Infrastructure Management

IPWEA NZ Conference 2019

New Zealand Engineering Skills Shortage

WAUGH

ideas | analysis | solutions

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1.0 ABSTRACT

Title
The criticality of people in the sustainability of infrastructure management service delivery in New Zealand.

Sentence Teaser
Everyone in public works service delivery knows about the skills shortage. It is about to get a lot worse. The problem and the solution are found in the Maori phase He tangata, it is the people.

Mini Overview
It is increasingly recognised that we are facing a major Engineering skills shortage in NZ. The reality is that this skills shortage is much wider than just engineering skills and is across the whole stack of skills needed to deliver public works services to our communities. This is becoming a core issue in our ability to sustainably deliver public works service levels in NZ, and is projected to get progressively worse over the next decade.

This presentation and accompanying paper will review the size and breadth of the skills shortage. An overview will be provided of the current range of education, industry and government initiatives in place to address the skills shortage.

The infrastructure management and service delivery impacts of the skills shortage will be unpacked including impacts on risks, quality, sustainability, procurement and service delivery cost.

The adequacy of current responses to industry skills shortage, the role of technology, expert systems, artificial intelligence and examination of possible additional industry responses will conclude the presentation.

2.0 INTRODUCTION

He aha te mea nui o te ao
He tangata, he tangata, he tangata

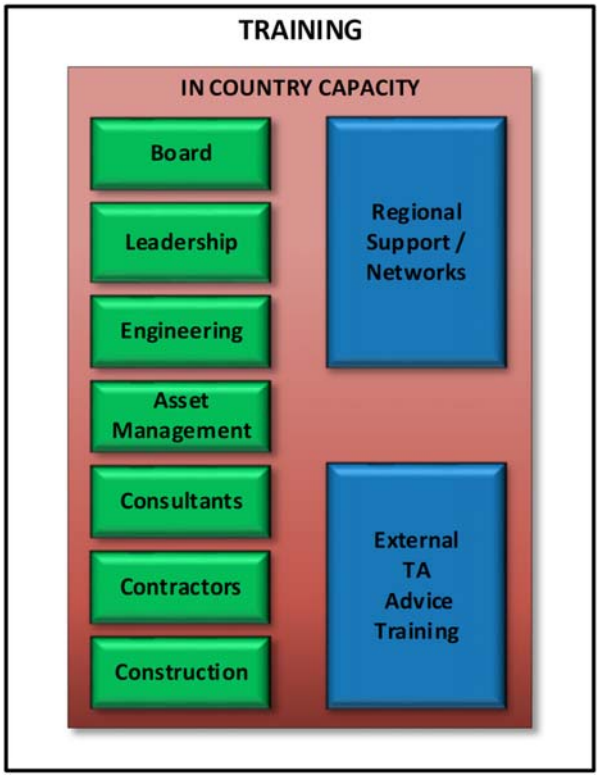
What is the most important thing in the world?
It is the people, it is the people, it is the people
Maori Proverb

It is increasingly recognised that we are facing a major Engineering skills shortage in NZ, but the reality is that this shortage is much wider than just engineering skills and is across the whole stack of skills needed to deliver public works services to our communities.

This is becoming a core issue of our ability to sustainably deliver public works service levels in NZ, hence my interest in the subject from a long-term sustainable asset management perspective.

The stack of skills is shown in the diagram below, drawn from my Master of Engineering (2018) research.

Figure 1: Training – Stack of Skills



2.1 Paper Methodology

The following methodology was used in the development of this paper

Compile Information

- Compile latest information from IPWEA, Future InTech, Engineers NZ, ACENZ, Water NZ, Contracting NZ etc. regarding the issues and current initiatives in place
- Review Australia IPWEA situation based on their 50% retired in ten years presentations that were made 10 years ago – current situation, and impact on Australasian marketplace
- Review Cebr (2016). Engineering and economic growth: a global view. Royal Academy of Engineering : London, UK and update as necessary from my Masters research

- Review NZ Govt Engineering Skills Shortage list information available
- Review Engineering training numbers and trends from Universities, Polytechs, NZIHT and Connexis to build current annual resource outputs and future projections
- Review Engineering and construction personnel retirement projections for NZ
- Review immigration numbers and projections for engineering and construction
- Review, collect and collate Council, CCO, Consultant training initiatives to determine the size and scope of these
- Participate in IPWEA South Island panel discussion 9th November and collate observations, questions and discussion on this subject
- Present at NAMS Advanced Forum on my Master of Engineering Research on this topic – collate questions and responses on topic

3.0 NZ INC OUTLOOK

Population 4,957,400

NZ Population 31 March 2019

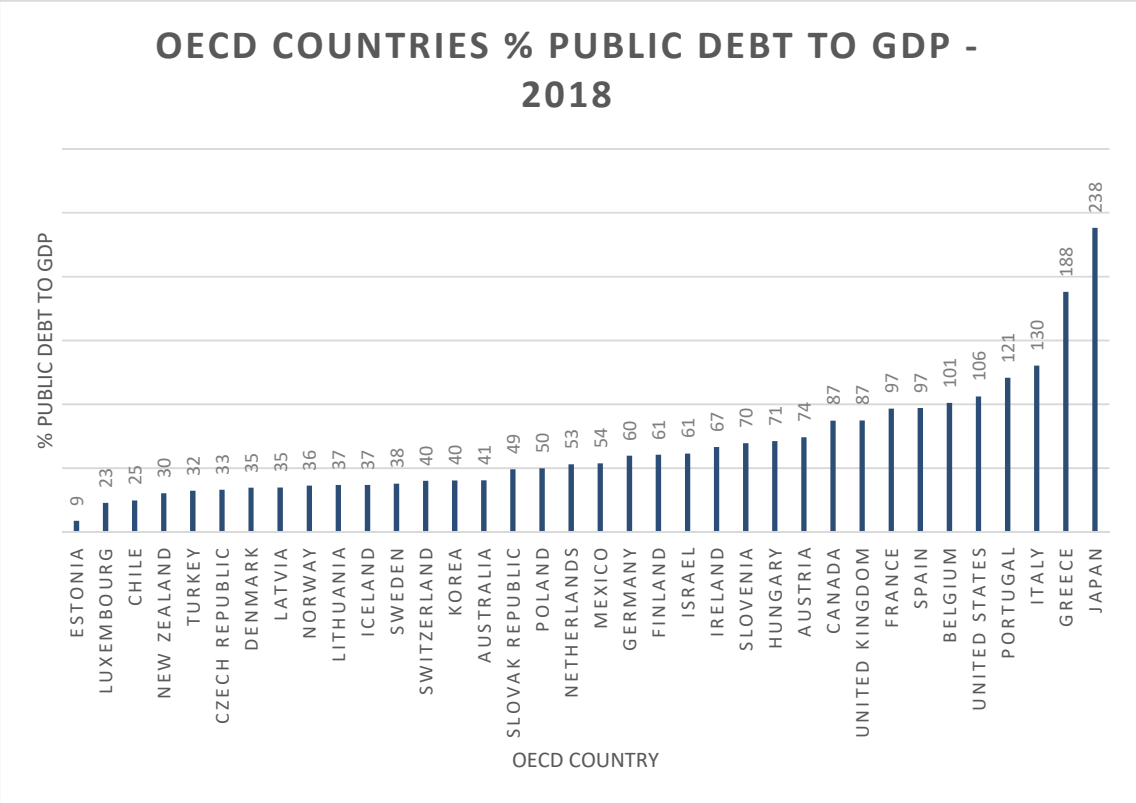
GDP $296 billion

NZ GDP, March 2019

3.1 Economics

The NZ Economy is in a relative 'sweet spot' for the next ten years with low debt, budget surplus (or break even), reasonable growth driven by agriculture, tourism and immigration, and the ability to pay for needed infrastructure.

Figure 2: OECD Countries % Public Debt to GDP - 2018



Note: Debt/GDP is an OECD calculation that shows NZ at 30%, this differs from the commonly used NZ figure of currently 20%.

5% or more reduction 2012-2018, less than 40% Public Debt to GDP in 2018.
New Zealand, Iceland, Czech Republic, Denmark.

http://www.oecd.org/about/membersandpartners/list-oecd-member-countries.htm
https://www.gfmag.com/global-data/economic-data/public-debt-percentage-gdp

The table below from the NZ Treasury long term fiscal projections report shows that NZ has expenditure constraints going forward, but that it is also in a relative 'sweet spot' over the next ten years.

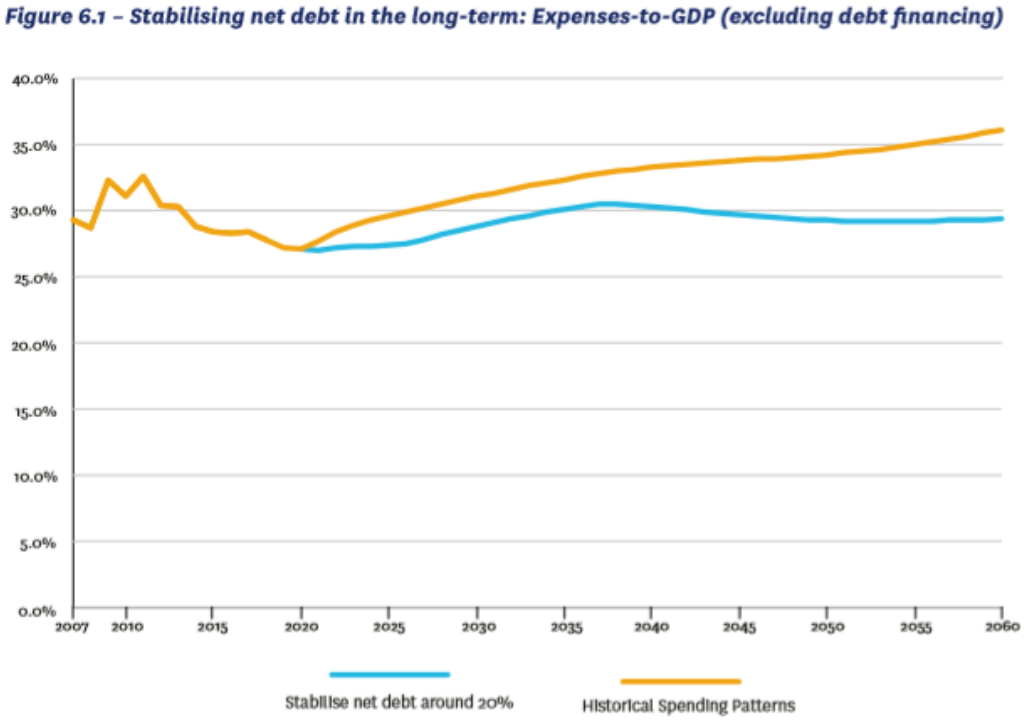
Figure 3: Projections for "Historical Spending Patterns" scenario (percent of GDP)

Table 6.1 – Projections for "Historical Spending Patterns" scenario (percent of GDP)

	2015	2030	2045	2060
Healthcare	6.2	6.8	8.3	9.7
New Zealand Superannuation (NZS)	4.8	6.3	7.2	7.9
Education	5.3	5.4	5.5	5.7
Law and order	1.5	1.4	1.4	1.4
Welfare (excluding NZS)	4.2	4.5	4.7	4.7
Other expenses	6.3	6.7	6.7	6.7
Debt-financing costs	1.6	2.2	5.3	11.0
Expenses	30.0	33.3	39.1	47.1
Tax revenue	27.6	28.6	28.6	28.6
Other revenue	2.3	2.4	2.4	2.5
Revenue	29.9	31.0	31.0	31.1
Operating balance	(0.1)	(2.3)	(8.1)	(16.0)
Primary expenses	28.4	31.1	33.8	36.1
Primary balance	0.5	(1.2)	(4.0)	(6.3)
Capital expenditure	0.7	0.9	1.0	1.0
Net debt	25.1	32.5	94.0	205.8
NZSF assets	12.2	21.0	25.1	31.7
Net debt incl NZSF	12.9	11.5	68.9	174.1
Net worth	13.8	16.1	(41.3)	(146.3)

Source: NZ Treasury Long Term Projections 2018

Figure 4: Stabilising Net Debt in the Long-Term: Expenses -to-GDP (excluding debt financing)



Source: NZ Treasury Long Term Projections 2018

NZ Borrowing Capability

Recent NZ Treasury analysis shows that NZ could prudently borrow up to 60% of GDP

- NZ currently has 20% of GDP loans
- A disaster 'insurance' buffer of 20% of GDP is required in the Treasury analysis
- This leaves 20% of GDP currently available for borrowing if required. With effectively $300 bn GDP this means that NZ can borrow $60 bn and still be within prudent limits

This issue is not the availability of money, as this short analysis shows, but rather the skilled resources needed to build infrastructure or provide services (for example health or education).

