A Study on the Usage of Wooden Poles and Crossarms in the New Zealand Electricity Network Industry

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Boon Khiang Tan

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New Zealand School of Forestry
University of Canterbury
Christchurch
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Abstract

Electricity network companies utilise poles and crossarms to support electricity lines in their distribution networks. Various materials are used for poles and crossarms, and this study specifically looks at the total current and potential future demand for wooden poles and crossarms in the New Zealand electricity network industry. In total, there are 27 electricity network companies in the country.

5 companies were initially visited to gather the necessary data and gain industry knowledge, and then the remaining 22 companies were surveyed by phone. The survey was designed to gather both qualitative and quantitative data. The qualitative survey was carried out in a 30 minute phone interview to gather information on trends in pole and crossarm utilisation, and a total of 23 companies provided information. 19 companies responded to the quantitative survey, which provided data on current stock and annual consumption of poles and crossarms, and product prices and specifications. Estimation of current stock and consumption of poles and crossarms was carried out for the entire industry using these data, and other data from published sources. The annual pole consumption preference is dominated by concrete poles (63%), followed by Softwood (21%), hardwood (14%), steel (0.21%) and other (1.61%). The estimated annual volume consumed by the industry is 1,812 m^3 for hardwood poles, and 2,108 m^3 for softwood poles. Significant portion of wooden poles are used in the South Island (81% of total annual wood consumption). This is mainly related to the ability of wooden poles to withstand dynamic load in snow loading areas. Annual crossarm consumption is dominated by hardwood (97%), and followed by steel (3%). The estimated annual volume requirements for hardwood crossarms is 740 m3. Wooden pole consumption is expected by industry participants to decline in the near future (especially hardwood), with the increasing competition from concrete poles. However, hardwood poles will likely remain competitive for special applications, and an increase in company confidence in softwood poles is required for it to be used more widely. Hardwood timber is expected to remain the preferred material for crossarms in the future.

Acknowledgements

First of all, I would like to express my great appreciation and gratitude to my Supervisor, David Evison, for his endless support and mentoring throughout this entire dissertation process. It has been an enjoyable learning experience that provided me with invaluable skills which I could not have otherwise acquired on my own.

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A special thanks to the companies who provided me with the opportunity to visit them at the initial stage of this study, and/or gave me extensive background knowledge required for this study. They are Brian Tapp (Malborough Lines), Merv McKay and Paul Kidgell (Orion Network), Peter Hurford (Mainpower), Ken Flynn (Electricity Ashburton), Rex McDonald (Alpine Energy), and Ron Coleman (Powerco).

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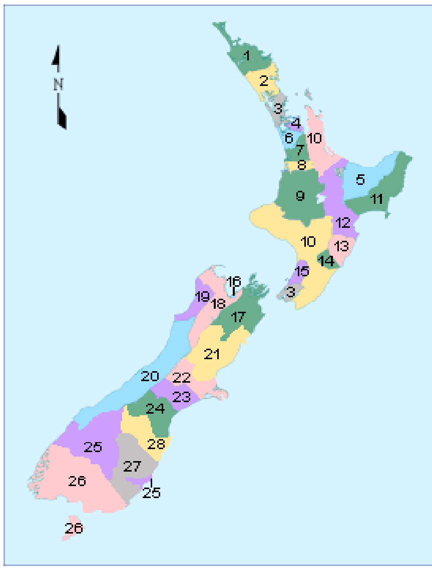
1.0 - Introduction / Background

There are 27 network companies in the entire New Zealand network industry that distributes electricity from the national grid (serviced by Transpower) to end users. The map below represents the areas serviced by the different companies in New Zealand, with more network companies operating in the North Island than the South.



North Island	South Island
Centralines	Alpine Energy
Counties Power	Aurora Energy (Delta)
Eastland Network	Buller Electricity
Electra	Electricity Ashburton
Horizon Energy Distribution	Mainpower
Northpower	Malborough Lines
Powerco	Nelson Electricity
Scanpower	Network Tasman
The Lines Company	Network Waitaki
Top Energy	Orion Group
Unison Network	Powernet/ Otagonet Joint Venture
Vector	Westpower (Electronet)
Waipa Networks	
Wellington Electricity	
WEL Network	

Source: www.electricity.org.nz/?page=networkMap

The distribution of electricity by the network companies requires poles and crossarms, and is particularly important for distribution and sub-transmission voltages (i.e. 22kV, 33kV, 66kV). Low voltage lines (400V) also requires poles and crossarms for electricity distribution, but in urban areas, significant proportion of low voltage lines are being put underground which reduces the need for them. High voltages such as 110kV are usually distributed using lattice steel structures, and therefore the requirement for poles and crossarms is low. Historically, wooden poles and crossarms were used due to their low cost and their ability to provide suitable performance, but with the increasing competition from other products such as concrete and steel, companies nowadays have more options to choose from to optimise their operation.

1.1 - Objective and Purpose

The objective of this study is to quantify the wood usage for poles and crossarms in the New Zealand electricity network industry. The results of the study will provide information for forest growers interested in supplying this market and this report will provide answers to the following research questions:

- What products are currently used for poles and crossarms?
- What is the current annual consumption of wooden poles and crossarms by the electricity network industry?
- What are the likely trends in substitution between wood and other materials for poles and crossarms?

Technical requirements for poles and crossarms will vary according to various factors. In turn, the decision to use a specific pole or crossarm type by the companies is dependent on the trade-off between price, strength requirements, product performance, environment/terrain, and product confidence/preference. These factors will be explained in detail in this report, and the common specifications for wood products used by the network companies will be presented. In addition, an overall assessment of the market size for wooden poles and crossarms in New Zealand will also be provided.

2.0 - Literature Review

Poles

Wooden poles from both hardwood and softwood species have traditionally been used by network companies for overhead lines. Wooden poles have been used by network companies around the world due to their ability to provide the required performance for overhead lines, and their availability has made them a cost-effective option. In New Zealand, various species of wooden poles have been used in the electricity network, such as Radiata pine, Corsican pine, Larch, Douglas fir, and Australian Eucalypt hardwood variants. Over time, competition from other pole types such as concrete and steel has increased, providing network companies with alternative sources of poles.

In the United States, tubular steel poles have been used for at least 10 years for transmission structures and also for distribution lines (Lash & Nicholson, 2000). The study carried out by Oliver (2001) looked at the suitability of concrete, wood, fibreglass, and steel poles as the options for line re-establishment after a major wind event that toppled 500-600 poles in the transmission and distribution system. After considering the benefits in terms of both long-term economics and basic engineering properties, the study concluded that steel will be the preferred option over wooden poles. Steel poles were preferred because of greater consistency, lower cost, availability, available lengths, and longevity (Oliver, 2001). CSIRO also did a test on steel poles and found they were preferable in environments that are prone to fire, as the results showed that steel poles were able to withstand fire exposure[1].

On the contrary, a lifecycle study done in Canada comparing wood with light-duty steel poles (equivalent of the tubular steel pole), fibreglass, and spun concrete poles found that wood remained the competitive, and the best investment compared to the alternatives (Western Wood Preservers Institute, 1997). Although wooden poles require more inspection and maintenance, its lower initial set-up cost was less than the alternatives. The cost incurred in the future for inspection and maintenance had

[1] "CSIRO Testing Confirms Steel Pole Advantage".
http://www.eea.co.nz/Story?Action=View&Story_id=1839&Highlight1=steel&Highlight2=pole
date visited: 6 October 2009

no significant "present value" (assessed based on the interest rate at that time), and therefore proved that this option was desirable (Western Wood Preservers Institute, 1997). In addition, Sedjo (2001) found that the total energy requirements associated with wooden poles are considerably lower than concrete and tubular steel poles; as a result, the use of wooden poles will produce significantly less carbon emissions. This will have an important implication for companies who are seeking a goal of becoming carbon neutral.

In Australia, Wooden poles make up over 80% of the country's estimated total poles in service (Francis & Norton 2006), with the majority of wooden poles sourced from native hardwood species. The demand for wooden poles is likely to continue in the future, as it will be prohibitive to convert all poles into alternative poles constructed using other materials such as concrete, steel, and fibre-glass. Francis & Norton (2006) found that even when the whole life cycle cost of the poles were considered in Australia, wooden poles were considerably less expensive than alternatives.

Limited literature is available looking at the comparison of wooden poles and alternatives in New Zealand, but based on the assessment of Asset Management Plans of all the network companies in the country (2008-2009), it is clear that concrete poles have become the main pole preference for many companies in the country. However, both hardwood and softwood poles are still used where it is considered "economical" to do so, and where specific technical performance is required- such as situations where there is snow-loading on the transmission and distribution lines.

Hardwood poles

The range of hardwood poles available from Australia consists of various species with varying strength and durability classes. However, the general requirements outlined by network companies in New Zealand are based on the Australian Standard AS 2209 "Timber- Poles for Overhead Lines", and the AS/NZS 4676: "Structural design requirements for utility services poles", which specifies the timber strength group to be S1 or S2, and timber durability of Class 1 or 2 (refer Appendix B for description). Due to the minimal durability of the sapwood, hardwood poles are treated with a H-5 class preservative treatment (refer Appendix B for description), and this often renders the poles more durable than the heartwood of the most naturally durable species (Francis and Norton, 2006). The lifespan of durability Class 1 poles have a life expectancy of about 50-60 years, but may be longer if it originates from superior-quality mature trees which can last up to 75 years in some Australian locations (Francis & Norton, 2006) (this is slightly higher than the guide given in Appendix B).

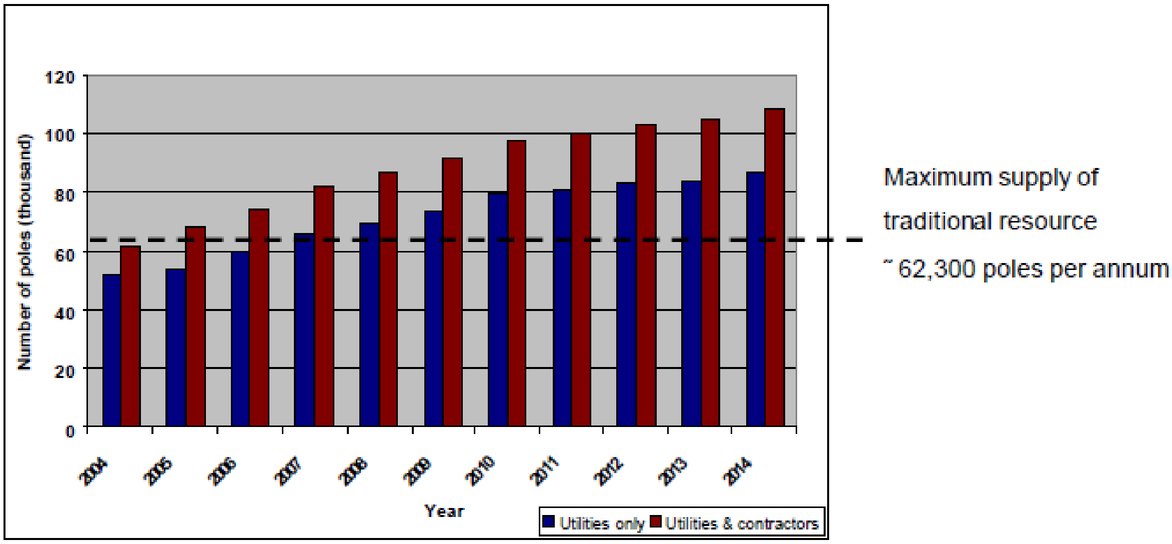


Figure 1: Estimated annual demand for durability class 1 & 2 poles 2004 to 2014 from Australia
(Source: Francis & Norton 2006)

The supply of native Australian hardwood has declined, and is expected to decline further over the next ten years. Figure 1 above shows that the supply of native Australian Hardwood is no longer able to meet the total demand in Australia. This has led to the use of alternative resources such as native plantation-grown hardwood poles. However, the durability of these poles is lower and consists of Class 3 & 4 durability (Francis & Norton, 2006). It is not entirely clear whether the supply of hardwood poles into New Zealand is purely of the durable natural forest hardwoods, or includes plantation -grown poles. But as presented later in this report, there are companies in New Zealand that experienced an increasing variability of the hardwood durability.

