED IN NEW ZEALAND – KIKIWA SUBSTATION.

At the engineering level, power systems engineers will require a greater understanding of the IT tools and systems that will maintain and monitor our assets in the future. At the field level, technicians will need to be as handy with a laptop as they are with a multimeter.

53 graduates have been taken on through this programme since inception – 32 of those in the last two years following programme expansion in 2008. We will continue the highly successful programme to address the ageing profile of our engineering workforce.

In 2010, we resolved to build an in-house team of specialist HVDC technology technicians to ensure we have the expertise going forward to maintain and operate the increasingly sophisticated control technology being employed on the HVDC link and in new devices such as STATCOMs and RPCs. The team will be trained within the commissioning programme for the new HVDC Pole 3.

We have a programme to work with our service providers to ensure we have sufficient skilled field staff going forward. For line workers, a critical and internationally mobile workforce, we have implemented a cadet scheme on our largest project – the 400 kV line. Planning is now under way to develop a programme to ensure our service providers are incentivised to develop and maintain technicians with the training and skills to operate the new IT-based networks. We are also conscious that we must give the service providers sufficient certainty of steady work to reward their investment in training and have restructured our service arrangements to do this.

Our challenges and our solutions are increasingly common across the wider electricity system. In developing our capabilities, we will focus on creating holistic capabilities and solutions, rather than taking a transmission-centric view.

Finally, we need to overcome our geographical isolation and expose our engineers to the experience of international grid owners and electricity system operators. Active participation in international technical forums (CIGRE, IEEE) will remain an important element of our people and technical development.

Transpower has long been highly regarded for its engineering talent and capability – we will not allow that regard to be diminished.

Platform 4: Corridors

Transpower has 11,806 kilometres of single and double circuit transmission lines and over 45 kilometres of underground or undersea cables interconnecting our 182 substations throughout the country. Only about 5 percent of the land through which these lines and cables pass is controlled (by ownership or easement) by Transpower.

The transmission corridors along which these lines and cables connect are irreplaceable assets. Securing new corridors is difficult and takes a long time. Equally, our ability to increase the load-carrying capacity of the grid through existing corridors is constrained.

Securing appropriate access to long-term corridors to support grid development into the future is a key platform.

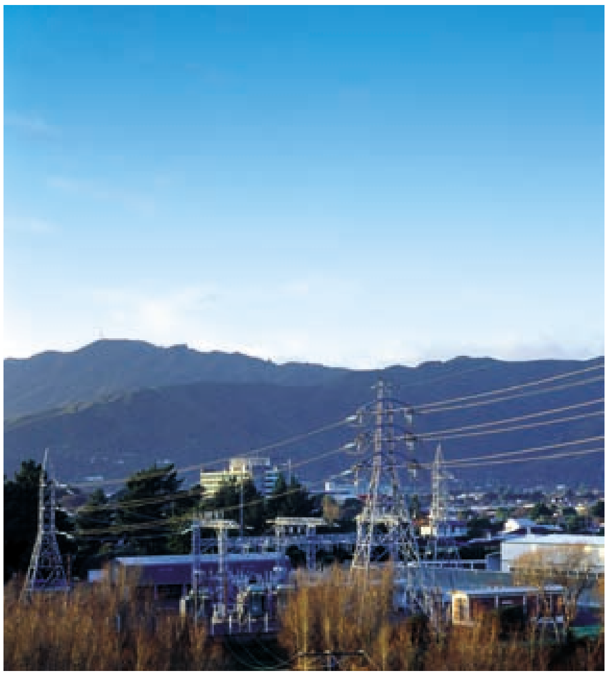
CHALLENGES IN UTILISING CORRIDORS TODAY

Our rights to operate, maintain and upgrade most of our existing lines are conferred by statute.[45] New lines (and major changes to existing lines, such as increasing voltage) require legal easements to be purchased from individual landowners.