Figure 5: Tourism Today – Total Annual Tourism Expenditure

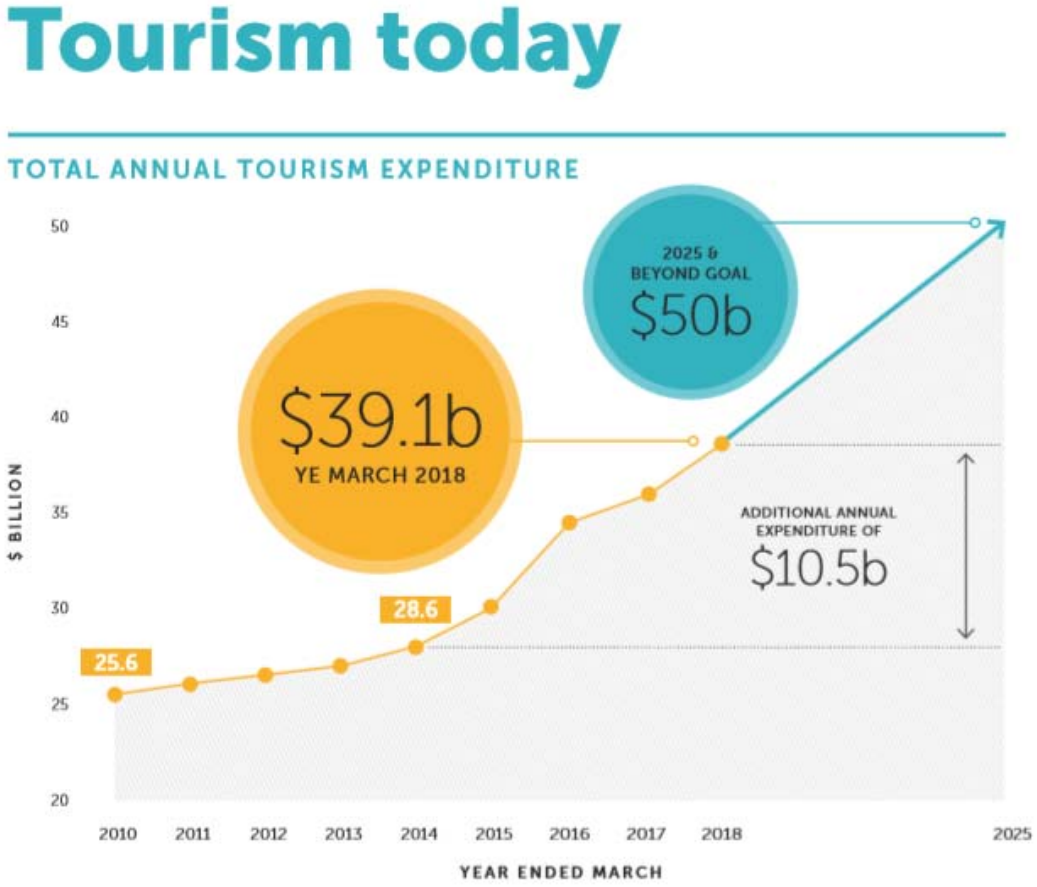
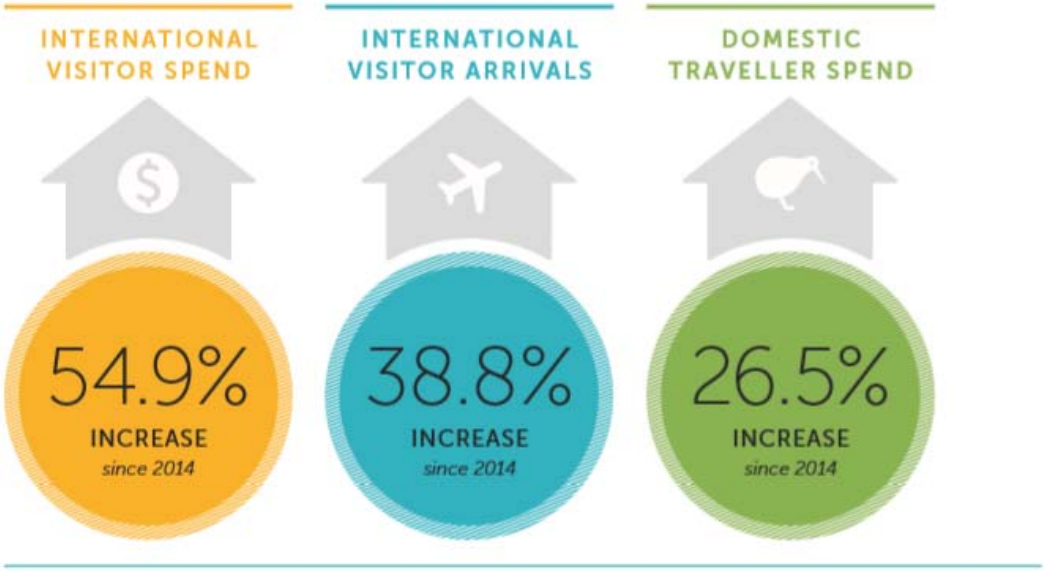


Figure 6: Tourism Today – International Visitor Spend & Arrivals, Domestic Traveller Spend



Continued tourism growth is projected over the next decade by NZ Tourism.

3.2 Population and Immigration

Figure 7: New Zealand Population Age Structure: 1972 - 2060

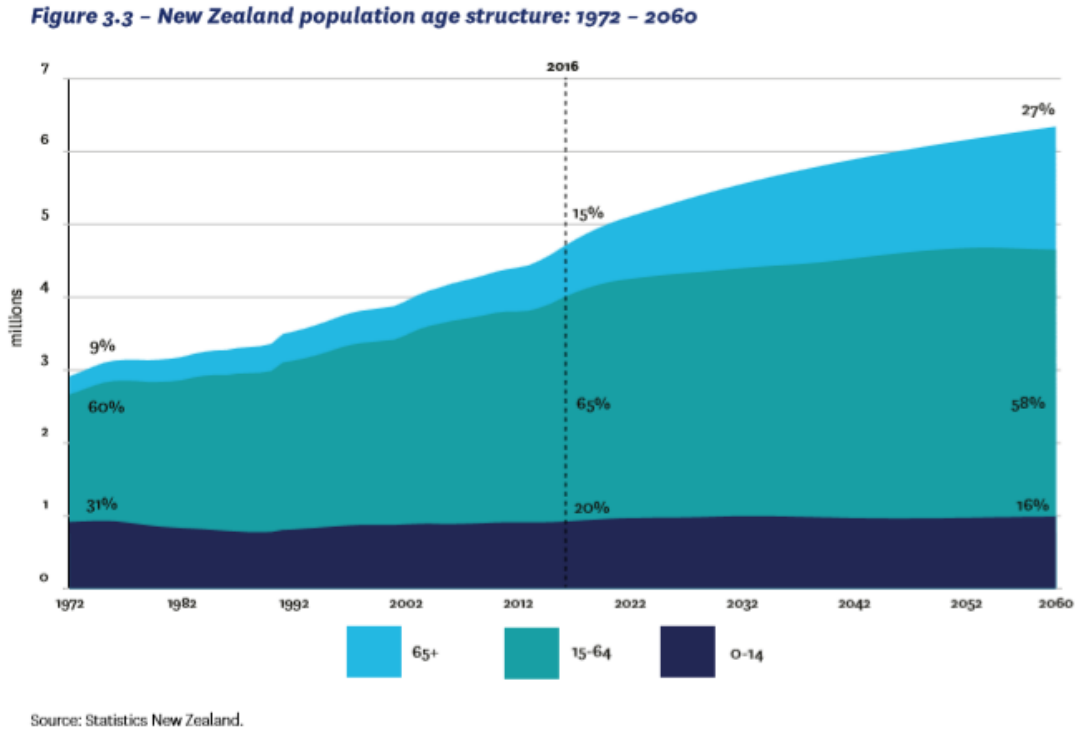


Figure 8: Migration Estimates (000) by Direction, Rolling Annual, Year Ended December 2001 to March 2019

