

Minimum Energy Performance Standards for Distribution Transformers

Prepared for:



By Murray Ellis

Dialogue Consultants Ltd

July 2003

Table of Contents

1.	Background	1
1.1.	Context	1
1.2.	Scope	1
1.3.	Public policy objectives	1
1.4.	Methodology	1
1.5.	Significance of market failure	2
1.6.	Counterfactual	2
1.7.	Cost of capital and discount rate	3
1.8.	Present and future energy prices	3
1.9.	Emissions value of energy saved	4
2.	The Transformer Market	4
2.1.	Transformer demographics	4
2.2.	Transformer supply	6
2.3.	Efficiencies	9
2.4.	Prices	9
2.5.	Technological development	10
2.6.	Options for maintaining efficiencies	10
2.7.	Regulatory activity and experience in other countries	11
2.8.	Measures in place	12
2.9.	Technical considerations	12
2.10.	Trade issues	13
3.	Analysis and results	13
3.1.	Energy consumption changes	13
3.2.	Economic impact	16
3.3.	Environmental impact	20
3.3.1.	Emissions reduction	20
3.4.	Uncertainty analysis	21
3.5.	Administration costs	21
4.	Business compliance cost statement	21
4.1.	Sources of compliance costs	21
4.2.	Parties affected	21
4.3.	Estimates of compliance costs	22
4.4.	Overlapping compliance requirements with other agencies	23
4.5.	Compliance cost minimisation	23
4.6.	Risk assessment	23
4.7.	Intangible factors	24
4.8.	Key issues	24
5.	Conclusions	24
5.1.	Net benefit of the proposal	25
6.	Recommendations	26

1. Background

1.1. Context

New Zealand is developing, largely in harmony with Australia, a suite of mandatory minimum efficiency requirements for specific appliances. The objective is to reduce national energy consumption without sacrifice of consumer benefits. Mandatory requirements are considered appropriate in situations where information and market forces cannot be expected to adequately encourage the use of the most cost-effective technologies.

Australia is proceeding toward the introduction of a minimum energy performance standard (MEPS) for distribution transformers, which is likely to be implemented in late 2004.

1.2. Scope

Distribution transformers are, in general terms, transformers with a capacity of at least 1 kVA, a high voltage primary and a secondary voltage at consumer level, i.e. around 415/240 volts¹. The definition in the standard is rather different from this, being “power transformers with power ratings from 10 kVA to 2500 kVA and system highest voltage up to 24 kV”. There is no prescription as to whether this voltage is on the primary or secondary, or what the voltage on the other winding may be. Hence transformers such as a 11kV/22kV SWER transformer will be included, whereas a 33kV/11kV SWER transformer will not be.

There are a number of transformer types that are not included. Most of these are special purpose devices not normally used in distribution systems. However, also excluded are “Transformers other than those on 11 or 22 kV networks”. As a result, transformers installed on 6.6 kV networks, of which there are still a considerable number in New Zealand, notably in Dunedin, are not covered by the MEPS, even if they are wound to enable subsequent conversion to operation at 11 kV.

1.3. Public policy objectives

The objectives of introducing a MEPS for distribution transformers are:

- increase New Zealand’s overall energy efficiency by reducing electricity losses in transformers, thereby moving New Zealand toward a sustainable energy future; and
- assist New Zealand toward a more productive and internationally competitive economy.

An important component of New Zealand’s economy is the maintenance of good international economic relationships. This especially relates to the Closer Economics Trade Agreement (CER) with Australia.

In determining a desirable level at which to set a MEPS it is New Zealand’s policy, as agreed jointly with Australia by ANZMEC in 1999, to match the best MEPS levels of our trading partners.

1.4. Methodology

This report considers whether there is any good reason to anticipate that market mechanisms alone will not result in the production and selection of efficient distribution transformers. The likely consequences of not introducing a MEPS are considered, and the change in transformer costs compared with the value of the change in electricity consumption. For this purpose overseas information on the relationships between efficiency and cost are sought and explored.

¹ These voltages are for phase to phase for 3 phase supply, and phase to neutral for single phase supply. They are slightly higher than the standard nominal supply voltages of 400/230 volts to allow for voltage losses downstream of the transformer.

Overseas MEPS are looked at for examples of existing MEPS for distribution transformers, and the relevance of these to the proposal considered. Trade issues, especially with Australia are considered, and the consequent requirements for the adoption of standards.

The overall value of introducing a MEPS is then estimated from the demographics of the distribution transformer population and likely rate of replacement.

1.5. Significance of market failure

With the present structure the network companies, which buy distribution transformers, have no financial interest in the electricity expended within them. Consequently the profit maximising option for network companies is to purchase the transformer with the lowest capital cost, without regard for efficiency. The consequent costs are incurred by consumers, who have no means to avoid them. To date, this incentive has been offset to a degree by:

- continuation of established engineering practices;
- lines company ownership by consumers through ownership by a trust or district council.