Softwood poles

Only Radiata pine softwood poles are used in the New Zealand electricity network. By contrast, 5 main softwood species are utilised in the United States, including Douglas-fir, Southern pine (which is made up of Loblolly pine- *P. taeda*, Longleaf pine- *P. palustris*, Shortleaf pine- *P. echinata*, and Slash pine- *P. elliottii*) , Western red cedar, Ponderosa pine, and Lodgepole pine (Mankowski *et al.* 2002). All softwood poles produced in New Zealand conform to the NZS 3603 "Timber Structures Standard", and are CCA treated to meet the requirements of H5 preservative treatement (NZ MP3640, 1992). Previously in New Zealand, Corsican pine was also utilised in addition to radiata pine, and both of these pole types have experienced significant problems with longitudinal twisting (Walford & Ormarsson, 2003). However, Corsican pine poles are no longer supplied in the New Zealand market as there not enough desirable supply from the forest[2].

Research has been carried out into the twisting of softwood poles, with findings suggesting that twisting can be reduced or eliminated when 20 growth rings are present in the pole (Walford & Ormarsson, 2003). The research also suggested that if the poles are pre-dried before installation to moisture content lower than 30% in the core, they will be significantly less likely to twist during service (Walford & Ormarsson 2003).

Crossarms

Wood has been again the traditional material preferred and used by network companies around the world due to its strength, durability, and electrical properties (Lash and Nicholson, 2000). In the United States, species such as Douglas fir and Southern Yellow Pine are used for distribution crossarms[3], while in New Zealand, virtually all wooden crossarms are Australian hardwood that originates from Australia. However, alternatives to wooden crossarms have also been heavily investigated, especially with materials such as steel and fibre composites (e.g. fibreglass) (Lash and Nicholson, 2000). There are various other products that have been looked into, such as parallel-laminated veneer crossarms in United States (Youngquist et al., 1977), and laminated wooden crossarms (White & Siemon 1992) in New Zealand.

All hardwood crossarms used in New Zealand conform to the Australian standard AS 3818.4- "Timber –Heavy Structural products- Visually grade, Part 4: Cross Arms for Overhead Lines", which requires it to have timber strength group of S1 or S2 (refer Appendix B) and durability class 1 or 2 (AS 3818.4, 2003).

[2] York D. - Goldpine Industries Ltd. Electropole Manager. Pers comm.6 August 2009
[3] http://www.crossarms.com/products.html Date Visited: 7 October 2009

3.0 – Methodology

An initial site visit to 5 network companies in the South Island provided a platform for understanding and gaining familiarity of the electricity network industry and its pole and crossarm requirements. The Asset Management Plans, Annual reports, and the Electricity Information Disclosure Requirements reports for each company provide data on financial performance and data on the distribution network of each company, which formed part of the data analysis presented later in this section. A draft survey instrument was initially devised and tested with these five companies, and based on the additional acquired knowledge from them, the final survey instrument was produced.

There were two parts to the survey instrument, which consisted of qualitative and quantitative question. The intention was to complete the survey with the remaining 22 (total of 27) electricity network companies in New Zealand. The 22 companies were all contacted by phone to request for the participation in the survey, and upon agreement with the manager, the quantitative survey was first emailed to the relevant personnel in the company, and then the qualitative survey was carried out at a later date/time over a 30 minute session with the company expert for poles and crossarms (usually network managers, operations manager, Asset manager or Design engineer). The qualitative survey required the companies to search and coordinate the collection of current and past company records, and therefore, the return period of the quantitative survey from the participating companies ranged from a few days to over a month depending on their availability.

However, it was not possible to include one company in the study due refusal to partake in the study, and also lacked published information for estimation. This company was very small relative to other companies in New Zealand, and therefore will not affect the final result of this study. Overall, this the study covers 26 companies and this is assumed to represent the entire electricity network industry. The questionaire involved in both qualitative and quantitative parts of the survey is described below, and a copy of the actual survey instrument can be found in Appendix D:

1-Qualitative survey

The aim of the qualitative survey was to fully understand the company's pole and crossarm utilisation rationale, by specifically asking the questions that revolved around the following:

- Past, Current, and future decision on poles and crossarm consumption
- Company's rationale for using different products
- Product supply source and capability
- The drivers for poles and crossarms consumption

In total, 23 companies completed the qualitative survey (5 site visits and 18 phone surveys), which translate to an 85% response rate.

2-Quantitative survey

A spreadsheet was sent out to the companies that allowed an easy "fill-in the gaps" approach, particularly focusing on the following (All the information below were also requested to be specified by different voltage levels where possible):

- Total number of current poles and crossarms by type in the network
- Consumption history of poles and crossarms for the past 3 years (either the number of poles and crossarms put into the network, or the number of poles and crossarms purchased)
- Proportion of the total pole and crossarm consumption split into 5 categories, namely: renewal, line upgrades, new line establishments, faults, and relocations. (This was not formally analysed due to the limited quality of the provided information)
- Pole and crossarm prices paid by the electricity network company

The response for the quantitative survey was more variable, with a varying quality of data returned from different companies. In total, 19 companies returned the quantitative survey, and the table below summarises the amount of data that was returned (In addition, a total of 9 companies provided prices for poles and crossarms):

Table 1: summary of quantitative response from 19 companies

No. of response	Total Current Poles in network	Annual pole consumption	Total current crossarms in network	Annual crossarm consumption
8	YES	YES	YES	YES
1	YES	-	YES	-
6	YES	YES	-	YES
3	YES	YES	-	-
1	YES	-	-	-

A full enumeration from all companies was not achieved, and therefore needed a methodology to estimate the four variables presented in table 1 for the entire country. The measure of company size was evaluated using information from the published data described before, such as lines revenue, overhead circuit length, number of network connections, and value of systems fixed asset. These data were used for regression with the total current poles in network, annual pole consumption, total current crossarms in network, and annual crossarm consumption to find the best estimate equation for each the four variables. The data analyses of these are presented in the following section.

3.1 - Data analysis

Regression Analysis

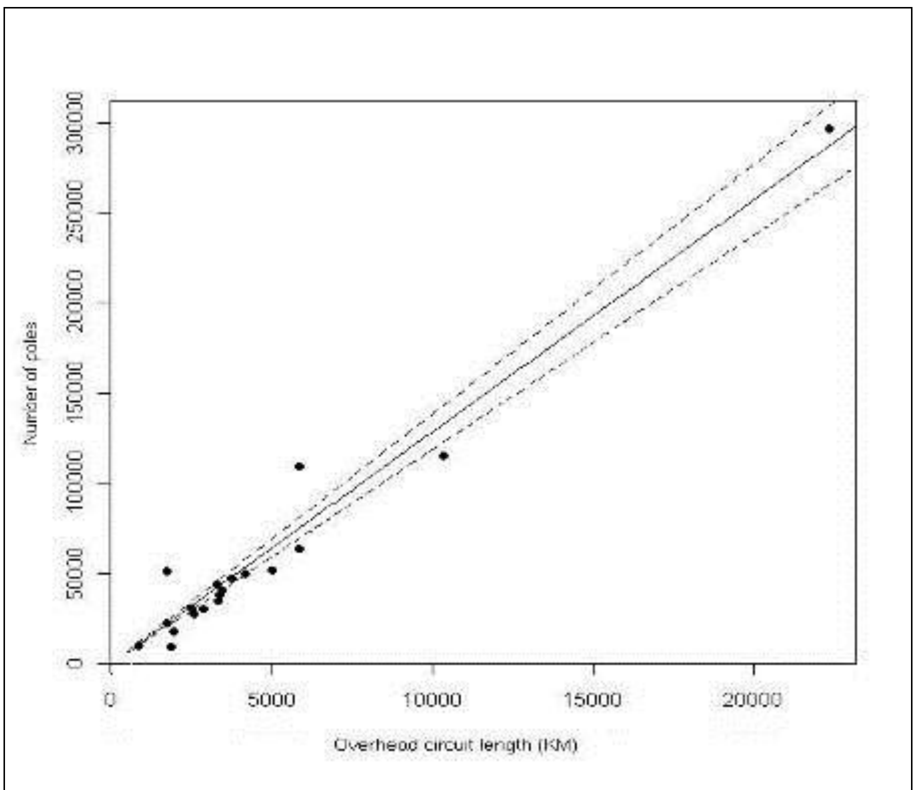
Due to the variability of completion of the quantitative survey, published data on the network companies was used to fill in any gaps that were present. The significance of each of the regression will be presented together with the graphs, with P-value calculated for each of the regressions and their associated intercepts and coefficients. A p-value of less than 0.05 indicates a statistically significant result, while p-value of greater than 0.05 suggest an insignificant result. These are presented together with the graphs below, and in addition, a 95% confidence interval is calculated for the estimations of each regression line shown by the matted lines.

1-Total current poles in network (sample size = 19)

Regression was carried out with the measure of size variables described above, and overhead circuit length provided the best fit for the regression below. The intercept of this regression line was forced through the origin instead of the y—axis, as it is not logical to have negative number of poles for a particular circuit length. This regression was used to provide an estimate of the total current poles in the network for the entire electricity network industry in New Zealand. However, estimation of each pole types for all companies was not possible as only 19 companies provided data:

Equation: Poles = 12.864 x Overhead circuit length

R-squared value = 0.9573 (P-values suggests highly significant relationship)



	P-value
Regression	1.51814E-15
Intercept	N/A
Coefficient for circuit length (X)	3.6166E-16

Figure 2: Overhead circuit length vs Total current poles in network

Of the 19 samples, 17 of the companies are small to medium sized, while one company was significantly larger than the rest. This equation was used to estimate the total current number of poles for the remaining 7 companies, of which, 6 are small to medium sized companies, while one company was relatively large with over 13,000 km of overhead circuit length.