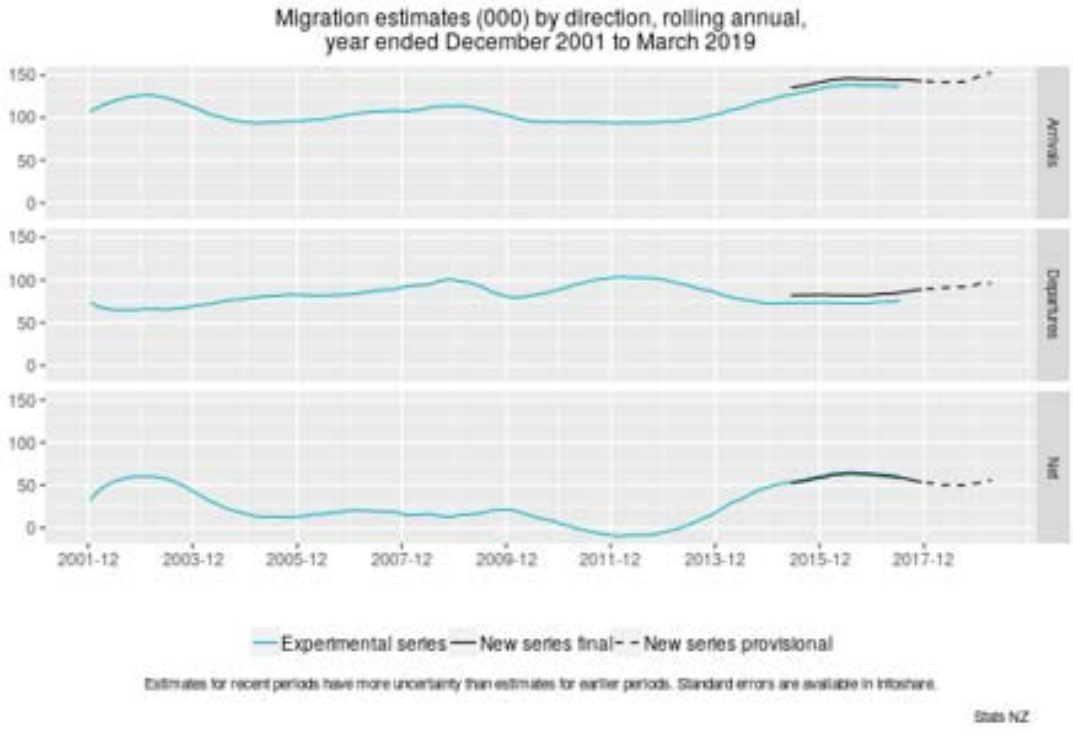


Figure 9: Annual Net Migration Inflow

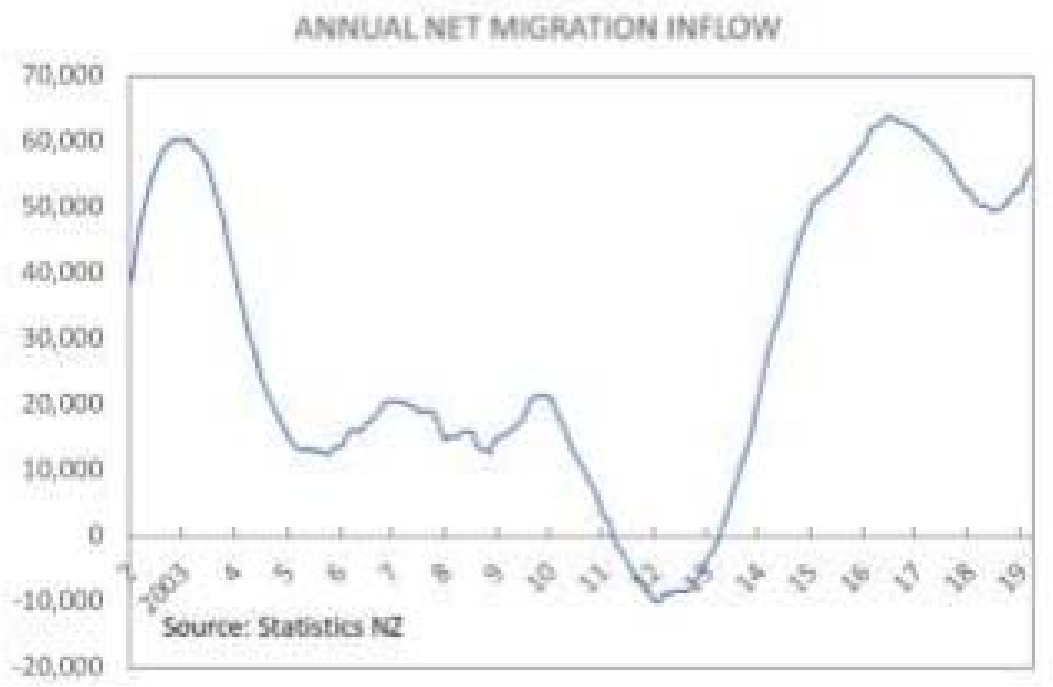
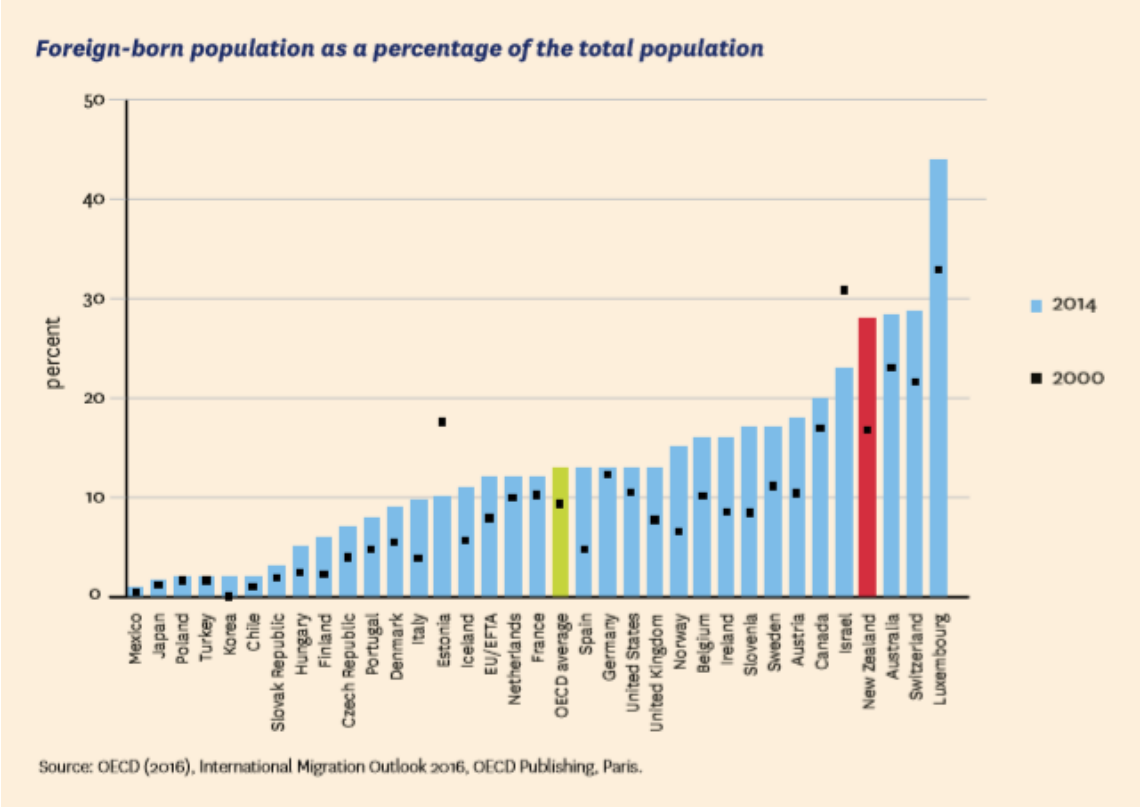


Figure 10: Foreign-born Population as a Percentage of the Total Population

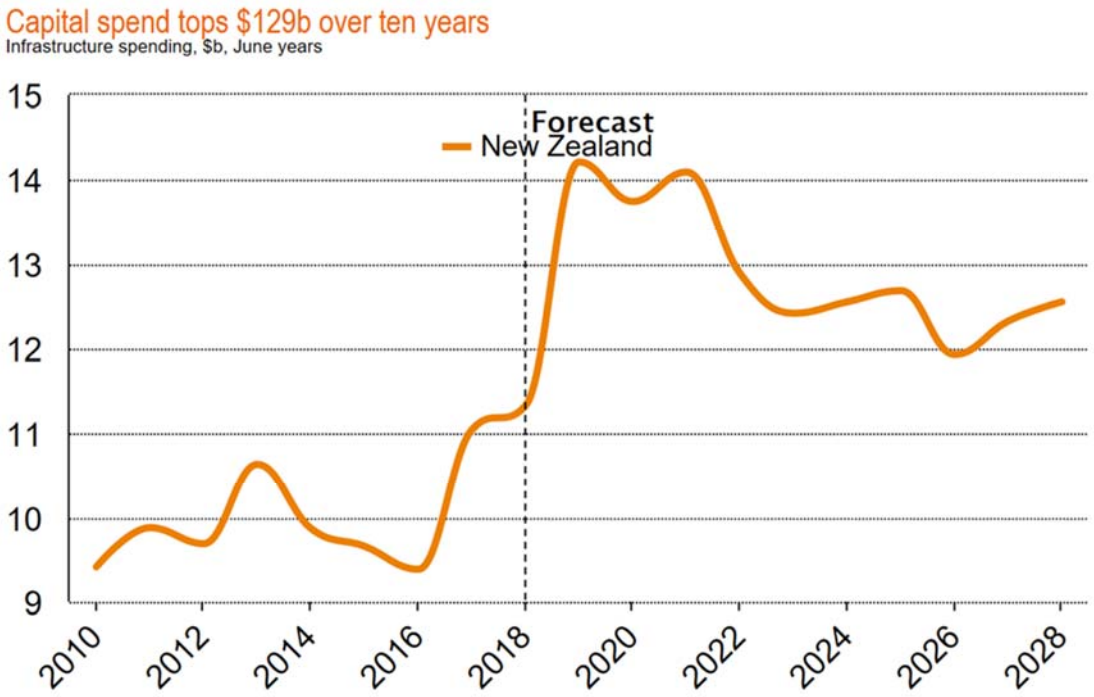


- Population 5M current projected to grow to 6M by about 2045

- 300,000 net immigration in last 6 years = 2X Hamilton CC in six years
- NZ and Australia have high levels of foreign born population as a % of total population (in relative international terms) but this seems to create relatively few issues in society

3.3 Capital Projects

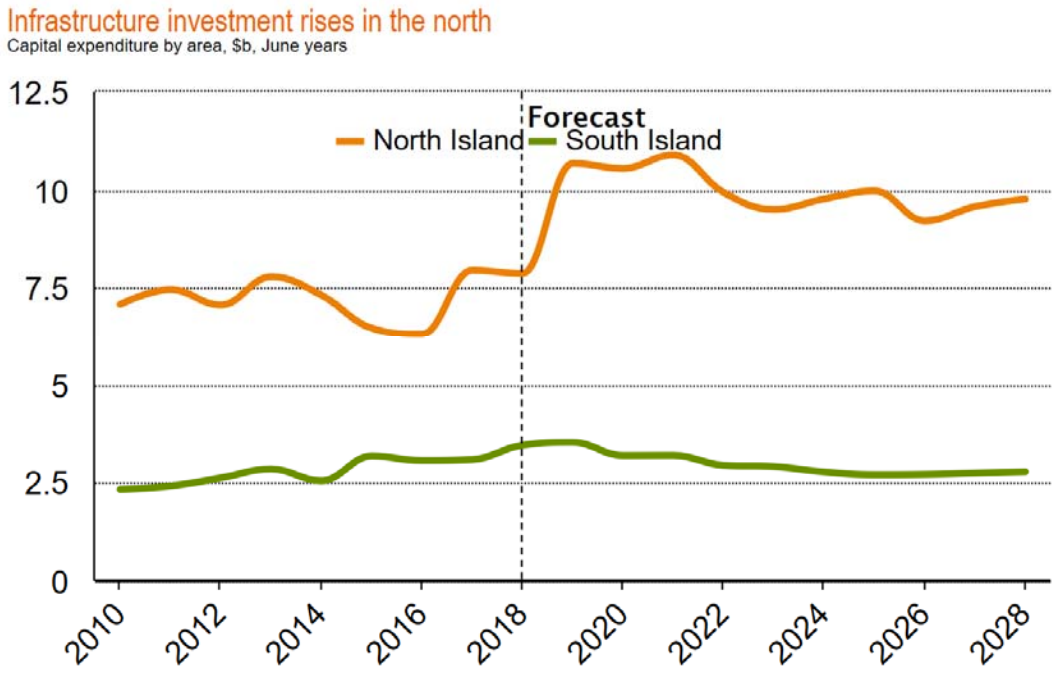
Figure 11: Capital Spend Tops $129b over Ten Years



Source: Infometrics
http://www.infometrics.co.nz/new-zealand-invest-129b-infrastructure-next-decade/

- $13 bn, year for next ten years
- Base 2010-2016 was approx. $10 bn / year
- Estimates show extra $4 bn per year for next ten years, almost all in the North Island

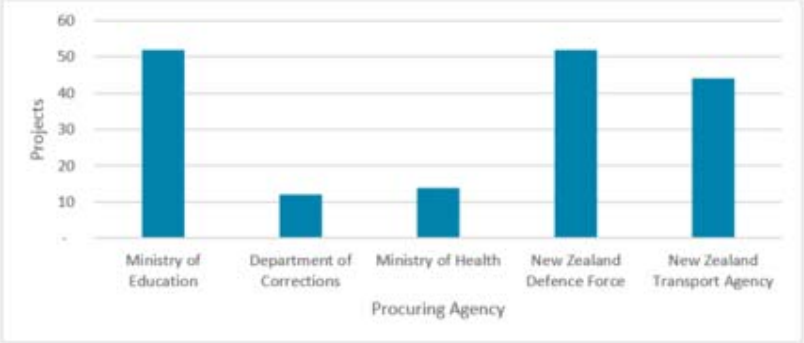
Figure 12: Infrastructure Investment Rises in the North



Source: Infometrics
http://www.infometrics.co.nz/new-zealand-invest-129b-infrastructure-next-decade/

Figure 13: Pipeline New Zealand Government

Large number of central government capital projects identified in pipeline.



Expand the table below

Agency	Number of projects in the pipeline
Department of Corrections	12 (7%)
Ministry of Education	52 (30%)
Ministry of Health	14 (8%)
New Zealand Defence Force	52 (30%)
New Zealand Transport Agency	44 (25%)
Total	**174 (100%)**

https://treasury.govt.nz/information-and-services/nz-economy/infrastructure/pipeline/analysis

3.4 NZ Inc Summary

- We can afford infrastructure for the foreseeable future
- Plenty of growth projected with supporting infrastructure needed
- Population 5M current projected to grow to 6M by about 2045
- 300,000 net immigration in last six years = 2X Hamilton CC in six years
- Tourism growth projected
- 13 bn per year capital projects for next ten years (4.4% GDP per annum)
- Constraint is the ability to build/construct - not finance or identified projects i.e. people with the right skills and experience

4.0 ADVANCE AUSTRALIA FAIR

Last Australia Recession was 1991 – 28 years ago. This coincided with the year that the last of the Berlin Wall was removed. The Australian economy is poised to grow steadily, and this will create more demand for engineers, operators and construction workers.

4.1 Australian Engineering Reports – the same issues observed

Engineers Australia and local government engineering in NZ have both recently released studies about the shortage of engineering resources. These are referenced below.

The 2017 'Engineers Make Things Happen' report outlines the need for an Engineering Pipeline Strategy that starts in the secondary schools.

Engineers Australia Media Release

https://www.engineersaustralia.org.au/News/media-release-new-report-shows-alarming-stem-skill-shortage-threatens-new-economy

Summary Report – Engineers Make Things Happen

https://www.engineersaustralia.org.au/sites/default/files/resource-files/2017-03/Engineers%20Make%20Things%20Happen%20-%20Summary.pdf

Full Report – Engineers Make Things Happen

https://www.engineersaustralia.org.au/sites/default/files/resources/Public%20Affairs/Engineers%20Make%20Things%20Happen.pdf

Local Government Skills Shortage

"The report reveals a workforce of 189,500 employees who are considerably older than the general Australian workforce and a sector confronted with declining levels of participation of workers under 30, a substantial a shortage of apprentices and a major skills shortage."

"Councils are facing a massive skills gap and falling behind on soft skills, according to the report, which revealed almost 70 per cent of local governments are facing a skills shortage and skills gap."

https://www.governmentnews.com.au/report-rings-alarm-bells-on-local-government-workforce/

To summarise the combined reports Australia is facing the following:

- Sustained need for more engineers across multiple sectors of Australian society
- Current requirements met mainly by immigrant engineers, with 57% of engineers born overseas from Australia (compared with 41% of other professions)
- 2006-2011 a 71% increase in the supply of engineers was from skilled migration – a large dependence on migrant engineers
- Developing internal engineering capacity requires STEM subjects being encouraged in secondary schools, which is becoming increasingly difficult as they are seen as 'hard' subjects

Australia's strategies to attract and retain enough engineers are:

- Continue to encourage skilled migration
- Further input and encouragement of school education in STEM subjects
- Workforce development

With the Australian local government analysis the following observations were made:

- The workforce is aging 54% above 45 years of age, and on average the local government workforce is older than the typical Australian workforce
- 69% of surveyed Councils are struggling to fill roles
- 60% of surveyed Councils had unmet training needs
- In rural and remote areas the issues of lack of skilled resources and small local talent pools were apparent

4.2 Trans-Tasman Market for Engineering Skills

Like New Zealand, Australia had a lot of infrastructure to build in the next decade – both new projects, and replacement of existing infrastructure that is coming to end of life. The State of Victoria alone is noted as having $100 Bn infrastructure development underway.