Existing lines in urban and urban fringe areas have been compromised by extensive underbuild. This makes maintenance difficult and limits upgrade potential.[46]

45 The Electricity Act 1992 Part 3.

46 Approximately 1,000 buildings have been erected under the key Otahuhu-Henderson line through Auckland. In 2009, a hoist in a container yard under the lines caused a four-hour blackout to 280,000 customers. Within 10 years, the Otahuhu-Henderson conductors will need to be replaced – this will be difficult and expensive to complete.



Our rights to operate, maintain and upgrade most of our existing lines are conferred by statute. New lines (and major changes to existing lines, such as increasing voltage) require legal easements to be purchased from individual landowners.

In rural areas, intensifying land use (such as irrigation) is increasing the impact of our existing lines on landowners. Affected landowners are seeking compensation for these lines, and upgrading is frequently being challenged.

Over the last 20 years, little provision has been made for new line or cable corridors. Transpower must instead rely on designating land under the Resource Management Act to secure routes for new lines. However, designations can only be secured for a committed project – by this time, land use has already intensified in the potential corridor, making securing routes very expensive and disruptive and often impracticable.

THE FUTURE

There will be an increasing need to find routes to underground existing urban lines, particularly when major upgrades to them become necessary.

In rural areas, undergrounding of our long transmission lines will remain uneconomic and technically impracticable for the foreseeable future.

National and local government policy-makers now recognise the need to plan long-term for future infrastructure. The 2008 introduction of the National Policy Statement on Electricity Transmission (NPSET) provides increased protection against future underbuild on existing lines.

Local authorities are now beginning to consider utility corridors in their long-term plans and provide for them through the use of spatial plans. This provides a mechanism by which future corridors can be protected from development incompatible with transmission use.

DEVELOPING OUR CORRIDOR PLATFORM

Our over-riding objective is to identify and protect corridors for future lines and cables and to maintain our ability to use existing corridors appropriately. Availability of corridors is our largest constraint to meeting future needs.

We will develop and maintain a 30-year corridor plan that identifies where additional capacity may be needed on our existing corridors and where new corridors may be required. This will cover both the backbone grid and the regional grids. The plan will be developed by considering scenarios of future development of generation and demand in New Zealand (see Part 2). It will include resilience studies, reflecting the need for corridors to provide diversity of routes to, into, within and around our major cities.

We will develop and maintain a 30-year corridor plan that identifies where additional capacity may be needed on our existing corridors and where new corridors may be required.

Measures will be taken to secure these corridors in liaison with local authorities, principally through designating or appropriately zoning land. For corridors for new lines or major upgrades, we will seek to have buffer zones established that prevent incompatible development occurring in the corridor.

We will start work on the corridor plan in 2011. It will become a companion to our Annual Planning Report.

PART 5

THE WIDER CONTEXT

WE HAVE FOCUSED ON WHAT THE GRID WILL BE LIKE AND HOW WE WILL OPERATE IT IN THE COMING DECADE AND BEYOND.

HOWEVER, THERE ARE MANY OTHER INFLUENCES TRANSPOWER MUST CONSIDER. THE MOST IMPORTANT OF THESE ARE SUMMARISED BELOW TO SHOW THE WIDER CONTEXT THAT DRIVES OUR THINKING.

Industry participants

Generators, distribution companies and other industry participants are our customers, but they are, above all, our partners in delivering a service to the consumer. We must work with them and be alive to their needs, to ensure consumer expectations are realised. Consumers will not differentiate between industry participants when supply is jeopardised.

Service provider partners

Transpower will remain reliant on specialist service providers to run the grid. These are long-term partnerships to ensure that competent services are available. We will maintain a direct interest in the capabilities of our service providers to ensure they meet the challenges of a changing grid.

Consumers

Ultimately, Transpower exists to provide a grid and operate an electricity system for consumers. We must continuously remind ourselves why we exist and what consumers expect us to deliver in the way of service, efficiency and foresight.