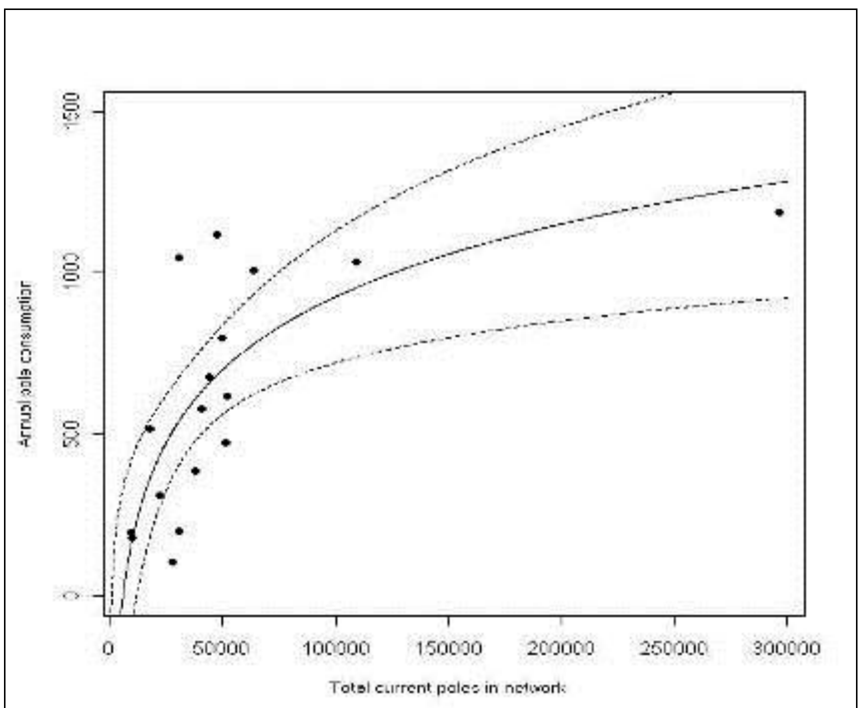
2-Annual pole consumption (Sample size = 17)

The annual pole consumption was regressed against “the total current number poles in network” and “overhead circuit length” to provide the best relationship below:

Equation:

Annual pole consumption = 325.07 ln(total current poles in network)- 2816

R-squared value = 0.5459 (P-values suggests highly significant relationship)



	P-value
Regression	1.4847E-231
Intercept	2.989E-230
Coefficient for pole consumption (X)	1.4847E-231

Figure 3: Total current poles in network vs Annual pole consumption

Due to the company with a data point that is significantly larger than the rest, a log transformation was needed for the linear regression to allow a best fit for the relationship. It shows that the annual pole consumption does not necessary follow a linear relationship as company size increases. A likely explanation for this is that larger companies tend to cover greater amount of urban areas that requires very little amount of poles for electricity distribution as a result of undergrounding; while the larger companies may have greater number of poles, their overall pole consumption requirements are reduced because of this reason. This relationship was used to estimate annual pole consumption for the remaining 9 companies, of which, 7 are small to medium sized companies, while 2 are large companies with over 100, 000 current poles in their networks. Of the 9 companies, about half of these companies (4) now use concrete pole exclusively and were assigned a 100% concrete for their pole consumption. The other 5 companies are minor wood users, and were assigned a consumption proportion of 90% for concrete poles, and 5% respectively for hardwood and softwood consumption. These were based on the best assumption from the qualitative survey.

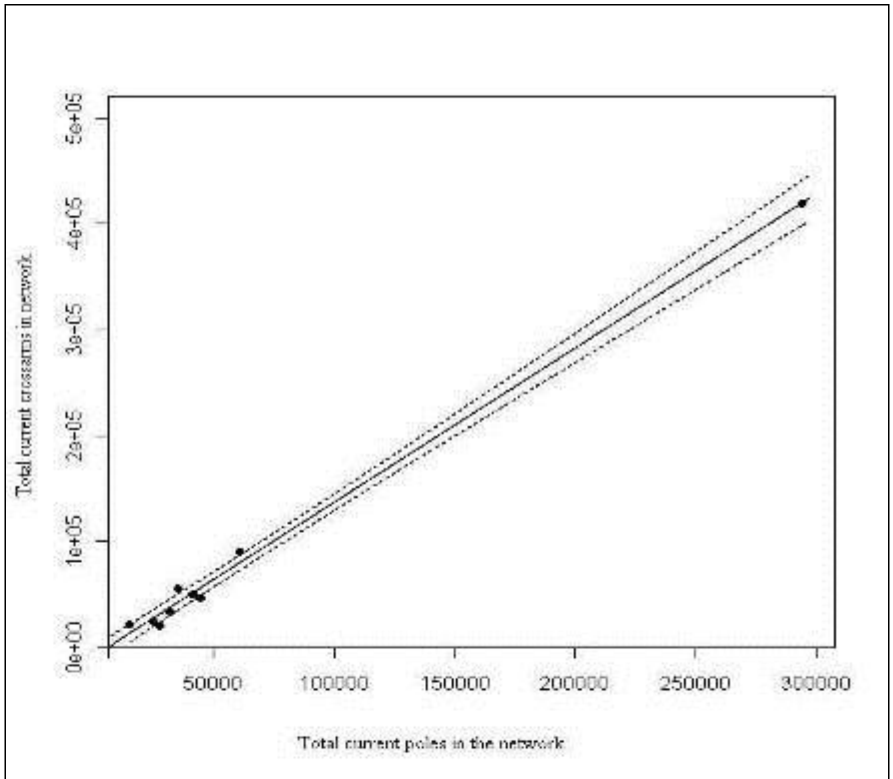
3-Total current crossarms in network (Sample size = 9)

There was a lack of data available for crossarms in many of the companies, but the 9 companies that provided the data either had accurate GIS record, or provided estimate based on their best knowledge. The available sample was tested against the 4 variables described in the beginning (company measure of size), and again, the intercept of the regression line was forced through the origin instead of the y-axis. This is more practical to avoid having negative number of crossarms for a particular number of poles.

Equation:

Total current crossarms in network = 1.445 (Total current poles in network)

R-squared value= 0.9953 (P-values suggests highly significant relationship)



	P-Value
Regression	2.43E-10
Intercept	N/A
Coefficient for total current poles (X)	1.96E-11

Figure 4: Total current poles in network vs Total current crossarms in network

Of the 9 companies, 8 are small to medium sized companies, while one was significantly larger than the rest. The equation is consistent with the information given by the companies, which suggested an average of 1.2-1.5 crossarms is associated with one standing pole in the network. This relationship was used to estimate the total current crossarms for the remaining companies.

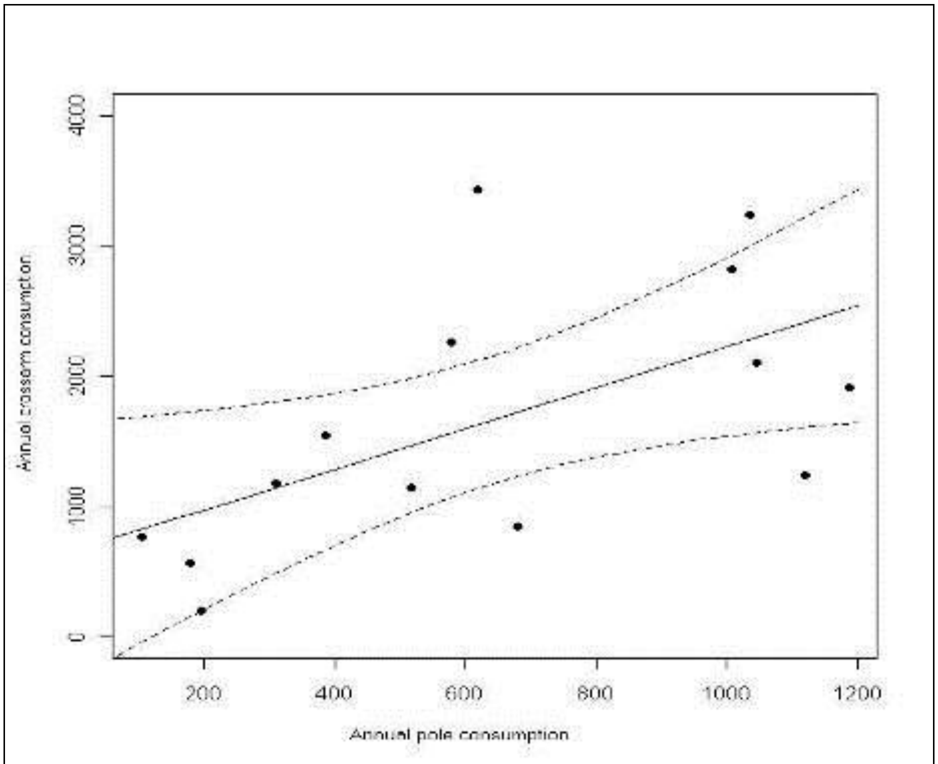
4-Annual crossarm consumption (Sample size = 14)

Regression was carried out against two variables, “Total current poles in network”and “Annual pole consumption”. Although the statistical test suggests that the regression and its associated parameters are not significant (P-values >0.05), the equation below provided the best fit:

Equation:

Annual crossarm consumption = 1.5624(Annual Pole consumption) + 662.17

R-squared value = 0.3519



	P-Value
Regression	0.025346
Intercept	0.168368
Coefficient for total pole consumption (X)	0.025346

Figure 5: Annual Pole consumption vs Annual crossarm consumption

It is clear that the relationship between annual pole and crossarm consumption is not particularly strong. But as mentioned in (3) earlier, companies suggested that on average, there are 1.2-1.5 crossarms per pole in the network. The coefficient in the above equation suggest that more than 1.5 crossarms are consumed for each pole that is consumed, which is on the high end of the given estimate; this may be because companies will also replace faulty crossarms on existing lines without replacing the pole.

Determining average pole and crossarm specifications

9 companies provided specifications for the hardwood and softwood poles that they used, and based on this, the average dimensions and volume (using Smalian formula) were calculated for each specification. The final weighted average volume for hardwood and softwood was then calculated. Where there are several strength ratings for a particular length, an average of the dimensions for all strength rating was calculated for the particular pole length. The strength ratings included 6kN, 8kN & 12kN for hardwood, and 6kN, 9kN, 12kN for softwood (these are top loading capacity).

Due to missing LED and SED for some pole lengths, assumption was made based on the pole specification standards provided by 2 companies. For hardwood pole lengths of 7m, 8m, and 9m, the LED and SED are based on the 9.5m dimensions. 12.5m and 13m hardwood poles are based on the 12m dimensions, while the 15m is based on the 14m dimensions.

As for softwood, the LED and SED of 7m and 8m length were based on the 8.5m dimensions, while 13m and 14m are based on 12m lengths. These assumptions for both hardwood and softwood poles may result in over/under estimating the dimensions for each of the pole length, but it should not affect the average dimensions and volume as a weighted average was carried out and presented in Table 2 & 3.

All wooden crossarms consumed by the 9 companies are hardwood, and a weighted average of the crossarm dimensions and volume were calculated from the available data, and can be found in Table 5.

4.0 - Quantitative Results & Discussions

4.1 - Poles

Current number of poles in the entire electricity network industry

There is estimated to be about 1.38 million poles in the New Zealand electricity network. Just over 60% are located in the North Island, and the remaining in the South Island (Figure 6). The difference in numbers between North and South Island is the result of greater network distribution coverage in the North Island.