Neither of these provides secure or lasting protection against deterioration in transformer efficiency. Lines company management is no longer dominated by engineers to the extent that was previously the case. The lines in a number of areas are now owned by companies which have their ownership interests elsewhere. This situation may well expand as the industry consolidates.

Concern for efficiency is potentially further attenuated by the optimised deprival value (ODV) valuation process. Additional expenditures to acquire transformers that are more efficient than necessary may not be credited under the ODV process, since this is based on the minimum necessary replacement, not historic, cost even for newly acquired assets.

The lines companies are coming under price control by the Commerce Commission. Price control could be used to provide a pressure to minimise energy losses. However the Commission's recent determination² does not do this. Indeed the decision may exacerbate the situation. It imposes an effective revenue cap on each company through setting a price path. The intended effect is to encourage the companies to minimise costs. Reducing the prices paid for distribution transformers will be a natural response to this. The potential consequence is a serious erosion of transformer efficiencies.

1.6. Counterfactual

Transformers are a very mature technology, and transformer efficiencies are already high. Nevertheless, past trends, up to the time of industry restructuring, were for a progressive improvement in efficiencies as materials improved and were taken up. The initial effects of restructuring were small, as there was little immediate change in decision makers or incentives. This situation is changing as financial expertise becomes more highly valued in the industry's management, and as the incentives change, especially with the introduction of price control.

Just how rapidly the efficiency of distribution transformers will deteriorate in the absence of a minimum efficiency requirement is purely speculative. There is anecdotal evidence that transformer selection has already moved toward minimum first cost. A more concerted move now needs to be anticipated. A harbinger of the new regime may be a statement in Vector's Asset Management Plan³: "*the use of oil filled distribution transformers and switchgear is being reviewed. Other types of transformers and switchgear and cooling and insulating mediums are being investigated*". Given the separate schedule of considerable lower efficiencies for dry-type transformers in the proposed MEPS, even the introduction of a MEPS will not be able to prevent a significant lowering of efficiencies by the suggested change.

² Regulation of Electricity Lines Businesses, Targeted Control Regime, Threshold Decisions. 2 May 2003

³ Asset Management Plan 2002/03, Vector

1.7. Cost of capital and discount rate

The cost of capital to a network business has been a source of considerable contention. In general the range of claimed costs has been in the range of 6 to 9%. To be a little conservative a rate of 8% is taken as representative.

Distribution transformers are also purchased by industries and commercial organisations which take electricity supply at high voltage. These businesses face much higher costs of capital than network companies, to a widely varying extent depending on the nature of their business. For present purposes a representative, but fairly high, rate is taken of 20% pre-tax.

As a general rule the network companies have purchased oil filled transformers while the dry-type transformers have been purchased by the industrial and commercial businesses. This is not a reliable rule: many of the transformers used by industrial and commercial businesses are oil filled, and some network companies have dry-type transformers, especially in sites where oil spills would be an environmental or hazard problem.

1.8. Present and future energy prices

The recent behaviour of electricity prices had been highly unstable, and provides a poor basis for setting a value for long-term policy making purposes. In principle, the longer term value provided by the hedge market is a better guide. Unfortunately the hedge market is very thin and has also exhibited considerable volatility. Prices have generally risen since the announcement of the reduced Maui reserves, and the consequent realisation that additional generation would be required from other, and more expensive, sources.

The Ministry of Economic Development's Energy Supply and Demand Forecast in 2002 estimated that future generating costs would be 6 to 6.5 cents/kWh, but also noted that the availability and price of gas would be crucial. In the absence of significant additional discoveries of gas "*new capacity from around 2007 for the next 15 years is expected to comprise renewables*". This was anticipated to be available from wind, geothermal and Project Aqua at costs up to 6.5 c/kWh. This suggests that 6.5 c/kWh is a reasonable value at which to estimate the future cost of electricity.

This value is for electricity at the generation plant. Costs and losses in transmission and sub-transmission are additional to this by the time the electricity reaches a distribution transformer. Transmission losses, and to a lesser degree costs, are highly dependent on location relative to generation. Losses vary as the source of generation varies. Strictly speaking, it is the marginal change in losses as electricity demand varies that is applicable. These are usually higher than average losses, but can be lower in situations where there are significant fixed losses, such as those in transformers. For present purposes an average marginal loss of 5% is assumed.

Losses in distribution up to the input to the distribution transformer can only be estimated, as the composition of distribution losses is not published. It is clearly highly variable between urban and rural locations, depending on the length of distribution line traversed by the power. A representative average that excludes the losses in the distribution transformer and low voltage reticulation is 2%. Losses in rural networks will considerably exceed this.