Victoria has a Skills shortage – Engineers, Electricians and a steel (materials) shortage as noted in the linked article below.

https://www.afr.com/business/infrastructure/infrastructure-boom-runs-short-of-engineers-electricians-and-steel-20190620-p51zrr

The skills shortage problems being experience in Australia are very similar to New Zealand.

The labour market for Engineering and Construction skills is Trans-Tasman, and therefore the shortages being experienced in Australia have potential to see increasing opportunities for skilled New Zealand staff to work in Australia.

This in turn has the potential to increase the level of the New Zealand engineering and construction skills shortage.

5.0 ENGINEERING FACTS AND PROJECTIONS

5.1 Engineering and Economic Growth

https://www.raeng.org.uk/publications/reports/engineering-and-economic-growth-a-global-view

Cebr (2016). Engineering and economic growth: a global view. Royal Academy of Engineering : London, UK

The following graphs and data have been taken from the 2016 Royal Academy of Engineering, London report 'Engineering and economic growth: a global view'.

The Cebr report compiles an Engineering Index. The table below shows the New Zealand Engineering Index results compared to the top 20 countries. This table suggests that New Zealand is significantly under investing in Engineering, when compared with peer countries, and that this will have long term impacts on New Zealand's infrastructure and economic performance.

Figure 14: Engineering Index and Component Scores for the Top 20 Countries

Table A.1: Engineering Index and component scores for the top 20 countries

		Engineering Index component								
Country	Engineering Index score	Research	Gender balance	Engineering employment	Wages and salaries	Engineering businesses	Human capital	Infrastructure quality	Digital connectivity	Engineering exports
Sweden	**75%**	64%	56%	100%	67%	100%	64%	77%	91%	46%
Denmark	**75%**	50%	73%	100%	81%	32%	63%	84%	100%	30%
Netherlands	**75%**	64%	32%	100%	80%	68%	42%	94%	100%	67%
Germany	**74%**	93%	71%	75%	79%	38%	56%	84%	76%	67%
Japan	**72%**	79%	9%	100%	82%	70%	62%	91%	63%	76%
Switzerland	**71%**	57%	13%	100%	64%	30%	60%	100%	100%	58%
Australia	**70%**	93%	34%	59%	100%	56%	60%	61%	83%	56%
Hong Kong	**69%**	72%	70%	50%	78%	70%	70%	96%	59%	62%
Norway	**66%**	0%	29%	100%	100%	64%	42%	65%	100%	58%
Austria	**66%**	50%	33%	74%	77%	52%	63%	88%	77%	57%
Finland	**65%**	0%	35%	95%	61%	42%	84%	92%	95%	52%
Belgium	**64%**	50%	34%	63%	89%	59%	54%	73%	63%	88%
Republic of Korea	**63%**	79%	41%	22%	55%	42%	100%	77%	100%	69%
United Kingdom	**63%**	100%	36%	36%	73%	35%	54%	71%	81%	47%
France	**61%**	57%	45%	62%	67%	35%	71%	86%	54%	50%
Singapore	**61%**	57%	61%	54%	49%	61%	61%	96%	58%	53%
United States	**60%**	100%	27%	22%	100%	0%	42%	82%	85%	43%
Luxembourg	**60%**	0%	35%	100%	80%	64%	21%	78%	100%	0%
Italy	**57%**	50%	85%	43%	68%	90%	43%	43%	42%	66%
Slovenia	**56%**	0%	42%	76%	50%	90%	74%	61%	56%	81%
New Zealand	**42%**	0%	51%	50%	37%	39%	52%	63%	78%	5%

Source: Cebr analysis

The following two figures show the top 20 countries by the percentage of engineering, manufacturing and construction students. The UK is shown for comparison. It is noted that NZ is well below UK levels.

Figure 15: Top 20 Countries by the Percentage of Students in the Tertiary Education Enrolled in Engineering, manufacturing and Construction Programmes

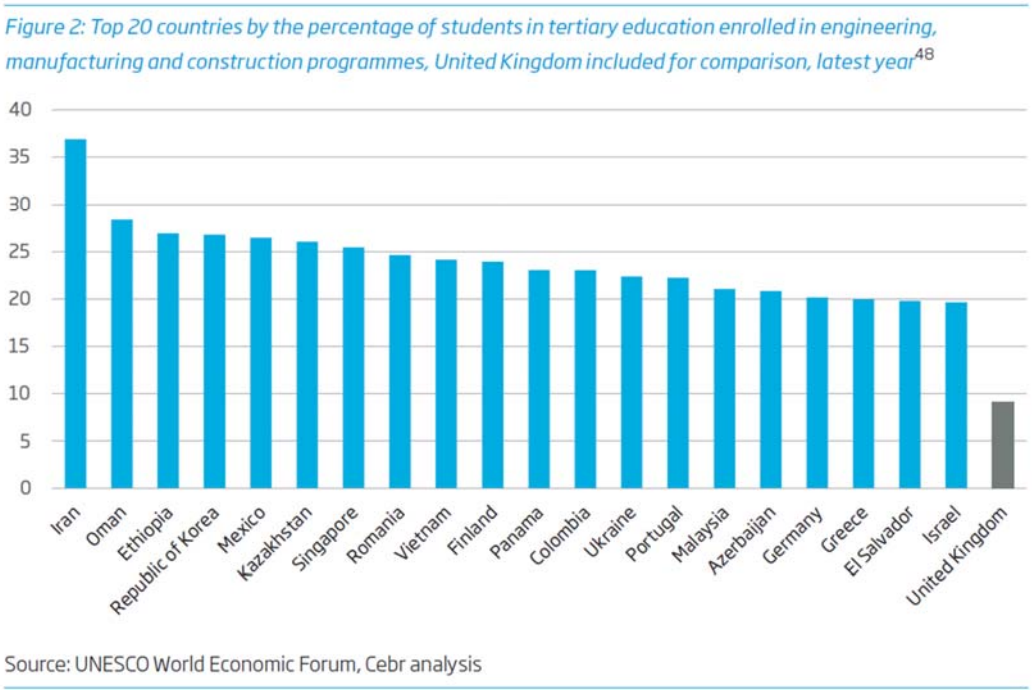
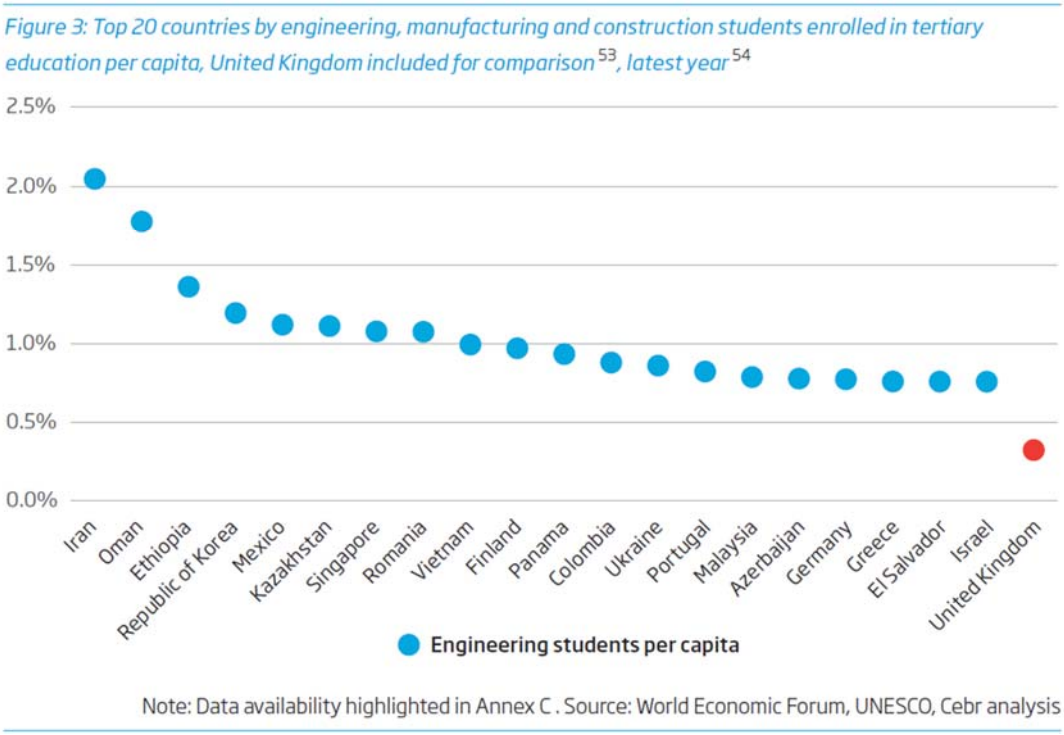
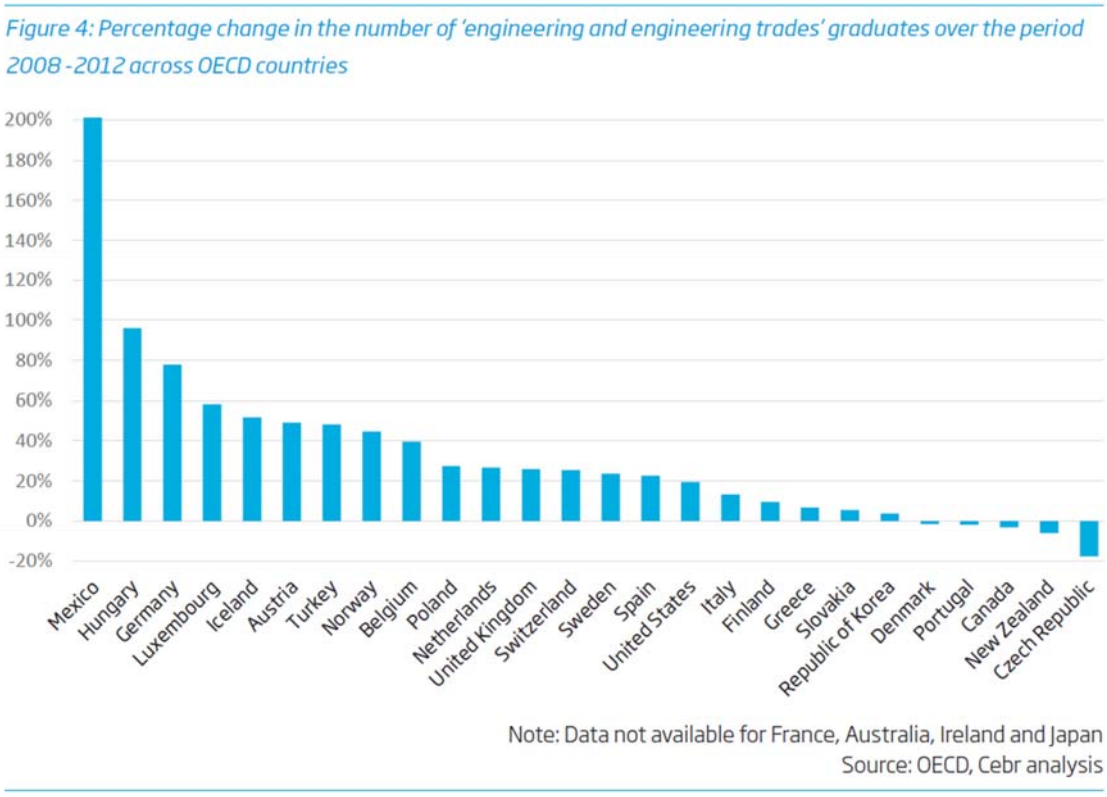


Figure 16: Top 20 Countries by Engineering, Manufacturing and Construction Students Enrolled in Tertiary Education per Capita



The following figure shows percentage change in 'engineering and engineering trades' graduates during the period 2008-2012. Whilst many peer countries show significant increases in this period, NZ decreased, which is adding to the industry skills shortage problems.