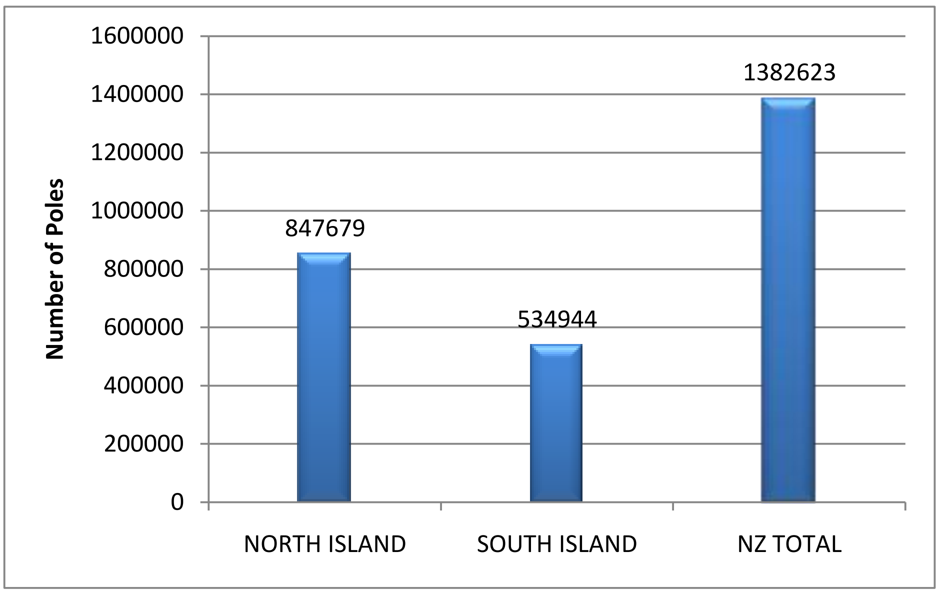


Figure 6: Estimation of the total current poles in the entire New Zealand electricity network

There are four common pole types used by the companies in New Zealand: concrete, hardwood, softwood, and steel. 19 companies provided the estimate of their current pole stock for each of the pole types in their networks as presented in Figure 7. Assumption is made that the data provided by the 19 companies is considered a good representation for the entire country. Concrete poles are the most common pole type found in the New Zealand network (58%), followed by wooden poles with a split of 19% of hardwood and 19% of softwood poles. The proportions of wooden poles may be slightly under-represented due to the missing data from a former major wood user that will have considerable number of old wooden poles in service in its network.

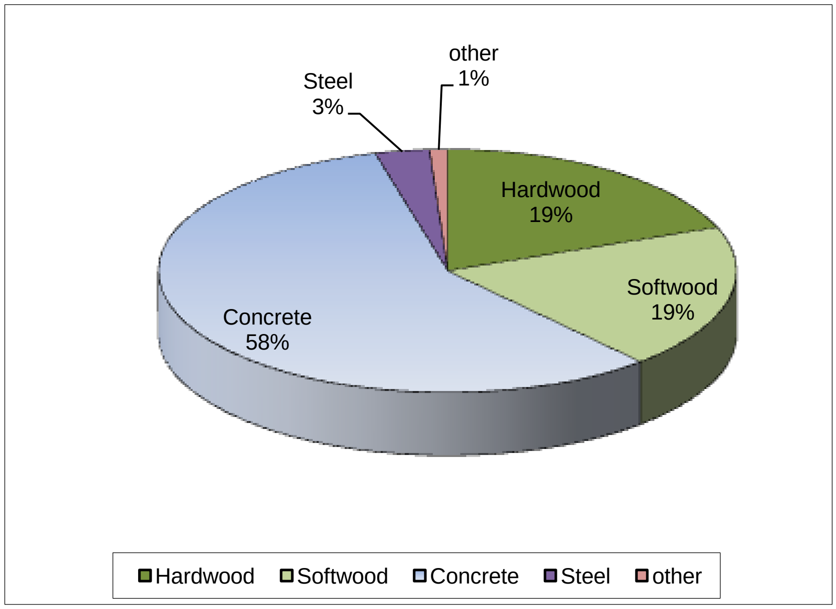


Figure 7: Proportion of current poles for each pole type of 19 companies

Annual pole consumption for the entire electricity network industry

Estimation of the annual pole consumption was possible for all companies (Figure 8) and the process of obtaining these is presented in the methodology section the report. Concrete poles appear to be the number one pole type consumed by companies at just over 63% of the total annual pole consumption. Softwood and hardwood poles follow behind at 21% and 14% respectively. Pole consumption can encompass pole renewals or line-upgrades, new line-establishment, faults (such as impact damage), and relocations.

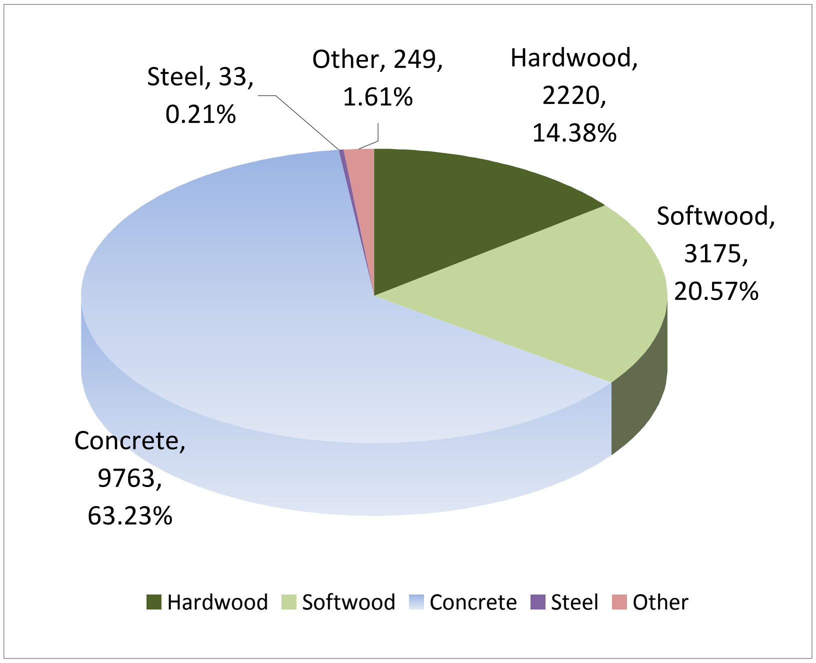


Figure 8: Estimation of Annual pole consumption by type, for ALL companies

Based on the estimated annual pole consumption for all companies, a total consumption rate of 1.14% of the total pole stock is expected per year. This is made up of consumption rate of 0.731%, 0.161%, 0.231%, 0.004%, 0.018% for concrete, hardwood, softwood, steel, and others respectively.

Comparison of the proportion of pole currently in network and currently consumed annually by type

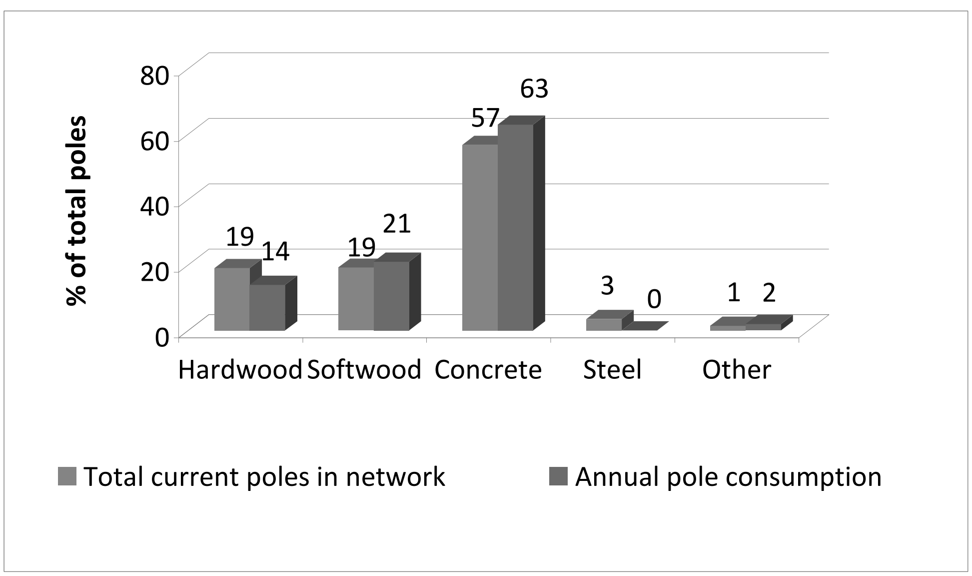


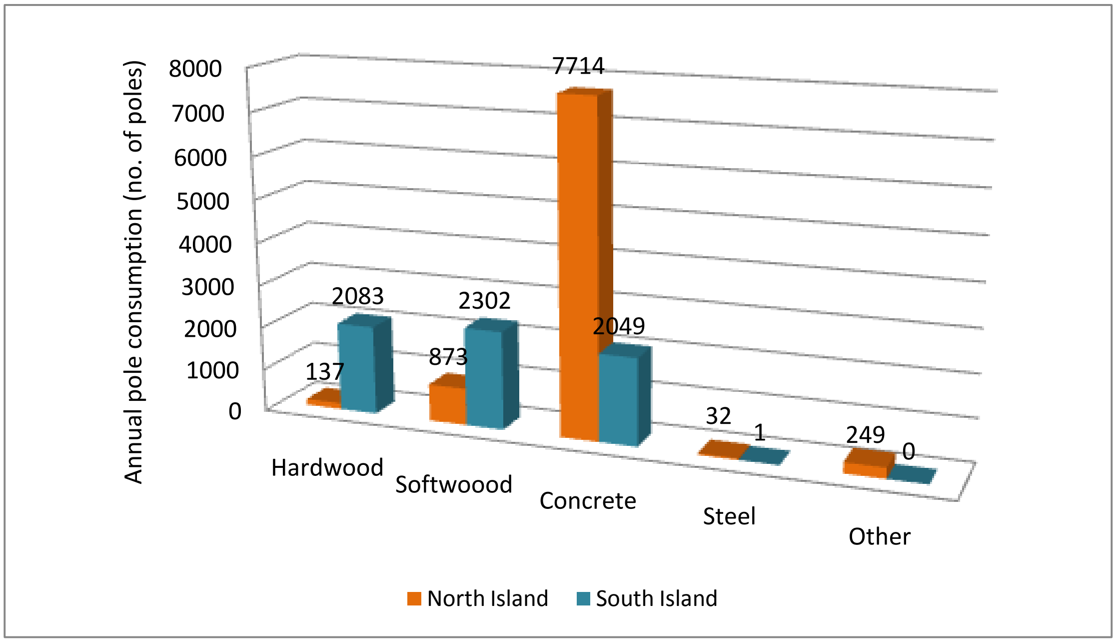
Figure 9: Comparison of % of poles by type, between total current poles in network for 17 companies and annual consumption for ALL companies (estimated)

A trend of increased consumption for concrete and softwood poles is observed in Figure 9. Both of these pole types show an increase in consumption of about 10% relative to their current pole stock proportion. This occur at the expense of mainly hardwood poles, which shows a decrease of about 26% relative its current pole stock proportion. In general, high proportion of pole consumption is carried out due to renewal and upgrades, but these poles are not necessarily replaced with the same pole type. In fact, most poles renewed or upgraded are old hardwood poles that have reached their end of life and are replaced with other pole types such as concrete and softwood poles as mentioned before.

New line-establishment are likely to utilise more concrete and softwood poles as well (more than hardwood and steel). Concrete poles are found to be an economical option for many companies, for reasons that will be discussed in the qualitative result. On the other hand, softwood poles have received a poor reception from most companies (based on the qualitative survey), mainly due to their twisting problem historically. However, softwood poles are likely to be the most economical option for non-critical poles such as poles used for service and private lines. For example, an increase in residential lifestyle blocks across in New Zealand may increase the demand for service, and private softwood poles.