Shareholder

Transpower represents a major capital investment for the shareholder. We must run our business effectively, efficiently and in a manner that easily withstands scrutiny. We are a publicly owned company and must meet the highest standards of accountability, openness and governance.

Landowners

Our business materially affects people over whose land our assets cross or are near. Working on our assets must be carried out in a manner that appropriately recognises and minimises our impact on landowners. Long-term stable relationships with landowners and communities near our assets will be a continuing objective.

Regulators

Maintaining open relationships with the Commerce Commission and the Electricity Authority is important to ensuring we can meet development objectives. In essence, the regulators represent consumers in ensuring our actions are fiscally as well as operationally prudent.

PART

6 THE FUTURE

WE ASPIRE TO BE AN INTERNATIONALLY RESPECTED TRANSMISSION COMPANY IN THE WAY WE PLAN, BUILD, MAINTAIN AND OPERATE THE GRID. ABOVE ALL, WE WANT TO MAKE THE MOST OF NEW ZEALAND'S INVESTMENT IN THE GRID THROUGH OUR INNOVATION AND RESPONSIVENESS TO PROVIDE A BETTER FUTURE FOR NEW ZEALAND.

WHAT WE COMMIT TO DEVELOPING AND BUILDING IN THE NEXT FEW YEARS WILL BE WITH US AND OUR SUCCESSORS FOR MANY DECADES. THE LEGACY OF OUR DECISIONS IS A LONG ONE.

Much of the grid built in the past remains vital to New Zealand's economic and social wellbeing – we must maintain that legacy of far-sighted planning and a willingness to take on big, complex and technically challenging projects.

The innovations of the past should inspire us to be bold and innovative in future. We should use the knowledge, talent and experience being gained now in major projects to good advantage moving forward.

There are challenges, and of course, predicting the future is an uncertain business. What does seem clear is that:

- because of continuing growth in the Auckland region and investment in renewable generation in the lower North and South Islands, the need for the national grid will endure
- technology will play a strong role, particularly in meeting uncertainty over the future – our small, stringy grid means we must be able to step outside the mainstream with uniquely New Zealand solutions
- our customers will demand even more of us in the way of security, service, efficiency and accountability
- our people must be kept ready and equipped for new industry challenges as they are unfolded to us.

There are many uncertainties. There is no one single view of the future. The Transpower 'glide path' strategy of the late 1990s can now be seen as too narrow because it was just one fixed view of the future.[47]

It is important that we maintain options to deal with the unexpected. Transmission planning is often said to be about minimising the mistakes from being wrong about the future. Investing prudently now to create those options will ensure that tomorrow's customers will have a fit-for-purpose transmission grid at the least possible cost.

We aspire to be an internationally respected transmission company in the way we plan, build, maintain and operate the grid. Above all, we want to make the most of New Zealand's investment in the grid through our innovation and responsiveness to provide a better future for New Zealand.

47 Under this strategy, it was assumed that distributed generation would expand quickly, negating any need to expand the grid or, possibly, to even maintain it in the longer term.

ADDRESS OF OFFICES

WELLINGTON
Transpower House, 96 The Terrace
PO Box 1021, Wellington 6140
Telephone 64 4 495 7000
Facsimile 64 4 495 7100

AUCKLAND
Level 5, Building 2
Central Park Corporate Centre
666 Great South Road
PO Box 17-215, Greenlane, Auckland 1546
Telephone 64 9 589 2300
Facsimile 64 9 589 2310

PALMERSTON NORTH
Level 5, IRD Building
Corner Ashley Street & Ferguson Street
PO Box 640, Palmerston North 4440
Telephone 64 6 357 0919
Facsimile 64 6 357 0917

CHRISTCHURCH
Level 3, 6 Show Place
Addington
PO Box 21-154, Edgeware, Christchurch 8143
Telephone 64 3 339 9800
Facsimile 64 3 338 1290

www.transpower.co.nz

www.transpower.co.nz