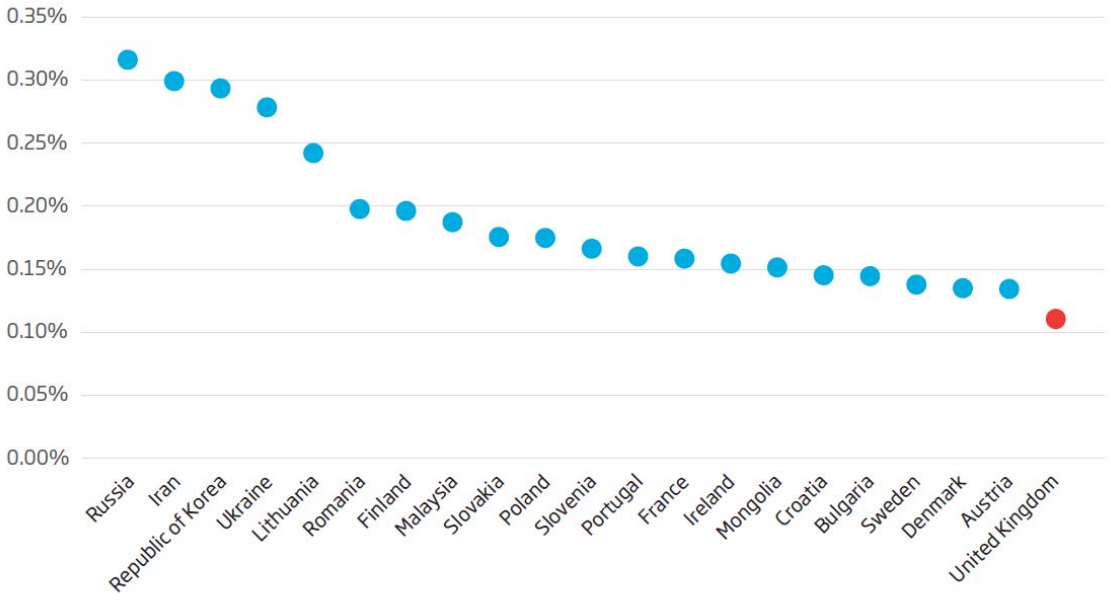
Figure 17: Percentage Change in the Number of "Engineering and Engineering Trades" Graduates over the Period 2008-2012 OECD Countries



The figure below shoes the top 20 countries for graduates per capita. NZ is not in the top 20.

Figure 18: Top 20 Countries by Engineering, Manufacturing and Construction Graduates per Capita (United Kingdom included for comparison (latest year)

Figure 5: Top 20 countries by engineering, manufacturing and construction graduates per capita, United Kingdom included for comparison,[61] latest year[62]

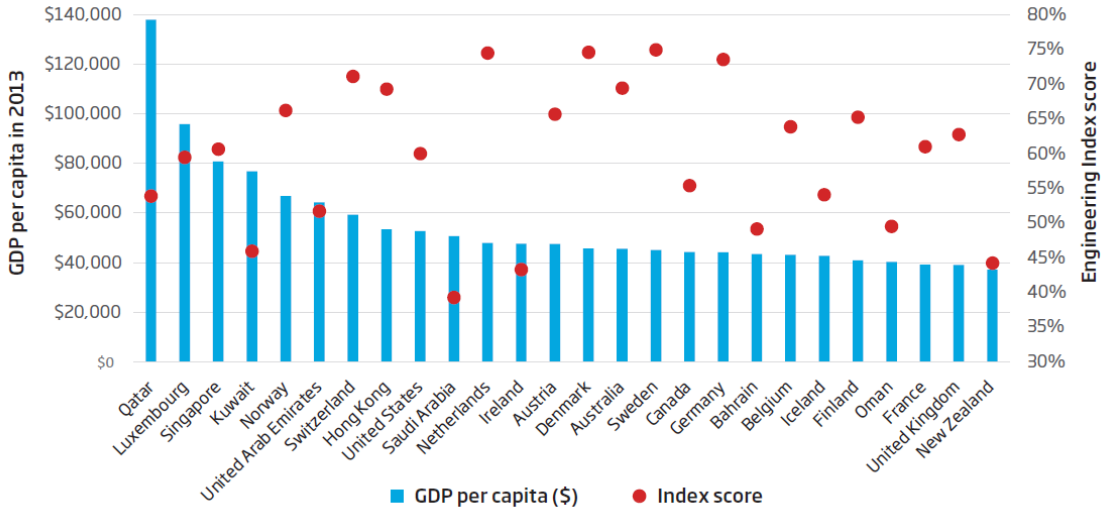


Note: Data availability highlighted in Annex C
Source: UNESCO World Economic Forum, Cebr analysis

NZ shows in this figure, but Engineering Index is low for relative GDP.

Figure 19: Highest Ranked countries by GDP Per Capita (International $PPP Terms, LHS) and Engineering Index Score (RHS)

Figure 23: Highest-ranked countries by GDP per capita (international $ PPP terms, LHS) and Engineering Index score (RHS)



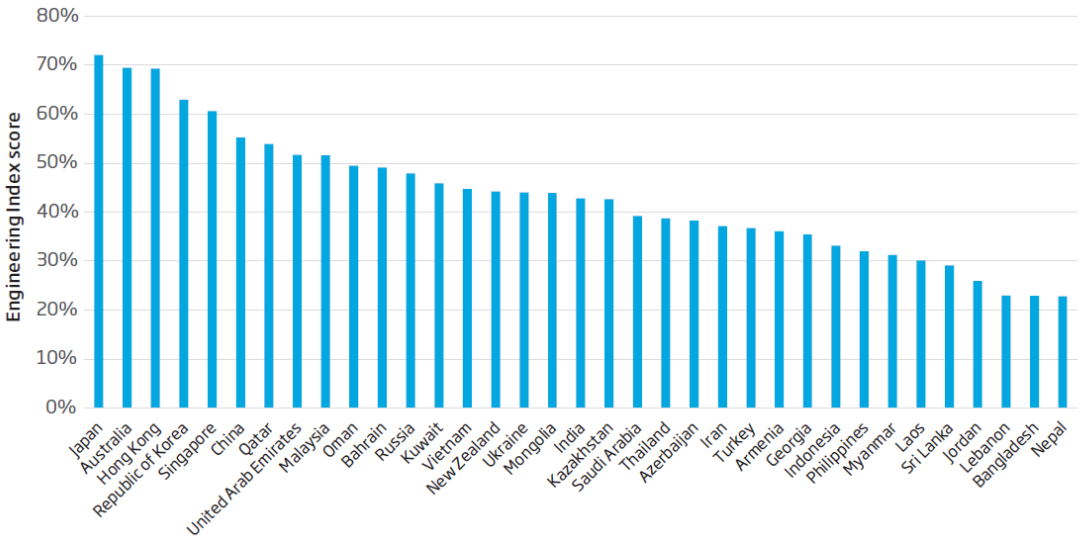
Source: Cebr analysis.

Note: Qatar GDP per capita for 2013 was $138,067 and for presentation is capped within the chart.

NZ Engineering Index score is middle of the range, but well below peer countries.

Figure 20: Engineering Index Scores by Country: Asia and Oceania

Figure 25: Engineering Index scores by country: Asia and Oceania



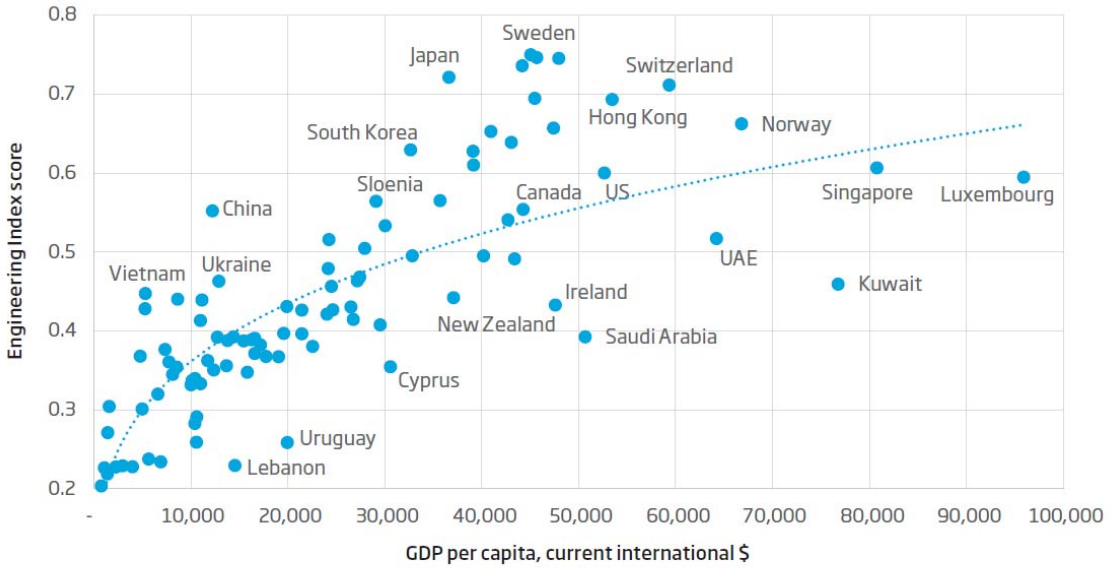
Source: Cebr analysis

The following two figures show the correlation between GDP and GFCF (net increase in physical assets in a period) and the Engineering Index. It can be noted in both correlations that NZ is well below the average, and peer countries.

This suggests a sustained investment in engineering in NZ is required.

Figure 21: Correlation Between GDP Per Capita and the Engineering Index

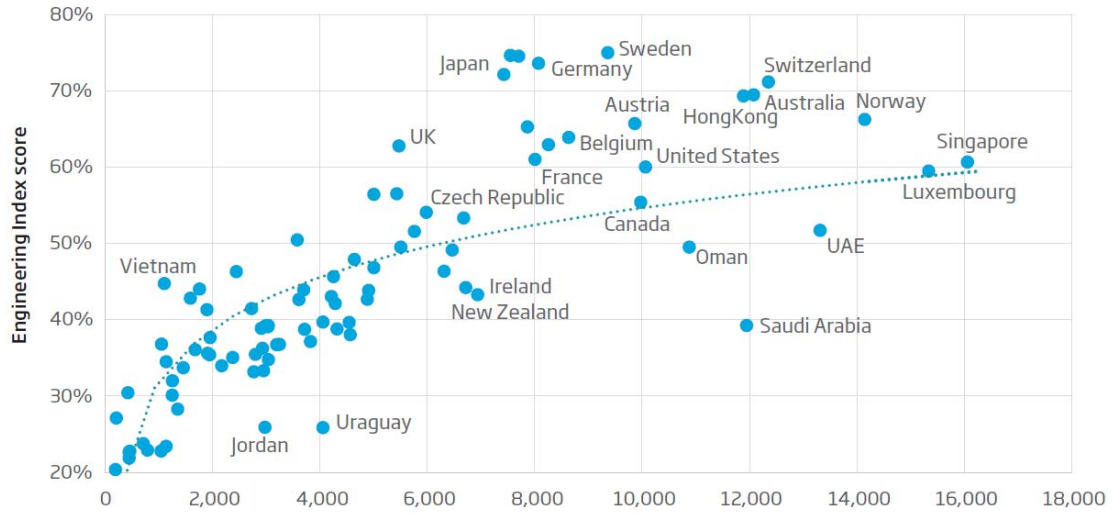
Figure 28: Correlation between GDP per capita and the Engineering Index



Source: The World Bank, Cebr analysis

Figure 22: Correlation Between GFCF Per Capita and the Engineering Index

Figure 28: Correlation between GFCF per capita and the Engineering Index



Source: The World Bank, Cebr analysis

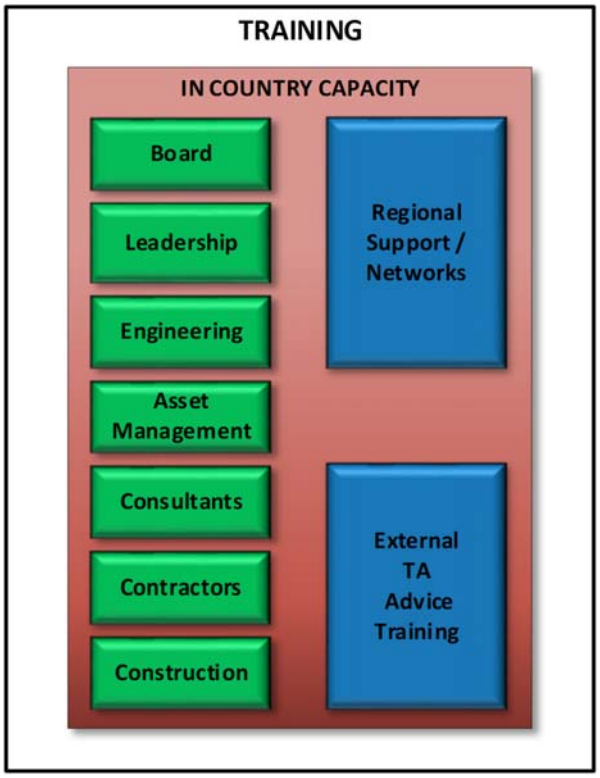
The data presented from the 2016 Cebr report raises a number of issues for NZ and indicates the comparative weakness of our engineering skill base.