Steel pole consumption is very low and a decreased in proportion consumed is observed in Figure 9. This is because the current steel poles in the network are mainly lattice steel structures that have not reached their end of life, and only a minute number of tubular steel poles are utilised by some companies currently (mainly in the higher voltage lines).

Variation in pole type consumption between North and South Island



	New Zealand	North Island	%	South Island	%
Hardwood	**2220**	137	*6*	2083	*94*
Softwood	**3175**	873	*27*	2302	*73*
Concrete	**9763**	7714	*79*	2049	*21*
Steel	**33**	32	*97*	1	*3*
Other	**249**	249	*100*	0	*0*
Total	**15440**	9006	*58*	6435	*42*

Figure 10: Annual consumption of different pole types in the North and South Island

Variation of pole type consumption between the North and South Island of New Zealand is evident from Figure 10. Concrete poles are consumed significantly more than any other pole types in the North Island, representing 79% of the total concrete poles consumed each year (21% of concrete poles are utilised in the South Island). The majority of wooden poles are used in the South Island, with the total exceeding the consumption of concrete poles in this region. Overall, 94% of the New Zealand's hardwood and 73% of softwood poles are consumed in the South Island. This is due to the ability of wooden poles, in particular hardwood, to withstand dynamic load in snow loading areas. Softwood poles also have the ability to withstand dynamic load, but it is more likely that they are preferred for their low cost, and lower weight for ease of transport into difficult terrain, in addition to their dynamic loading capability.

Further discussions on all the pole types will be presented in the qualitative result section later in the report.

Wooden Poles: Description and Specification

Hardwood

There are various species that are permitted by network companies to be used as poles, including *E. fibrosa* & *E. paniculata* (Red & Grey Ironbark), *E. paniculate*, *E. creba*, *E. siderophloia*, *E. maculata* (Spotted Gum), *E. pilularis* (Blackbutt), *E. albens* (White box), *E. resinifera* (Red Mahogany), and *E. acmenioides* (White Mahogany)[4]. However, Spotted Gum and Iron Bark are the two most common species used in New Zealand. The requirements for all hardwood poles used in New Zealand follows the Australian Standards AS 2209: "Timber- Poles for Overheard Lines", and the New Zealand/ Australia shared standard AS/NZS 4676: "Structural design requirements for utility services poles".

All hardwood poles are imported from Australia, and are treated with H-5 preservative treatment with the sapwood intact[5]. The requirements for the treatment of Hardwood poles are outlined in the Australian standard-AS 1604.1: Specification for preservative treatment - Sawn and round timber, which is used by electricity network companies in New Zealand. Table 1 presents the specifications of the hardwood poles utilised by the companies, and the process for estimating volume per pole is outlined in the methodology section of this report. It is clear that 10m and 11m poles are the most common lengths, covering 28 % and 48% of all the hardwood pole specifications provided. Based on the weighted average of all the specifications, the average volume of a hardwood pole is calculated to be 0.816m3/pole. More discussion on hardwood poles will be presented in the qualitative results.

[4] McKay M. - Orion Network. Infrastructure Manager. Pers comm. 26 June 2009
[5] Flynn K. – Electricity Ashburton. Project Manager. Pers Comm. 01 July 2009.

Table 2: Average hardwood specification for different lengths

Hardwood	SED (m)	LED (m)	Smalian volume (m3)	Weighted average volume (m3)
HW 7m	0.228	0.320	0.42444	0.00022
HW 8m	0.228	0.320	0.48507	0.00349
HW 9m	0.228	0.320	0.54571	0.00343
HW 9.5	0.228	0.320	0.57603	0.02363
HW 10m	0.255	0.355	0.75035	0.21092
HW 11m	0.235	0.340	0.73801	0.35593
HW 12m	0.250	0.375	0.95733	0.05074
HW 12.5m	0.250	0.375	0.99722	0.00787
HW 13m	0.250	0.375	1.03711	0.00634
HW 14m	0.255	0.395	1.21544	0.02840
HW 15m	0.255	0.395	1.30226	0.07808
HW 15.5m	0.260	0.410	1.43485	0.03301
HW 17m	0.265	0.430	1.70341	0.01411
			TOTAL	**0.816 m3/pole**

Softwood

There are a number of softwood species that were used for poles in the past, such as Radiata pine (*Pinus radiata*), Corsican pine (*Pinus nigra*), Larch (*Larix spp*) , and Douglas fir (*Pseudotsuga menziesii*). However, only Radiata pine is currently supplied to the softwood pole market in New Zealand. Again, the requirements for pole design are outlined in AS/NZS 4676, and NZS 3603: "Timber Structures Standard" outlines further requirements for softwood poles. All radiata pine poles are CCA treated to meet the requirements of H5- Group B in accordance to NZ TPA MP 3640- "Specification of The Minimum Requirements of the NZ Timber Preservation Council Inc."

Depending on the supply source of the radiata pine poles, quality and performance of the poles can vary. In the South Island, Goldpine is the main supplier and provides Radiata pine poles that are sourced from the Golden Downs forest in Nelson, and this has been proven by the supplier to have greater density than poles sourced from other forests (Higher density poles are known to be stronger). Poles coming from the Nelson region have a density range of 435kg/m3 to 600kg/m3, with an average density of 550kg/m3[2] .The minimum density specified by the electricity network companies for softwood poles is at least 450kg/m3 [5]. As presented in Table 3, 10m and 11 m poles are the most common softwood lengths used, representing 22% and 47% of all the softwood pole specifications provided. The weighted average volume for a softwood pole is calculated to be 0.664m3/pole.

Table 3: Average Softwood specification for different pole lengths

Softwood	SED (m)	LED (m)	Smalian volume (m3)	Weighted average volume (m3)
SW 7m	0.230	0.282	0.36407	0.00019
SW 8m	0.230	0.282	0.41608	0.00505
SW 8.5m	0.230	0.282	0.44208	0.00175
SW 9m	0.235	0.290	0.49248	0.09313
SW 9.5m	0.240	0.305	0.56200	0.02537
SW 10m	0.250	0.325	0.66031	0.14772
SW 11m	0.253	0.333	0.75560	0.35260
SW 12m	0.258	0.257	0.62501	0.02387
SW 13m	0.258	0.257	0.67709	0.01251
SW 14m	0.258	0.257	0.72917	0.00154
			TOTAL	**0.664 m3/pole**

Estimated wood pole volume required annually for all network companies

Table 4: Summary of annual wooden pole consumption for the entire network industry

	Poles consumed/yr	**Average volume (m3)/pole**	**Total volume consumed (m3)/yr**
Hardwood	**2220**	**0.816**	**1812m3**
Softwood	**3175**	**0.664**	**2108m3**

The estimated number of hardwood poles is consistent after being crossed checked with the main hardwood pole supplier in New Zealand[6] and also with New Zealand trade data on imports (refer appendix A3). However, the estimated softwood consumption is significantly lower than the indicative figure given by one of the softwood supplier, and this can be due to underestimating the proportion of softwood poles used by companies that did not provide consumption data. Companies still use softwood poles for minor applications such as private and service lines, and it is likely that the quantity used for these purposes are underestimated.

[6] Kingham M.- Transpacific Timbers. General Manager. Pers comm. 06 August 2009.

4.2 - CROSSARMS

Current number of crossarms in the New Zealand Network

The total current crossarms estimated for the entire electricity network is just under 2 million crossarms, with 62% in the North Island and the rest in the South Island. The difference in numbers between North and South Island shown in Figure 11 is again the result of greater network distribution coverage in the North Island. Only hardwood and steel crossarms are used by the companies across New Zealand (although some a few other crossarm types are being trialled), and it is obvious that hardwood crossarms are used almost exclusively as demonstrated in figure 12.

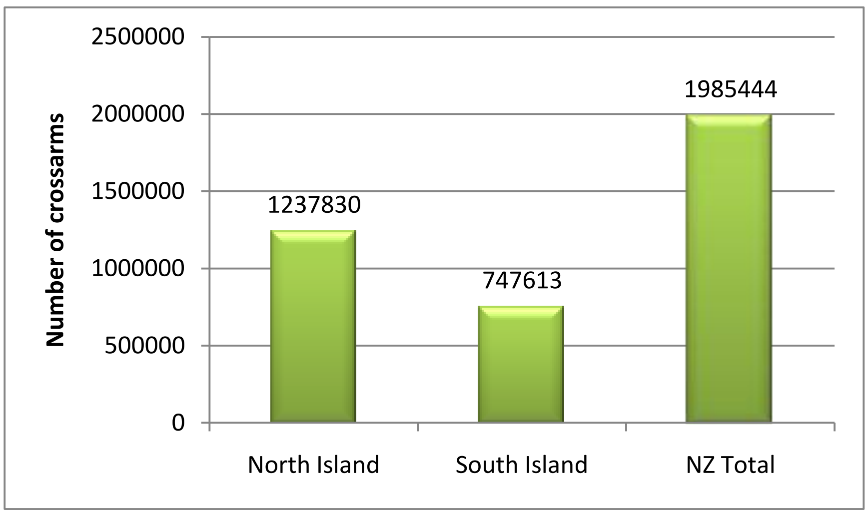


Figure 11: Estimation of the NZ's current total crossarm stock in the network

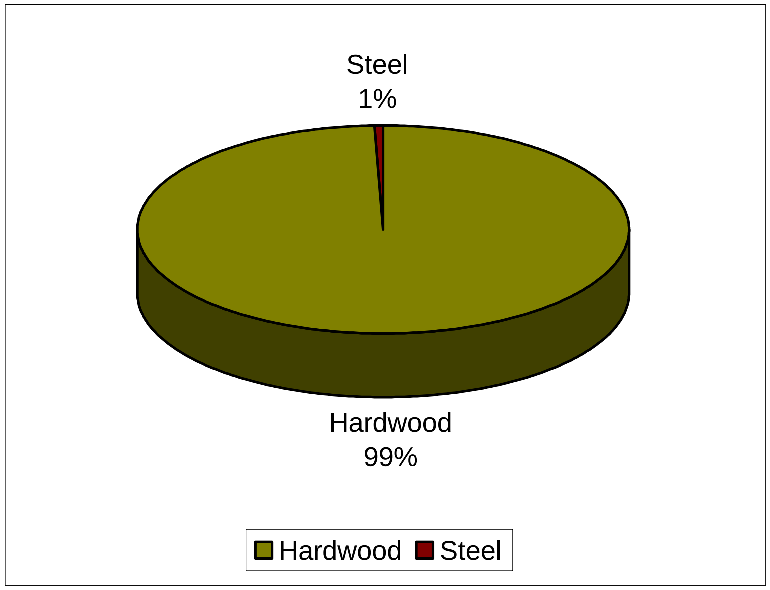


Figure 12: Proportion of current crossarms by type for ALL companies (estimated)

Annual crossarm consumption for the entire electricity network industry

The process of obtaining the estimation of the annual pole consumption for all companies (Figure 13)is presented in the methodology section. Hardwood is the dominant material consumed; representing 97% of the total annual crossarms consumed. The remaining 3% is made up of steel crossarm consumption and are usually only used in special circumstances where high loading capability is required. Only one company is using steel as its main crossarm type due to difficulty in obtaining reliable sources of hardwood.

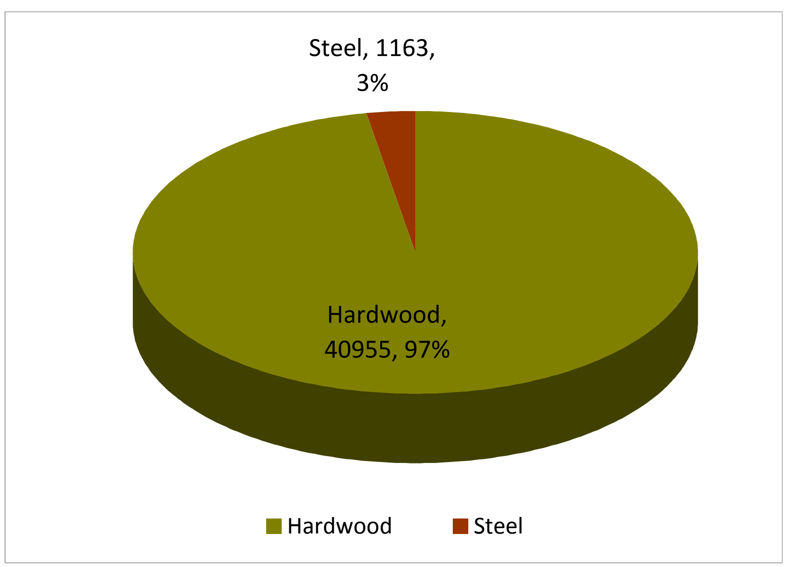


Figure 13: Estimation of Annual Crossarm consumption by type, for ALL companies

Based on the estimated number of crossarms per year, the total consumption rate of crossarms is about 2.1% per annum of the total current crossarms in the network, with hardwood consumption rate of about 2% per annum. The annual crossarm consumption rate is close to two times the pole consumption rate. This is expected as the lifespan of hardwood crossams are shorter than the lifespan of poles, and will need to be replaced or renewed at least once before being replaced at the end of life of the pole.

Unlike poles, the consumption pattern did not show a trend away from hardwood, and the geographical variation of the two regions in New Zealand did not play a role in affecting the crossarm preference. There is an almost-unanimous preference of using hardwood crossarms, apart from the one company mentioned before which account for most of the steel crossarms in the result. Even then, this may be an over-estimation for steel crossarms as it was based on a qualitative feedback only. The graphical representation of these is provided in Appendix A1.

<u>Hardwood Crossarm: Description and specification</u>

Tallow-wood was traditionally the preferred species for crossarms, but supply constraints mean that now Spotted Gum and Ironbark are the two most common species used by network companies. However, other species are also permitted by the companies, including Blackbutt, White Box, Red Mahogany, and White mahogany [5]. All hardwood crossarms are treated with preservatives before being imported into New Zealand, and most will also have gangplates attached at both ends to prevent splitting from occurring. Some companies also order crossarms pre-drilled to their specification. All crossarms must meet the Australian Standard AS 3818.4: Timber- Heavy Structural products- Visually graded, Part 4: Crossarms for Overhead Lines, which is the standard that the companies comply with when considering the suitability of the crossarms. Other relevant documents which are used included the "New Zealand Building Code Clause B2- Durability"

The common specifications of the crossarms were compiled from 9 companies and summarised in table 5. The most common lengths used by network companies are 2m-2.4m. These crossarms are commonly used for the low voltage, 11kV, 33kV, and some 66kV lines. The longer dimensions such as the 5m-6m lengths are only used in situations where heavy loading requirements are needed, such as supporting heavy transformers. 5-6m lengths requires consistent properties for the entire length of the crossarm, and have been suggested that they are difficult to source due to this particular reason.

Table 5: Common crossarm specifications

Hardwood Crossarm Dimensions	Volume (m3)	Weighted Average volume
75 x 75 x 1.3	0.00731	0.00020
75 x 75 x 1.5	0.00844	0.00004
75 x 75 x 1.7	0.00956	0.00028
75 x 75 x 1.8	0.01013	0.00016
100 x 75 x 1.5	0.01125	0.00003
100 x 75 x 1.8	0.01350	0.00004
100 x 75 x 2.0	0.01500	0.00156
100 x 75 x 2.1	0.01575	0.00648
100 x 75 x 2.3	0.01725	0.00009
100 x 75 x 2.4	0.01800	0.00224
100 x 75 x 2.7	0.02025	0.00008
100 x 75 x 3.0	0.02250	0.00031
100 x 75 x 3.6	0.02700	0.00002
100 x 75 x 4.8	0.03600	0.00000
100 x 100 x 1.5	0.01500	0.00003
100 x 100 x 2.0	0.02000	0.00075
100 x 100 x 2.4	0.02400	0.00312
100 x 100 x 2.7	0.02700	0.00137
100 x 100 x 3.0	0.03000	0.00055
100 x 100 x 3.3	0.03300	0.00005
100 x 100 x 3.6	0.03600	0.00008
100 x 100 x 4.8	0.04800	0.00015
100 x 100 x 5.0	0.05000	0.00002
100 x 100 x 5.4	0.05400	0.00008
100 x 100 x 6.0	0.06000	0.00007
100 x 125x 3.0	0.03750	0.00002
100 x 125x 5.0	0.06250	0.00000
100 x 150 x 3.0	0.04500	0.00002
100 x 150 x 3.5	0.05250	0.00001
125 x 125 x 3.2	0.05000	0.00004
150 x 150 x 2.4	0.05400	0.00015
Weighted Avearge Volume (m3)/ crossarm		0.018055

Estimated hardwood crossarm volume required annually for the entire electricity network industry

Table 6: Summary of annual hardwood crossarm consumption for the entire network industry

	Crossarm consumed/yr	Average volume/crossarm	Total volume consumed/yr
Hardwood	40995	0.01805 m3	740 m3

It is estimated that 40,995 hardwood crossarms are consumed per year by the network electricity industry in New Zealand, representing an estimated total volume of 740m3. This is lower than the figure provided by a supplier which suggested imports of an average of 980m3 per year. Analysis of survey data may have underestimated the total annual crossarm consumption due to limited sample size of crossarm data.

4.3.-Indicative prices for Poles and Crossarms

Table 7: Indicative prices for poles and crossarms paid by network companies

	Pole	
Hardwood	$1177/ Pole	$1442/m3
Softwood	$370/ Pole	$489/m3
Concrete	$738/Pole	
Steel	$7788/Pole	
	Crossarm	
Hardwood	$54/ crossarm	$3123/m3
Steel	$250/ crossarm	

The prices provided above should only be treated as indicative prices paid by network companies for each pole and crossarm types. It is notable that there are significant differences in prices between the different materials. Softwood poles have the lowest cost, followed by concrete, hardwood, and steel. However, the cost of steel was only based on the cost given by one company, and may be higher than the actual market price. Hardwood crossarms is significantly cheaper than steel at $54/crossarm.

5.0 - Qualitative Results and Discussion

This section of the result will present the information gathered from the interview with network companies. Specifically, it will provide information that was outlined in the methodology section of this report. Each of the pole types (hardwood, softwood, concrete, and steel) and crossarm types (hardwood, steel) will be presented in detail. Other potential substitutes for wooden poles and crossarms will also be presented.

5.1 -Poles

Historically, there have various types of poles used by network companies in the past, of which wooden poles were used extensively. These included Variants of Australian hardwood, Treated pine poles (Corsican pine, Radiata pine, and some Douglas fir), Larch poles, Concrete poles (Re-inforced and Pre-stressed), Old iron rails, and Lattice steel structures. The dynamics of pole type usage has changed overtime, and currently, the pole types used are Australian Eucalypt variants (mainly Spotted gum and Ironbark), CCA treated radiata pine poles, Concrete poles (Re-inforced and Pre-stressed concrete) and Tubular steel poles. Each of these pole types will be presented in detail below.

Hardwood – Australian Eucalypt Variants

Hardwood poles are well-known for their high strength and ability to withstand dynamic loads. There are no weakness points along the pole as it meets the load requirement in all direction along the pole length[7]. This is particularly important in snow loading regions such as the lower South Island. In the circumstance where the settled snow falls off the conductor and dynamic load is imposed on the poles, hardwood poles will have enough resilience to absorb the load and keep the entire line intact [4]. They are also utilised for high loading requirements (critical poles), such as termination poles, strain poles, and deviation poles [6] (Refer Appendix B).

[7] Coleman R. Powerco. Technical Services Manager. Pers comm. 16 July 2009

Based on the general feedback from the network companies, hardwood poles have a life span ranging from 50 years to 80+ years, depending on the environment they are used in. A common response from the network companies suggests that they have higher maintenance requirements, as they need to be periodically tested for the pole reliability (visual inspection will not suffice). Due to this, companies suggested that the overall life cycle cost of hardwood poles is increased. However, this has not been quantified and could be an area for further work. In addition, companies have expressed concerns about the possibility of below ground failure, and greater variability in pole properties when compared to manufactured poles such as steel and concrete.

Due to the high cost associated with using hardwood poles (actual pole cost and maintenance cost), companies are progressively using them only to meet special load requirements in specific applications explained earlier. This is true for most companies across New Zealand who uses hardwood, apart from one which utilises virtually all hardwood poles in its network.

There are companies who suggest that the quality of hardwood poles is decreasing and variability increasing over time, for example, one company has experienced quality of hardwood poles decreasing from a class 2 to class 3 durability, which is thought to be the result of the fast growing trees from plantation forests[8]. On the other hand, some companies do not have any issues with the supply of hardwood, and are quite content with the quality from the current supply source.

Softwood Poles

Radiata pine poles have the ability to withstand dynamic load, but are limited to low loading applications as they can only service up to 12kN top load (such as low voltage lines and service poles in particular). In addition, radiata pine poles are light in weight (300-400kg) [9] which makes them an economical option when helicopter transportation is required for transporting poles into difficult terrain. The general

[8] Harwood N. & Patterson D. Delta networks. Projects Manager. Pers comm. 06 July 2009

[9] Norris B. The Lines Company. Engineering Manager. Pers comm. 28 July 2009

costing provided suggested that transportation of a pine poles by helicopter will cost \$1500/hr, while up to \$7000/hr is required for transportation of a concrete pole as larger sized helicopters are required (these are solely transportation cost and are indicative only)[10]. In addition, when softwood poles are transported using tractors and trucks, partial ground contact is acceptable as they can tolerate abrasion.

There is a high degree of concern about the performance of softwood poles in the network industry. All companies that used softwood poles in the past have experienced problems with poles twisting, which was very expensive and disruptive. This was thought to be due to the lack of seasoning of the pole before being put into the network, with twisting occurred longitudinally along the pole length as it dries. Due to the high cost associated with line re-work, network companies have avoided using softwood in critical lines by using other substitutes (such as concrete).

However, pole suppliers claim the incidence of poles twisting has been reduced significantly[2]. Goldpine New Zealand described a process whereby trees are carefully selected from the Golden Downs Forests, which then undergo a series of testing and treatment processes and are air dried to < 30% moisture content (drying period of up to 12 months)[2]. After the drying period, the moisture content of the inner portion of the pole will not go back over the 30% level. This screens out any poles that will twist, and poles that did not show any sign of twisting after drying are far less likely to have any twisting occur in service[12]. They also believe the twisting problem is significantly reduced by specifying a minimum of 20 growth rings at the top of the poles used in the network by network companies[10].