Countries with a high percentage of Engineering graduates offer suggestions for likely sources of skilled engineering migrants, although the report notes the overall shortage of engineers worldwide, and NZ can note the fact we are completing for skilled resources with Australia, Canada and the UK.

6.0 RESEARCH INSIGHTS AND OBSERVATIONS

6.1 Master of Engineering Research Insight

Figure 23: Training – In Country Capacity



One of the findings of my 2018 Master of Engineering thesis on 'Asset Management for Developing Countries' was that through the entire stack of roles shown in the figure above, there was much turn-over of staff and resources, and a need for constant training to maintain skills and resources.

The underlying reason for this was small skill/resource bases and that much of the work in developing countries was project based, with skills/resources moving with projects.

When I reflected on this research finding, it seemed from my experience, and New Zealand industry observations, that New Zealand in fact had many of the same issues as developing countries.

Whilst I had known for some time that New Zealand had an Engineering skills shortage, this idea that this skills shortage extended throughout the service delivery stack seemed probable but needing some further investigation and research.

The investigation of this observation has led to this paper and keynote.

6.2 IPWEA Northern SI Meeting Responses (November 2018)

To test this I presented on the subject at the 2018 NAMS Forum, and also the November 2018 Northern South Island IPWEA Branch Meeting.

The Northern SI Branch Meeting involved a presentation, and working groups to discuss the information presented, and possible solutions. The observations from four working groups this Branch Meeting are recorded below:

- Extended retirement, flexible retirement and career breaks need to be catered for
- How to keep people, and keep people current with industry changes
- Mix of old/young people and diverse backgrounds is important
- How to maintain skills, retraining – who pays for this
- More global philosophy needed to gain/keep people in Engineering
- How to advance career paths – technical verses management
- Strong role models are needed in the industry – how to promote this
- Use of new technologies drones, AI, treatment plant automation all occurring, but still need people – just with different skill sets
- Procurement needs to adjust, be more flexible and adaptive
- Engineering apprenticeships are an exciting development
- Need to attract young people into the profession, including the ability to retrain, and widening the funnel of candidates
- Major cadet employers vanished in the 1980s/1990s and haven't been replaced in the current structures. Very hard for smaller councils, organisations to train cadets
- More flexible working arrangements including use of secondments need to be in place, but how does this work in practice
- Workforce changes – how to retrain staff, need for more flexible working arrangements to accommodate families etc. and widen potential workforce
- Keeping in touch with people who move or leave can be important for future recruitment
- Mentoring internal and external is needed across the industry to ensure the transfer of knowledge and skills
- STEM – there is a need to educate teachers and career advisors about industry opportunities, careers and requirements
- Future-in-Tech are we doing enough? Probably not
- High School Students – can we have open days, shadowing people in the sector to assist recruitment
- Not just professional engineers – the issues being observed include technicians, operators, contractors
- Some technology solutions will assist in solving these issues, but not all of them
- Local Government – how to attract people to work in local government
- Local Government – Elected members, how to educate about the skills issues, and involve in the decision making around this

Several Questions were raised during the Branch Meeting working groups as follows:

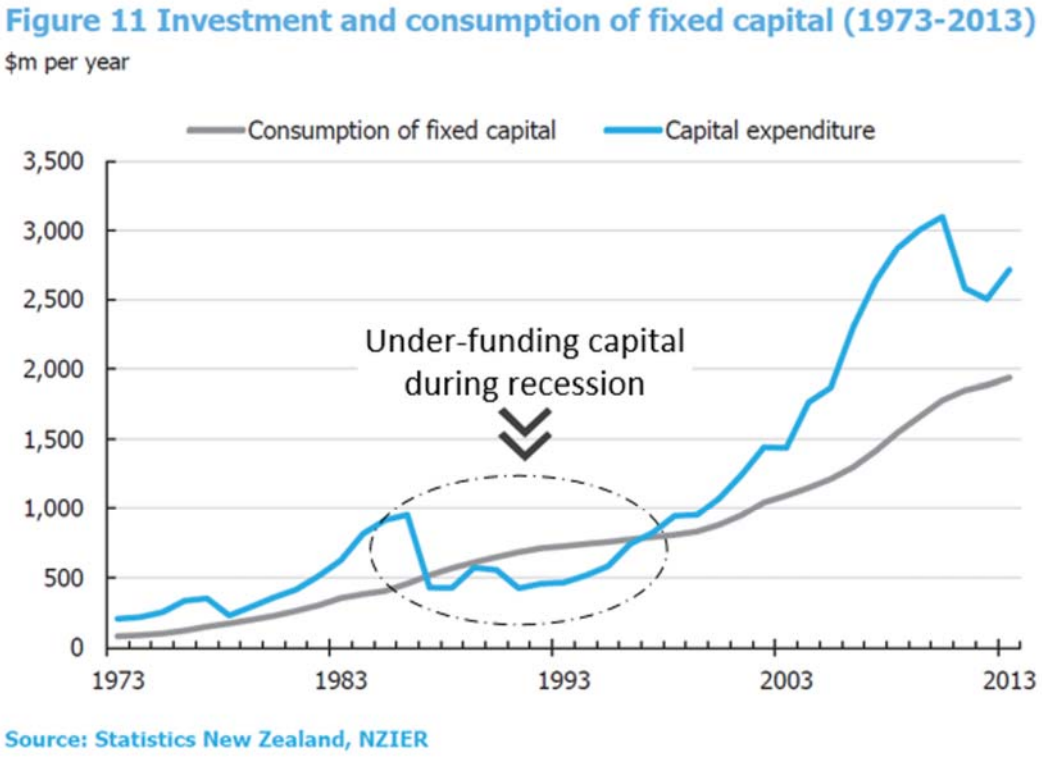
- Do we need wider diversity in our industry?
- Is Engineering too narrow?
- Should wider skills be promoted?
- Are we open to related sciences being employed – how to arrange bridge training?
- Can secondment programmes be used to provide wider experience?
- Graduates need team leaders and mentors - how can this be effectively arranged?
- How to help immigrants to quick gain the required NZ communication and systems knowledge skills
- There are a range of skills shortages – design verses project management – how to effectively identify and meet specific skills shortages?

The need for employers and employees to be flexible and adaptable was noted as we move forward to resolve the issues identified.

7.0 PROCUREMENT AND SUPPLY CHAINS

7.1 Impacts of the 1987-1993 Recession

Figure 24: Investment and Consumption of Fixed Capital (1973-2013)



New Zealand suffered a major recession during the period 1987-1993. During this period structural changes to the New Zealand economy were made.

These changes included the formation of SOE's, the drive for efficiency in procurement though contracting work, and wide-ranging changes in training arrangements within the economy.

At the height of the recession NZ had 12% true unemployment across the economy, and across all sectors of the economy.

With surplus labour available, a major need to make the economy more efficient apparent, and many New Zealander's moving to Australia for work and opportunities, the need to train staff wasn't there, and many of the government organisations that had previously provided sector wide training were dis-established.

The logical, and short-term gains from these decisions have led to the longer-term skills sustainability issues that are currently being faced.

7.2 Training Responsibility Shifted

Prior to 1987 training was undertaken across the economy by the service delivery government departments and local authorities. During the period of the 1987-1993 Recession this model of training largely ceased, and the current training model of students paying for their own training was implemented.

There have been notable exceptions to the new model, for example the Opus Cadetships, but these have been minor in the context of the total Engineering market.

The model currently deployed has not delivered enough Engineers over the past 20 years, and like Australia, New Zealand has been heavily dependent of immigrant Engineers.

With the approaching 'baby boom' retirement wave through to 2035, coupled with an economy and population that is growing steadily, is exposing the broad shortage of engineers and construction staff in the New Zealand economy.

It is clear that a different approach to training and skill development is required which will incorporate the learning of the past 30 years:

- Cadetships
- Scholarships
- Internships
- Engineering Apprenticeships
- Wide ranging industry support for people entering engineering and construction
- Salary and wage structures to support long term retention of staff
- In service training throughout careers
- Transition training for non-engineering STEM staff transitioning into the sector
- Multiple pathways of learning, accreditation and career progression

7.3 Procurement and Supply Chain Assumptions are not Valid

Similar to the change in training practices, procurement and supply chain practices also changed during the 1987-1993 NZ Recession, with the widespread adoption of contracting out services – professional and construction.

Due to the lack of work in the economy, contracting and consulting work packages were keenly completed for, with multiple tenders received, and ongoing innovation and efficiency delivered in the sector.

These procurement and supply change practices were appropriate for the economy during and immediately following a major recession. The 2008 GFC, whilst nowhere near as severe for the NZ economy as the 1987-1993 NZ Recession produced many of the same behaviours.

With major skills shortages now becoming apparent in engineering and construction marketplace in New Zealand, the procurement and supply change assumptions and practices adopted in the early 1990's are no longer valid.

This is already showing up in NZ local government procurement, where increasingly I am hearing from clients of tenders they are letting that attract only one bid.

There is significant potential as the skills shortage increases that local authorities will release tenders to market that attract no bids, simply because the market has no capacity to respond.

This suggests that 1990's era practices need to be reengineered for current realities, which are far more likely to require long term, total supply chain management collaborative relationships, that include skills development throughout the period of the relationship.

7.4 Re-engineering Supply Chains for the next 20 years

David Langford, New Plymouth District Council has already done some excellent thinking on this subject, and presented on it at the March 2019 RIMS Conference in Dunedin. The link to David's paper is provided below:

https://www.ipwea.org/newzealand/bookshop/ourlibrary?defaultview=folder&libraryfolderkey=e6bc10c6-2bb7-4767-bb23-ddb30b3fff9f

The main points David made were:

- We need to achieve supply chain leadership in procuring services
- 'Lowest price conforming' is a race to the bottom, and does not provide long term sustainability of services
- Due to 20+ years pf 'lowest price conforming' procurement our industry has a skills problem and has a low skilled workforce
- We need to rethink our contract design, duration, required outcomes and long-term sustainability
- Workforce capability planning is required
- We need to build and sustain talent pipelines
- We need to apply supply chain management thinking and techniques to talent management
- Talent management and pipeline development requires collaboration

I would encourage readers of this paper to access David's paper and look at the points he is raising.

Our current procurement and supply chain management practice is not 'fit for purpose' in a long-term skills short environment.

An outcome of this analysis is that we will have to reengineer this area of practice to continue be able to continue to deliver sustainable services to our communities.

Part of this reengineering will need to engage with communities about why services are costing more, and why they will continue to cost more for a long time into the future.

David Langford has already experienced this in New Plymouth as he has sought to develop and implement sustainable supply chains.

8.0 SKILLS SHORTAGE NZ ENGINEERING INDUSTRY

8.1 Risks and Issues with a Skills Shortage

The skills shortage brings a number of risks and issues that can impact if insufficient skills are applied to engineering design, project management and asset management. Potential impacts are:

- Quality of planning and design
- Quality of workmanship
- Risks implicit with a skills shortage – insufficient or inexperienced resources contain their own risks in terms of the adequacy and sustainability of service delivery
- Impacts on the sustainability of service delivery
- Long term cost implications for service delivery

8.2 Governance and Management

Governance and management skills are important with regard to asset management and the delivery of services, as these provide the policy framework, financial parameters, and organisational direction setting.

Where there is a lack of knowledge, or lack of appreciation of the risks and issues associated with asset management and service delivery this provides the potential for less than optimal decision making.

Governance training and support is broadly provided by LGNZ, although there is still much work to be done on asset management and service delivery training for elected representatives.

Management training and support is provided by SOLGM. With the rotation of senior managers in the sector this are ongoing training requirements to ensure senior managers are provided with good understanding of asset management and service delivery risks, issues and associated financial implications.