Network companies around the country are still cautious about this potential problem, but there are a few companies who are confident and consume softwood poles very widely in their network. This may explain the increase in softwood consumption as discussed for Figure 9 before. In addition, CCA treated Radiata pine can have the potential to last up to 100 years [10], though there has not been a general consensus on this.

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[10] Hurford P. Mainpower. Network Manager. Pers comm. 29 June 2009

Concrete poles

Pre-stressed and re-inforced concrete poles are the two most common types used in New Zealand. There are multiple variants of concrete poles in the market, but in general, pre-stressed concrete is the most widely used. Concrete poles are produced pre-drilled with attachments according to the company's requirements, and also have bonding points for the purpose of pole earthing.

Concrete poles are available in a range of loading capacities and are able to be used from low voltage lines up to the sub-transmission voltage (refer Appendix B for description). Companies that are major concrete poles users favour the consistent properties of concrete poles, as they are less variable than wooden poles and are expected to last over 100 years [13]. The performance of concrete poles is easier to assess during service, as only visual inspection is required. Companies suggested that concrete poles in general have a lower life cycle cost compared to wooden poles, but further work is required to quantify this.

The disadvantage of using concrete poles is their inability to meet dynamic load during service, and loading capacity can vary along the pole length with different load direction [7]. Consequently, concrete poles are not favoured to be used in snow loading areas, as the dynamic load caused by the snow can result in snapping of the poles, leading to the collapse of the entire line[11]. Their inability to handle dynamic load also make it an unsuitable pole type for supporting pole mounted transformers to meet seismic requirements [6].

The life span of concrete poles is dependant on the environment which they are used in. Coastal areas are found to have a corroding effect on the poles and there have been cases where the concrete poles did not meet the expected life span. In these areas, wooden poles are expected to be re-introduced to reduce this problem[12].

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[11] McDonald R. Alpine Energy. Lines Designer. Pers comm. 01 July 2009

[12] Graham E. Top Energy. Maintenance Manager. Pers comm. 10 July 2009

Steel Poles

The types of steel poles used in the past were mainly railway irons and lattice steel structures. Railway irons are progressively being replaced by other pole types. Tubular steel poles have superior strength over all the other pole types and are particularly suited for sub-transmission lines (e.g. 66kV & 33kV) where high ground clearance and high loading capability is required[13]. Steel poles can also be custom-made to the required specification and can easily be transported into difficult terrain in sections to reduce payload. The high cost of tubular steel poles makes it hard for most companies to justify the use of the product currently, but many companies have given an indication that it is an option for use in the higher voltage lines in the future when the cost becomes justifiable.

5.2 - Crossarms

Hardwood and steel crossarms are the only two main types that are currently being used in the network. There are other crosssarm types that are being trialled, such as fibreglass, concrete, and laminated softwood. As presented in Figure 13, the majority of crossarm consumption is hardwood for reasons explained below.

Hardwood crossarms

Hardwood crossarms provide excellent insulation properties for the electricity line, and reduce bird strikes (when birds come in contact with both crossarm and the conductor) that can result in faults. In addition, they are versatile and easy to work with as they can be drilled and modified for additional fittings even when in service. The range of the life expectancy given by the network companies ranged from 25 years to up to 50 years and some companies are able to extend the life of the crossarms by periodically (e.g. every 5 years) tightening loose bolts and nuts [8].

[13] Tapp B. Malborough Lines. Operations Manager. Pers comm. 18 June 2009

In general, most network companies are satisfied with the current supply of hardwood crossarms from Australia, but with a few companies experiencing/experienced decline in supply quality. One company has moved away from hardwood (to steel) as their main crossarm type because of this. However, according to the importer of hardwood crossarms, the quality always exceeds the New Zealand standard requirements before being imported into the country [5].

Steel crossarm

In general, steel crossarms are stronger and longer lasting (more than 60 years) than hardwood crossarms, but are mainly used for high loading requirements only (such as supporting pole mounted transformers). Depending on the company's specific line design, the crossarms are produced and pre-drilled according to the design requirements before installation. However, they are not very versatile as they cannot be drilled and modified in service. This makes it unsuitable for low voltage lines as it will require frequent upgrades such putting on additional attachments.

Other

There are various types of crossarms being trialled by network companies, including fibreglass, laminated softwood, and concrete crossarms. However, the results for these have not been convincing enough for companies to use them widely in the network.

5.3 - Overall market for wooden poles and crossarms

Table 8 below summarises the current total demand for wooden poles and crossarms in the electricity network industry.

Table 8: summary of wood demand for poles and crossarms

Product	Volume (m3) required / yr
Hardwood pole	1815
Softwood pole	2109
Total wooden pole	3924
Hardwood crossarm	710

If the entire network industry utilised only wooden poles, the estimated demand would be 12724m3 per year. This is an indication of the possible market size, but it is a very unlikely scenario. The estimates for softwood poles and hardwood crossarms are lower compared to the estimates given by the suppliers as discussed before, but the result still indicates that the overall market size for wooden poles and crossarms is relatively small.

6.0 - Conclusion and Recommendations

6.1 – Poles

There are varying preferences for pole types between different companies, and this depends on the interaction of multiple factors, such as cost, product performance (loading capability -strength, & lifespan), environment and terrain, product knowledge and preference. As presented earlier, each of the pole types has their advantages and disadvantages, and the choice of pole type depends on the specific requirements of a particular company.

To some degree, the confidence in the product plays an important role in affecting the pole type choices made by the companies. The concrete pole industry has made a significant presence in the market, with quite a few different suppliers supplying the network companies using locally-sourced gravel. Some companies have manufactured their own concrete poles in the past, but have now sold the operation to major concrete pole producers. This may be an indication that the wood pole industry may be able to perform better with more active promotion for the use of wooden poles.

The pattern of pole type consumption will likely change in the near future, with the proportion of concrete poles increasing due competitive price and its ability to substitute for wooden poles in many circumstances. This will be at the expense of hardwood poles as high cost has resulted in companies moving away from them. However, hardwood pole consumption is unlikely to decline beyond a certain level, because there are circumstances where hardwood poles are not feasible to be substituted due to its ability to cater for special requirements as discussed before (e.g. snow loading areas).

New Zealand-grown softwood poles still encounter a lack of confidence by the network companies because of their past inconsistent quality and problems with twisting. The likely trend for softwood poles is unclear, as it seems that there is a disparity in opinion by companies on the use of this pole type. There is a possibility that the use of softwood poles can further increase, provided that the electricity network companies can be convinced of their ability to perform. Even if the demand for softwood does not increase, it is likely that it will remain favourable for service or private lines (lower strength requirements) due to low cost. Furthermore, softwood poles are economical to use when helicopter transportation is required.

The steel industry has yet to prove itself in the New Zealand market, even though it is thought to be the desired pole type especially for high voltage lines. Most companies are still trying to justify the high cost of steel, and are trialling this product to determine its actual performance. Steel poles have a potential to become a strong competitor in the market when the price drops to an acceptable level.

6.2 - Crossarms

The consumption trend for crossarms is much less complicated than poles, as there are limited varieties that are suitable and competitive in the current market. The results presented earlier clearly show that hardwood crossarms are used almost exclusively in the network, not only because of competitive price, but also versatility and excellent insulation properties.

In the future, hardwood is likely to remain the preferred crossarm product, as there is no immediate indication by network companies of their intention to use other products. However, with the increase use of concrete poles, companies may slowly shift towards steel crossarm to complement the longer life span of the concrete poles in order to minimise maintenance throughout the life cycle of the line. The future use of other products including laminated softwood, fibreglass, and concrete crossarms is not easy to estimate, but is unlikely to be significant in New Zealand.

6.3 - Overall wooden pole and crossarm market

The estimated annual demand of 4634m3 of wooden poles and crossarms is comparatively small. However, if the indicative prices are put into perspective, it is clear that wooden poles and crossarms are high value products. In particularly, at about $\$3000/m^{3}$, hardwood crossarms can be a potential high value niche market that

New Zealand forest growers should consider. Unlike poles, there are currently very few viable substitute products.

Hardwood poles have the ability to cater for special requirements, and because of this, it is likely that there will always be a market for hardwood poles in New Zealand. If the demand for hardwood poles is to be increased, plantation grown hardwood will need to be able to provide comparable properties to the Australian native hardwood, produced at a competitive price.

Australian native hardwood poles and crossarms are experiencing supply constraints, as presented in the literature review. Australia has already looked into forest-grown hardwood poles as an alternative for the shortage of native sources, but these are of lower durability (class 3 & 4) (Francis & Norton, 2006). This presents an opportunity for New Zealand to grow alternatives hardwood products. Although New Zealand market for hardwood poles and crossarms is relatively small, it is worth noting that there are other countries that utilises native Australian hardwoods, and there is a wider market potential for these products outside of the country.

With escalating interest in climate change and greenhouse gases reductions globally, wooden poles and crossarms may experience an increased in interest due to the fact that they are carbon neutral. In comparison, concrete and steel poles have significantly higher global warming potential than wooden poles (Sedjo, 2001). If companies have to pay a premium for the carbon emissions produced by their products, it would cost them more in emissions payment for concrete and steel poles. In fact, this may be one of the reasons why some companies in New Zealand are more wood based than the others.

On the final note, it is clear from the findings that there is the potential for New Zealand to cater for the wooden poles and crossarms market both locally and overseas. There are other aspects that need to be considered, and will be discussed in the penultimate section of this report.

7.0 - Limitation and further work required

One of the main limitations of this study is the difficulty in obtaining consistent data from all companies. This is expected as not all companies will have the data requested, or enough resources to provide the data voluntarily. The analysis of this study took this into account to minimise the effect of this limitation.

Further work should be undertaken on the life cycle cost of each of the different products. Information of this type would provide better information for network companies to choose between pole types. This will also provide an indication of how much the companies are willing to pay for each product relative to each other. Studies such as these have been carried out in Northern America and have produced varying results as presented in the literature review.

The future demand of wooden poles and crossarms was considered in this study only in a qualitative way. Projections could be determined from the network maintenance, replacement and expansion plans of the companies, if there were available, using the relationships developed in this report.