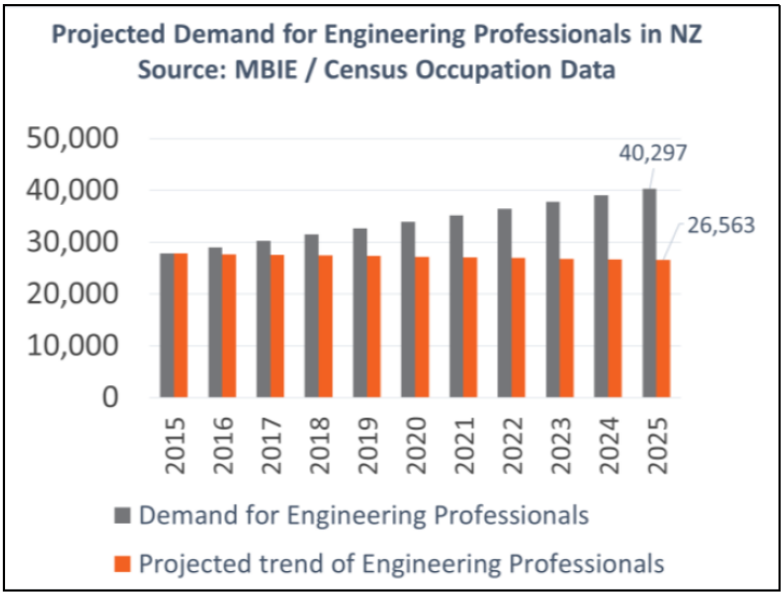
8.3 Engineering and Asset Management

The Engineering and asset management skills shortage is well documented, with ongoing input from Engineering NZ and IPWEA NZ.

MBIE has produced the analysis shown in the figure below, which shows a shortage of 14,000 total engineers in the sector by 2025. This is 50% short based on current projected trends.

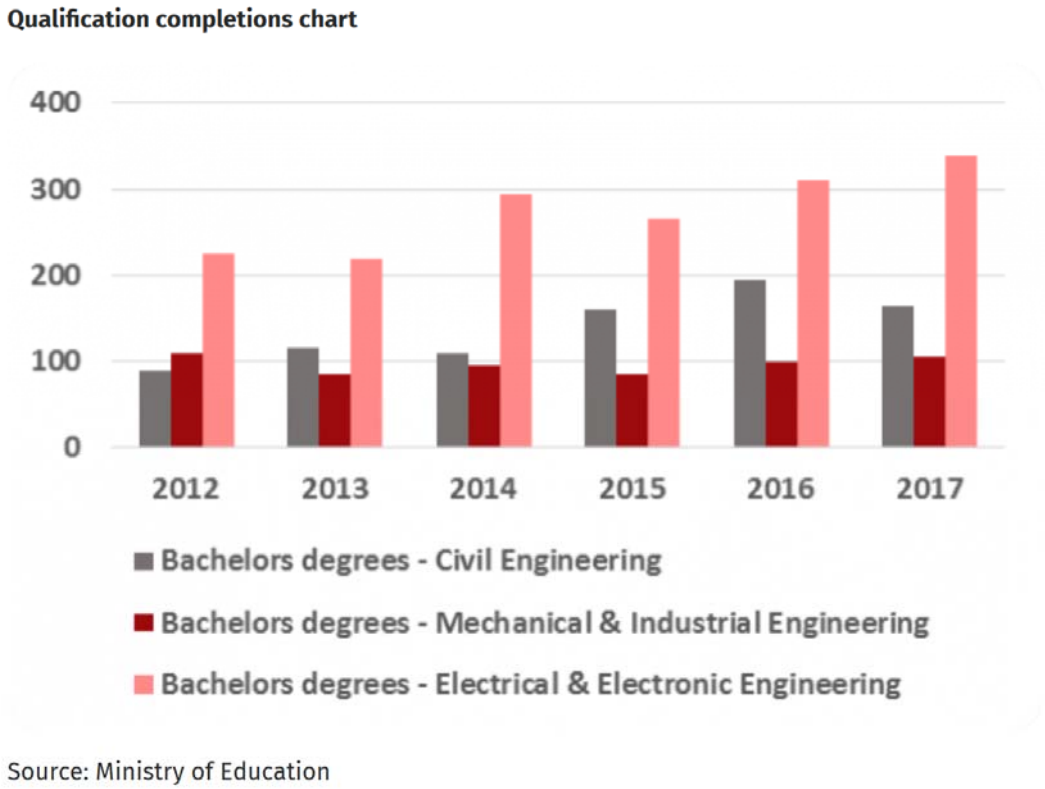
These figures were prepared a few years ago, and since then additional large capital projects have been added to the project pool, which indicates that the numbers presented below may be on the light side – i.e. the gap may be bigger.

Figure 25: Projected Demand for Engineering Professionals in NZ



Examining the total engineering completions of approximately 600 per year, that provides 3,600 additional engineers by 2025, with the projected shortfall being 14,000. The figures for civil engineering are approximately 200 per year, or 1,200 by 2025 – assuming that everyone stays and works in NZ.

Figure 26: Qualification Completions Chart



Source: Ministry of Education

Clearly, based on this data, we need to find approximately 10,000 to 11,000 additional engineers by 2025 over and above university completions.

The issue is compounded by the rapidly aging local government work force, as shown in the figure below. Other sectors of the economy such as education have similar aged workforce profiles, but local government is at the higher end on percentage 50+ (at 40%).

Figure 27: Workforce Age Breakdown

1. **What is the age profile of workers in Councils? How does this compare to the average age profile for organisations in NZ What about different industries? i.e. is this a unique problem to local government that may suggest it is not attractive?**

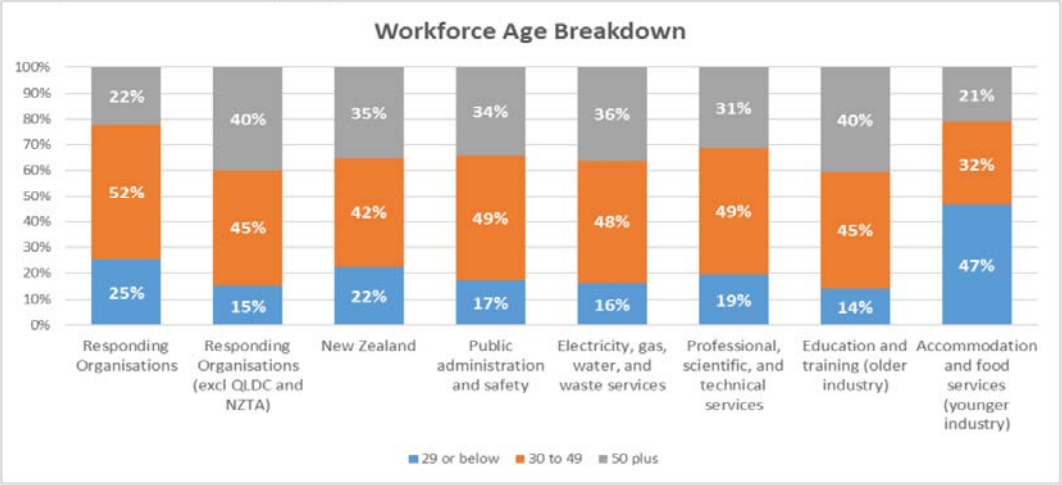
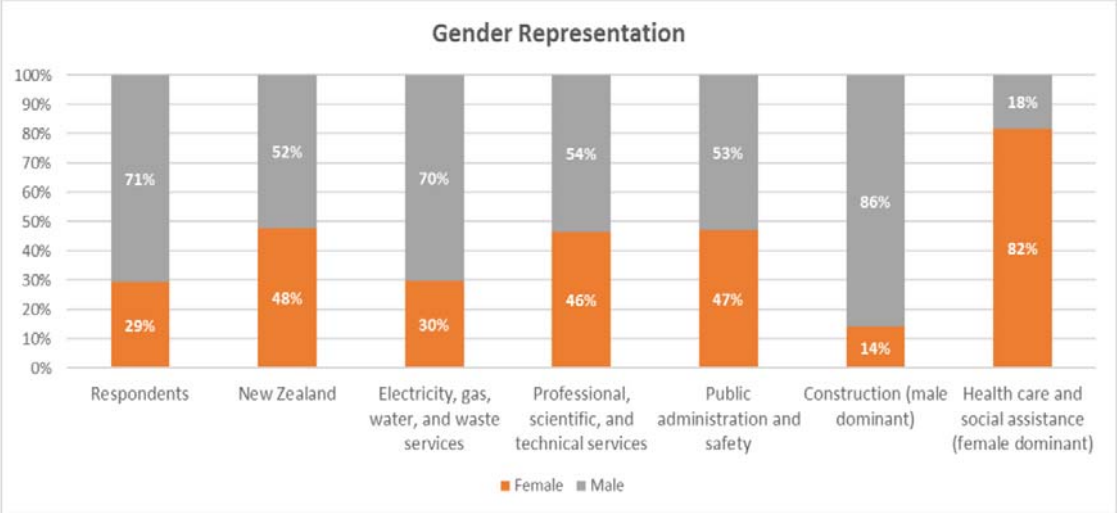


Figure 28: Gender Representation



Females are underrepresented in the industry relative to New Zealand and similar industries.

One in six public works professionals are women, and attracting women to the profession is part of the solution mix.

A key statistic is that one in three public works professionals will be at retirement age in the next 15 years. For provincial authorities that rises to one in two (half).

8.4 Operators – Machinery

As part of the research and preparation for this I discussed the issues associated with machinery operator training and retention with both Downers and Fulton Hogan and would like to acknowledge their openness and willingness to discuss these issues.

As companies at the construction end of the industry, but also employing engineers for design and project management their insights were interesting.

Attracting and retaining staff with the right skills is an ongoing issue for both companies, and they are competing across the board in a very skills short marketplace.

Machinery Operator training is mostly on-the-job and has a range of challenges around both health and safety, and the rapidly changing nature of machinery. The way contracts are currently structured there is no space or downtime for on-the-job learning opportunities.

Different skills are needed compared with a few years back, as machinery becomes technology oriented, and required a wider range of skills and competencies.

Literacy and numeracy skills remain an issue in the industry, especially with 'second chance' workers.

Capturing staff knowledge, skills and techniques is acknowledged as a challenging issue, particularly with an aging workforce with many skilled machinery operators nearing retirement.

Fulton Hogan are attempting to address this internally with the development of best practice guides, based on interaction and feedback from experienced staff.

Both firms are working with arrange of government departments to provide employment programmes for Maori staff, and also 'second chance' workers. These programmes have a range of training challenges.

It was noted that staff retention in the construction end of the industry remains a huge issue, with two years quoted as an average duration of employment in some areas.

Both firms are continuing to adapt to become learning organisations and to equip new and existing staff to the changing and developing work requirements.

An overall observation was there need to be long term and sustainable programmes of industry skills development, to ensure we have sufficient, and well trained workers to provide services.

8.5 Operators – Treatment

The research around Treatment Plant Operators was undertaken with assistance from Jim Graham, Water NZ and Jonathon Mackie, WSP Opus. Their support in providing information for this section of the report is acknowledged.

In 2011/12 a survey of Treatment Operators was undertaken with 50% of the industry being over 50 years of age.

To state that another way in 15 years half the countries treatment operators will be retired – is this something the industry is prepared for?

It was noted that the typical age of operators when the industry training school was running was early 40's, and that there were eight to ten training conclusions per year. Whilst these statistics are no longer available is it assumed that not much has changed in the last decade.

Water NZ lead a Water Industry Training Review in 2018. The results of this review are still being worked through.

One of the key findings of the review was that there is now a fundamental lack of industry training opportunities available.

Given the pending wave of water operator retirements in the next ten years, the issue of bringing in new staff, appropriate training, and industry retention is a matter that needs to be urgently addressed.

It was noted that like other parts of the industry the skills sets required are changing, with more technical, risk management, asset management and compliance requirements being added to roles. Current industry qualifications will require updating to meet these requirements.

This suggests a lifting of professional standards required is being experienced, however this is not well supported by industry training.

8.6 Construction Teams

It can be observed in both horizontal and vertical infrastructure construction that the New Zealand industry has a wide range of issues.

The recent wave of vertical infrastructure company collapses suggests major problems in industry structure and the way work is being priced and procured. Discussions are underway in government and within the industry about possible paths for industry reorganisation.

Publicly discussed figures (January 2019) suggest that the NZ construction industry is currently 10,000 staff short,

This shortage of skilled resources is showing up in the inability to accelerate construction programmes – for example the governments KiwiBuild programme.

It is clear the NZ construction industry is highly stressed, and this is showing up in the high suicide rates noted in the recent SiteSafe report https://waughinfrastructure.com/suicide-in-the-new-zealand-construction-industry-what-can-we-do/

8.7 Skills Shortage Conclusion

This short review of the issues associated with the NZ Engineering and Construction Industry skills shortage demonstrates that we have major shortages across the whole engineering and construction industry stack.

It has taken nearly three decades of skills and training underinvestment in our industry to get to the position we are in today.

The skills shortage problems are large and will not be easily fixed – it is going to take a sustained investment across the industry to resolve these issues.

Business as usual is not going to solve these issues, and to return to sustainable industry resource and skill levels is going to require many changes to the way we do business.

9.0 INDUSTRY INITIATIVES IN PLACE

The Engineering Skills shortage has been identified for a number of years and a range of initiatives have been developed over this time:

- E2E http://www.engineeringe2e.org.nz has been operating since 2014 under the leadership of Sir Neville Jordon, who stepped down at the end of last year. The role of E2E is *"By working together to improve the understanding and perception of engineering, we make it easier for people to find a career path that can offer them every opportunity in the world".*
- E2E provides extensive documentation on their website about the discoveries, and the progress that has been made over the past 5 years
- 5 E2E micro credential pilots are running in 2019
- IPWEA NZ is developing 6 micro credential badges in 2019, with more information available at this conference
- The government has funded additional engineering training capacity at New Zealand Universities
- Alternate learning pathways are being developed, including pathways for Maori and Pacifica learners
- BEngTech degree apprenticeships have been launched in 2019
- IPWEA NZ and E2E have developed the Fostering our Future Programme to https://www.fosteringourfuture.works to Attract, Develop and Retain staff in engineering careers
- Fostering our Future has developed business cases to future accelerate the programme and delivery learning outcomes via micro credentials

Encouraging progress is being made by E2E as noted in their most recent February 2019 newsletter http://www.engineeringe2e.org.nz/assets/e2e/newsletters/7d5104df4d/e2e-news-52-feb-2019-2.pdf

This progress to date is still well short of providing the number of engineers needed to cover the projected skills shortage over the next 6 years.

For mechanical plant operators and construction workers training has either been developed in-service or via apprenticeships. The current shortfalls of staff in the sector are an indicator of the needed for expanded programmes.

Treatment Plant Operator training is in a state of transition, with studies to improve and redevelop this training being led by Water NZ. Given pending industry retirements further Water Operator training development is needed as a matter of urgency.

10.0 FURTHER OBSERVATIONS

None of these observations are new, and much of them are covered by E2E and also the Australian sector reports.

These observations include:

- How to get women into our industry, and career change retaining opportunities
- Lifetime training, and reskilling as required – progress in the micro credentials and in-service professional apprenticeships in 2019 is encouraging
- Changing the mix of skills to support changing and emerging technologies
- Wider skills mix in the industry, with an acceptance and encouragement of related disciplines to join the industry and reskill
- Wider diversity in the industry
- Raising the profile, investment, and status in Engineering

11.0 EMERGING TECHNOLOGIES

What about Industry consolidation, technology, expert systems and AI?

- Does industry consolidation solve the problem?
- Can further application of technology assist in closing gaps?
- Can we deploy expert systems to reduce skills gaps?
- Will AI help?

11.1 AI, Expert Systems, Machine Learning and Knowledge Bases

The role of emerging technologies, AI, Expert Systems, Machine Learning and Knowledge Bases was discussed during the research into the development of this report.

There was general agreement that all these technologies and trends will impact and will create efficiencies over time.

The was also general agreement that different skill sets will be needed to develop and use these technologies in engineering practice, which points to further training needs.

The discussions tended to point not to less need for skilled staff, but rather adapting and different skills sets to leverage the technological changes that are coming.

11.2 Industry Consolidation

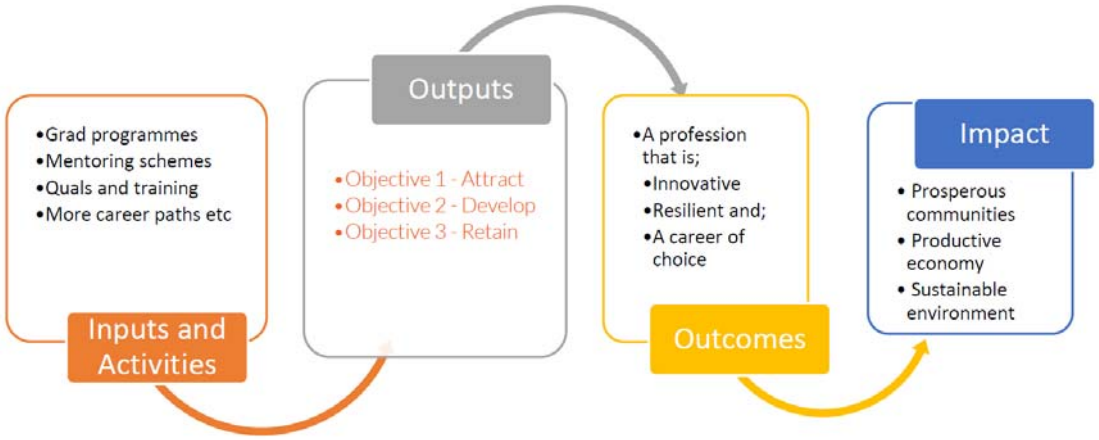
The discussion around industry consolidation is one of the benefit of efficiencies of scale. This is already being tested across a range of engineering practice and service delivery in New Zealand – for example in development and deployment of the State Highway NOC contracts, the creation of Wellington Water, and the ongoing discussions around regional delivery of 3 Waters services.

Given the size of the projected Engineering Skills Shortage, and the large wave of provincial engineering retirements in the next 10-15 years, it is likely that the skills shortage will be one of the drivers of continued adaptation, industry consolidation and change.

12.0 RESPONSES

The diagram below is drawn from Fostering our Future material and shows the proposed pathway to achieve the required outcomes and community impact. In summary we must attract, develop and retain engineers, operators and construction staff to close the Engineering and associated skills gaps.

Figure 29: Inputs and Activities, Outputs, Outcomes, and Impact



12.1 Reaching into Secondary Education

As noted in the Australian reports there is a need to build an Engineering Pipeline Strategy that starts in the secondary schools.

Some work has been done in New Zealand with the Future-in-Tech programme, but this needs to be expanded and developed to assist at the start of the Pipeline.

As also noted in the Australian reports it is essential that suitable students do not drop STEM subjects because they are perceived as hard subjects to complete.

The advantages of engineering and associated public works careers, and the satisfaction of providing good service to communities needs to be consistently 'sold' at a secondary education level, to assist in creating the pipeline of suitable students into public works engineering careers.

12.2 Training Programmes

Significant work is underway by E2E and Fostering our Future around the development of modern micro credential qualifications. This is encouraging.

The development of the BEngTech degree apprenticeships is also encouraging.

There is a need for expanded BE and ME education opportunities in NZ, perhaps matched with scholarships and in-work training opportunities to incentivise student enrolment and course completions.

Further expansion and support of technician level National Diploma in Engineering and Treatment Operations training is needed, and again should be incentivised with scholarships and in-work training opportunities.

If we doubled current Engineering trainees across all levels - NDE, BEngTech and BE over the next five years it would still not be enough to meet the skills shortage.

12.3 Industry – Research Linkages

The Cebr (2016). Royal Academy of Engineering Report highlights how far behind peer countries that New Zealand is in our overall engineering.

New Zealand's long term national economic productivity and inventiveness will be considerably enhanced by a much stronger engineering base to our society.

One of the ways of achieving this is strengthening Industry-Research linkages and by leveraging, and applying research, and by empowering additional research.

This should be included as a priority as we move to address the issues of the engineering skills shortage.

12.4 Delayed Retirement

The large wave of potential retirements in the next 15 years has been noted as one in three nationwide, and one in two in provincial New Zealand.

One of the mechanisms to offset this, and the related skills shortage is to encourage and facilitate delayed retirements of skills engineers.

Trends in this regard can already be observed.

Accommodating delayed retirements will require significantly more flexible workplace arrangements and attitudes than currently deployed, and a rethinking of how part time or semi-retired employees can be best used to add value to organisations.

12.5 Immigration – Importing Engineers

For the past two decades the lack of sufficient New Zealand Engineering training has been offset by immigration – the importing of skilled engineers.

Other countries losses have been New Zealand's gain.

For the foreseeable future New Zealand will need to continue to import skilled engineers to assist in closing the skills shortage, and offsetting pending engineering retirements.

New Zealand is competing for these skilled engineers in an increasingly crowded marketplace, which as noted earlier includes Australia, Canada, UK and USA.

To attract and retain skilled migrant engineers further work could be undertaken to streamline immigration processes, expedite recognition of qualifications and experience, and provide new immigrant engineers with New Zealand specific engineering, standards, and legal framework training to assist them in settling in and being productive as soon as possible.

Advice on what would be useful and practical could be gained from existing resident immigrant engineers. Using the network of existing immigrant engineers to invite classmates, colleagues and friends would also assist in attracting engineers to New Zealand.

12.6 Supply Chain and Procurement Adaptation

Using supply chain and procurement models based on post major economic recession requirements makes no logical sense in an era of sustained skills shortages.

Supply Chain and Procurement adaptation is required to be 'fit for purpose' in the current environment.

This could include adding:

- Resourcing sustainability clauses in the Local Government Act?
- Resourcing sustainability requirements in service delivery mechanisms and contracts?

David Langford, New Plymouth DC is developing thinking and practice in this area, and provides good example case studies for review.

12.7 Industry Sustainability, Taking a Wider View

Given the analysis of the engineering and construction skills shortage, it is easy to see that our industry is not currently operating on a sustainable basis.

We are running the risk of service delivery failure due to the lack of adequately skilled resources.

Current approaches to solving skills shortages have taken a lot of cooperation, coordination and hard work, but need to be expanded and multiplied to bridge the identified skills shortage gap.

Building the cost of adequate industry skills development back into the cost of service delivery is going to take tough conversations with elected representatives and communities.

Resolving the engineering skills shortage is going to require increased communication across communities, increased engagement, and a wide range of engagement with central government.

There are no quick fixes, and business as usual is not going to solve the issue.

Given Engineers are some of the most talented people on the planet, this represents a good challenge, but is also going to require sustained and wide ranging engagement across our industry.

13.0 LOOKING FORWARD – ACTIONS

13.1 Become Informed

This report is a start to becoming informed. There are a wide range of additional information and resources available from IPWEA NZ, Engineering NZ, E2E and Fostering our Future.

13.2 Become Involved

Please engage and lend your support and expertise to being part of the solution to the issue of the Engineering and Construction skills shortage. The solution is going to require sustained across industry support and engagement.

13.3 Start the Hard Conversations

There are difficult conversations needed with elected representatives, communities, staff and clients. We have a major problem, and there will need to be wide ranging adjustments to address the problem.

This will require changes in procurement, changes in staffing policies, and a recognition that the cost of staff and services is likely to increase significantly faster than underlying inflation.

The move to sustainable provision of skills and resources is going to cost more than current arrangements. The failure cost of doing nothing will be orders of magnitude higher again.

13.4 Commit Resources and Funds

Scholarships, Degree Apprenticeships, Staff training, Cadets, Micro credentials, course development all require resources and funds. The skills shortage an industry wide issue, and will require an industry wide response, including from you and your organisation.

13.5 Re-examine your Supply Chain and Procurement

There is significant work required in adapting your supply chain and procurement to be ‘fit for purpose’ in the skills short environment. There are developing examples that can be used.

13.6 Plan How to Manage your Skills Shortage

The skills shortage is going to impact your organisation, and how you deliver work and services. The wave of retirements in the next 10-15 years will also have an impact on your organisation. Start your planning for this now and develop strategies and plans for how your organisation needs to adapt and manage the skills shortage.

14.0 ACKNOWLEDGEMENTS

This paper has been produced with the willing and open assistance of participants across the New Zealand industry. These participants are acknowledged below:

- Simon Hunt, Strategic Asset Engineer, Fulton Hogan Ltd
- Vaughn Crowther, Navigator, Utility
- Steve Browning, IPWEA NZ Training
- Peter Higgs, IPWEA NZ CEO
- Hugh Blake-Manson, Northern SI IPWEA Branch Chair
- Chris Chapman, Downer NZ
- Lisa Stafford, Downer NZ HR Manager
- Jim Graham, Principal Adviser Water Quality, Water NZ
- Jonathan Mackey, Work Group Manager – Training, WSP Opus
- David Langford, New Plymouth DC

15.0 REFERENCES

The links and references used throughout this report are collated here for ease of reference.

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16.0 AUTHOR INFORMATION

Ross Waugh
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Ross is the founder of Waugh Infrastructure Management and is an asset management and systems integration specialist with over 30 years' experience in municipal infrastructure asset management and engineering. Ross has been consulting in infrastructure management for 20 years, in the areas of transportation, utilities, community facilities, buildings and property.

Ross has contributed to a number of New Zealand national data capture, research, advisory, government enquiry, and infrastructure standard setting projects, and is a section author of the International Infrastructure Management Manual 2011 and 2015.

Ross has experience of seven cycles of integrating infrastructure asset management planning with long term financial planning within the New Zealand context. He has also completed infrastructure asset management assignments in Australia and the Pacific.

Ross was recipient of the IPWEA Presidents Award in 2016 for leadership in the field of infrastructure asset management and for commitment to IPWEA over many years.

Ross takes an active interest in on-going International infrastructure asset management trends and is the author of Inframanage Blog, which has an international focus http://inframanage.com/inframanage-blog/.