8.0 - References

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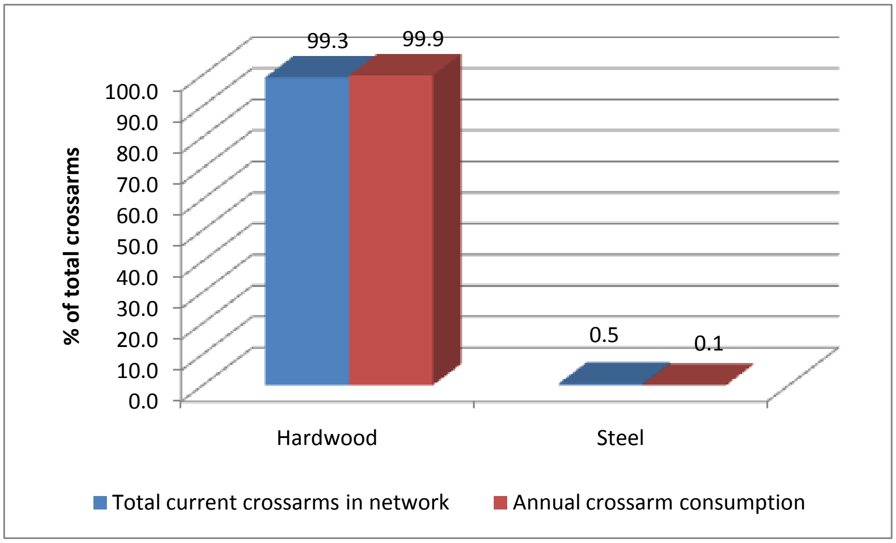
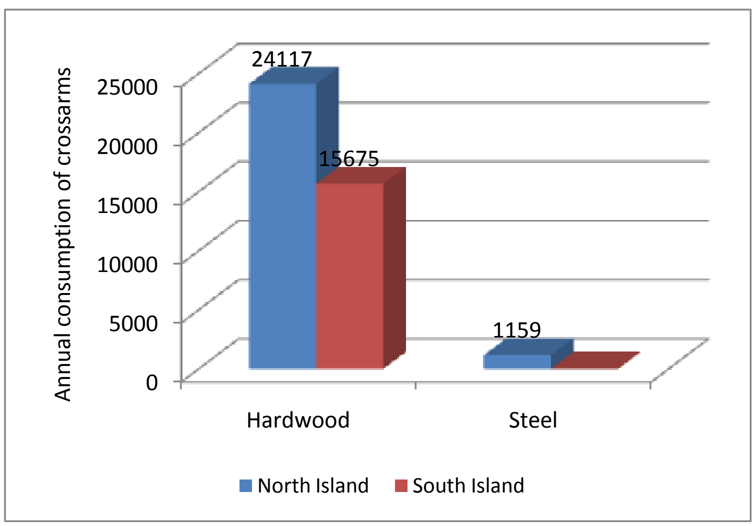
http://www.crossarms.com/products.html Date Visited: 7 October 2009

9.0 – Appendices

9.1 – Appendix A – Graphs and Tables



Appendix A1: Comparison of percentage of crossarms by type, between total current crossarms in network and annual consumption for ALL companies (Estimate)



	New Zealand	North Island	%	South Island	%
Hardwood	39792	24117	60.6	15675	39.4
Steel	1163	1159	99.7	4	0.3
Total	40955	25276	61.7	15679	38.3

Appendix A2: Crossarm types distribution across the North and South Island of New Zealand

Appendix A3: Trade data on imports for the following: *Wood; of non-coniferous species, whether or not stripped of bark or sapwood, or roughly squared; treated with paint, stains, creosote or other preservatives, not sawlogs or veneer logs*

	Quantity	Cost including insurance and freight	Value for duty
1988	0	0	0
1989	0	0	0
1990	0	0	0
1991	0	0	0
1992	0	0	0
1993	0	0	0
1994	255	155,584	118,234
1995	527	331,631	261,863
1996	825	611,050	506,921
1997	1,875	821,763	621,733
1998	2,341	1,037,595	740,101
1999	2,019	795,647	623,203
2000	3,935	1,982,106	1,467,730
2001	4,109	2,274,945	1,747,723
2002	3,902	1,407,454	1,058,389
2003	1,162	766,703	546,753
2004	1,709	1,234,002	854,529
2005	2,205	1,524,312	1,009,505
2006	2,702	2,313,681	1,518,447
2007	2,373	1,991,012	1,357,388
2008	2,085	1,828,510	1,194,648

	Quantity	Cost including insurance and freight	Value for duty
Total	32024 poles	$19,075,995	13627167
Average	2135 poles/yr	$596/pole	$426/pole

9.2 – Appendix B - Glossary of Terms

CCA Preservative treatment group – In accordance to NZ TPA MP3640, with the following description:

- H3 – Sawn timber for exterior exposure, not in contact with the ground.

- H4 – Sawn or round timber fence posts, agricultural posts, vineyard posts, horizontal sawn timber rails for retaining structures where replacement is relatively simple and easy.

- H5 - House poles and piles, retaining wall poles, transmission poles, horizontal sawn timber rails for retaining walls where replacement is a major exercise. Some lightly fertilized horticultural soil has a fungus that decays the poles at ground level, which can be managed by wrapping the pole with a plastic bag near the ground surface.

- H5b- Slightly higher retention than H5, marketed by some companies specifically for buildings. Only H5 or H5b treated poles are normally used for buildings and retaining walls.

- H6 - Marine exposure, to increase life to 50 years from general 20 year life, the wet area above ground level may be covered with a double layer of densotape and protected with plastic tape (although the practicality of this suggestion should be borne in mind for each situation).

Deviation poles- Poles that are located along the line which are required to support additional stress and strain due to change in direction of the line

Distribution network- Consist of 33kV, 22kV, and 11kV set-up

Durability Class- Assigned class 1 – class 4 based on the natural durability of the timber. Class 1 being most durable, and Class 4 being least durable. The exact description of durability class can be found in AS2209 & AS/NZS 4676, and the general guide on life expectancy is presented in the table below:

	General life expectancy (years)	
Durability class	Above ground (exposed to weather)	In-ground contact (exposed to weather)
Class 1: Very Durable	40+	25+
Class 2: Durable	15 to 40	15 to 25
Class 3: Moderately Durable	7 to 15	5 to 15
Class 4: Perishable/Non-durable	0 to 7	0 to 5

Dynamic load- The load that is created due to sudden fluctuation of line tension, such as the sudden flux of snow load on the conductor (the cable that carries electricity)

Earthing- All means and measures for making a proper conductive connection to earth

Overhead service line- An overhead line operating at a voltage less than 1000V generally located between the electricity supply authority's overhead line and the point of connection to an electrical installation

LED- Large end diameter of the pole

Low Voltage network - Consist of voltages lower than 1000V. Most commonly 400V.

SED- Small end diameter of the pole

Snow loading areas- Areas that are prone to snow deposits. Line design in these areas are required to take into account the extra load that will be placed on the line. These areas also requires poles that have high dynamic loading capability due sudden flux of snow load on the conductor.

Strain poles- Poles that are required to support additional stress and strain due to other applications

Strength Group- Based on the strength of green timber with the general description in accordance to AS/NZS 4676 & AS2209, and the general description is presented below as a guide:

Minimum values for strength groups for green timber							
Property	S1	S2	S3	S4	S5	S6	S7
Modulus of Rupture (MPa)	106	86	73	62	52	43	36
Modulus of Elasticity (GPa)	16.3	14.2	12.4	10.7	9.1	7.9	6.9
Maximum Crushing Strength (MPa)	52	43	36	31	26	22	18

Sub-transmission network- Commonly consist of 66kV and 33kV set-up, but can include 50kV as well.

Transmission network- Operated by Transpower on 110kV

Termination poles- Poles that are located at the end of a line construction which are required to support additional stress and strain

9.3 - Appendix C- relevant standards for wooden poles and crossarms

Hardwood poles

AS 2209 – Timber – Poles for Overhead Lines

AS 1604.1- Specification for preservative treatment – Sawn and round timber

AS 1720.1 – Timber structures code

AS/NZS 4676:2000 Structural design requirements for utility services poles

Softwood poles

NZS 3605:2001 Timber Piles and Poles for Use in Building

AS/NZS 4676:2000 Structural design requirements for utility services poles

NZS 3603: 1993 Timber Structures Standard

NZ TPA MP 3640 Timber Preservation

Hardwood crossarm

AS 1604.1 Specification for preservative treatment – Sawn and round timber

AS 3814.4 Timber –Heavy Structural products- Visually grade, Part 4: Cross Arms for Overhead Lines

9.4 – Appendix D- Survey Instrument

Survey of trend and usage for poles and crossarms

Contact: Boon Khiang Tan

Student – BForSci (Hons)
University of Canterbury
School of Forestry
Mobile: 021-1759 182
Fax: 03 364 2124
Email: bkt16@student.canterbury.ac.nz / tbk889@gmail.com

The aim of this survey is to estimate New Zealand consumption of wooden pole and cross-arms by electricity lines companies. The first page of this survey contains questions which I will be discussing with you over the phone. The second page, plus the excel spreadsheet attached describes the data required. You may key your data directly into the spreadsheet, or if it is easier for you to provide the information in any other ways (for example faxing through the data), please feel free to do so. All the information provided will be used to produce national averages, and confidentiality will be maintained. We sincerely appreciate your support for this study, and look forward to talk to you soon.

Phone survey questions

Poles:

1-What are the pole types that the company used in the past?
2-What are the current pole types used by the company now?
  a.If hardwood is included, please specify the common species and the whether it is treated or not.
  b.If treated softwood is included, please specify the common species and treatment type.
3-What drives your decision to use the different pole types, and if the company has moved away from specific pole type in the past, what is the reason behind this decision?
4-Where does your supply of different pole types originate from?
5-Are there any supply issues, especially in regards to hardwood poles?
6-Is there a preference of pole type usage in certain conditions/design (e.g. Voltage level, underbuilt, snow loading areas, terrain, seismic design, life cycle cost, etc…please specify)?
7-In the future, which direction do you see your company most likely to head in terms of the usage of different pole types? Why is this?
8-Are there any potential substitutes in the future that the company may use (for example, fibreglass etc)?

Crossarms:

1-What are the different crossarm types that the company used in the past?
2-What are the crossarm types used by the company now?
  a.If it is hardwood, what is the most common species used?
3-What drives your decision to use the specified crossarm type(s)?
4-Where does your supply of crossarms originate from?
5-Are there any supply issues, especially in regards to hardwood crossarms?
6-Is there a preference of crossarm type usage in certain conditions/design (e.g. Voltage level, snow loading areas, transformers, seismic design, life cycle cost, etc…please specify)?
7-In the future, which direction do you see your company most likely to head in terms of the usage of crossarms? Why is this?
8-Are there any potential substitutes in the future that the company may use, or have looked into (for example, fibreglass, laminated crossarms etc)?

Drivers for replacements, maintenance and new establishments:

1-How does your company decide when to replace poles and crossarms that are reaching their end of life?
  a.If available, what is the average life span that the company gets for the different pole types and crossarms?
2-In the circumstance where pole and crossarm replacements are carried out as a result of line upgrade, what are the factors that determine their replacements?
3-What are the drivers in your region that dictates new line establishments?
4-What is the estimated length of new overhead line expansion in your network per year? Which voltage level is this most likely to be?

Description of data required:

1-What is the company's expected annual capacity growth and how does this relate to line upgrades and new line establishment?

Poles:

1-What is the current number of poles in the network by each pole type, for each voltage level?

2-What is the price that is paid for each of the different pole types by your company?

3-What is the consumption of poles (by types and specification) by the company for the last 3 years? EITHER provide :

a. How many poles for each pole type, by specification are being put into the network each year for the last 3 years?
OR
b. How many poles for each pole type, by specification are purchased each year for the last 3 years?

4-Of the number given for the last financial year, how many poles (or %) were used

a. to replace poles that reached their end of life?
b. for line upgrades? (e.g. as a result of increase in load demand)
c. for new line establishments?
d. due to faults?
e. due to relocation driven by others?

Crossarms:

1-What is the current number of crossarms in the network, for each voltage level?

2-What is the price that is paid for crossarms by your company?

3-What is the consumption of crossarms (by types and specification) by the company for the last 3 years? EITHER provide :

a. How many crossarms, by specification, are being put into the network each year for the last 3 years?
OR
b. How many crossarms for, by specification, are purchased each year for the last 3 years?

4-Of the number given for the last financial year, how many crossarms (or %) were used

a. to replace crossarms that reached their end of life?
b. for line upgrades? (e.g. as a result of increase in load demand)
c. for new line establishments?
d. due to faults?
e. Due to relocation driven by others?