To this must be added the energy or demand based charges for transmission, and for distribution as far as the input to the distribution transformer. This is equivalent to the line charges for a large industrial or commercial consumer taking power at high voltage. These are also highly variable between network companies, and even within each network company's area, partly because the variation in the level of Transpower charges that they face. A review of the charges of a number of network companies suggests that a rate of 1.3 c/kWh is appropriate. In principle a rate somewhat lower than this could be attributed to the electricity input to a network company's transformer, if actual costs were the guide, however it is the addition to charges levied on end-consumers that is more relevant.

In aggregate the cost of energy, after transmission and sub-transmission losses is 7 cents/kWh. Adding the charges increases this to 8.3 c/kWh.

It is noted that this situation differs considerably from that reported in Australia, where expected marginal costs (in Australian currency) of electricity into network company transformers was 3.3 to 4.9 c/kWh⁴ (depending on state), whereas the cost into transformers owned by large users was estimated at some 7.3 to 14.1 c/kWh. This reflects structural differences between the two markets.

1.9. Emissions value of energy saved

If, as anticipated by the Ministry of Economic Development, future increases in electricity production are met from renewable sources, the emissions consequences of a small and gradual change in electricity consumption will be very small. They will comprise only the carbon dioxide and hydrogen sulphide gases from geothermal generation. The rate of emissions of these gases varies widely between fields.

If, on the other hand, renewable sources of electricity prove insufficient to supply all increases in consumption, the long run marginal source of generation will most probably be coal. In the early years this can come only from Huntly. This will result in a greenhouse gas (GHG) emissions rate of some 890 tonnes of carbon dioxide equivalent per GWh (tCO₂e/GWh). At some stage new plant would presumably take over this role from Huntly, with a higher efficiency, but likely to obtain a greater part of its fuel from underground mining, and thus with higher methane emissions from the mining process. This could bring the emissions rate down to some 860 tCO₂e/GWh.

2. The Transformer Market

2.1. Transformer demographics

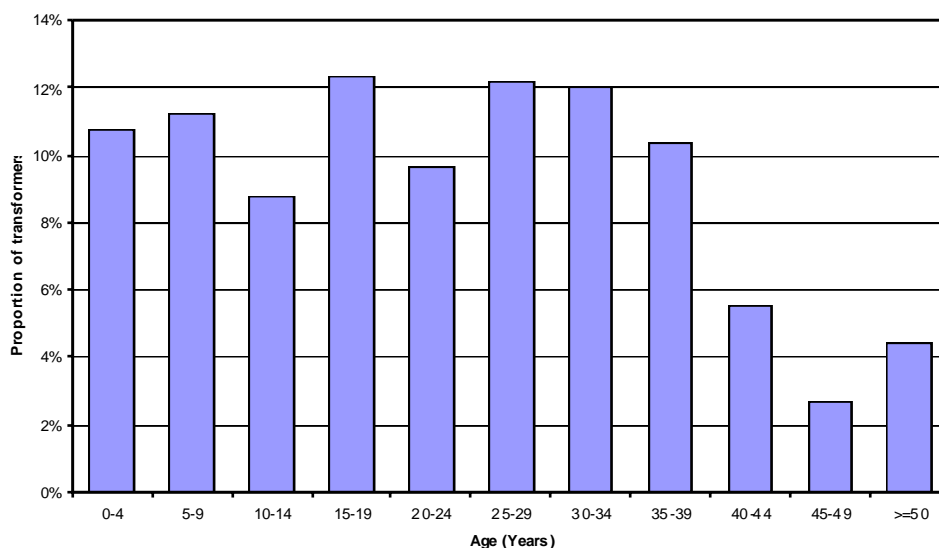
There has been no co-ordinated collection of information about physical plant from network companies since deregulation. In 1986 the “Annual Statistics in Relation to Electric Power Development in New Zealand” recorded a total of 121,954 distribution substations with a total capacity of 31,860 MVA. Since this is an average of 261 kVA per transformer, it is clear that high voltage power transformers are included in these totals. However the number of distribution transformers would be only a little lower, perhaps some 121,000.

Unlike the situation in Australia, there has been no prior assessment of the numbers and characteristics of distribution transformers. To obtain some information to fill this gap a review of a wide range of network company asset management plans, plus information provided by a number of network companies, has been undertaken. This indicates that the number of transformers owned by network companies has now reached some 175,000, and the total capacity is some 10,700 MVA. No information is available on transformers owned by consumers.

From this information the age distribution of existing transformers has been estimated, as shown in Figure 1.

⁴ Regulatory Impact Statement on MEPS for Distribution Transformers, George Wilkenfield and Associates, May 2002

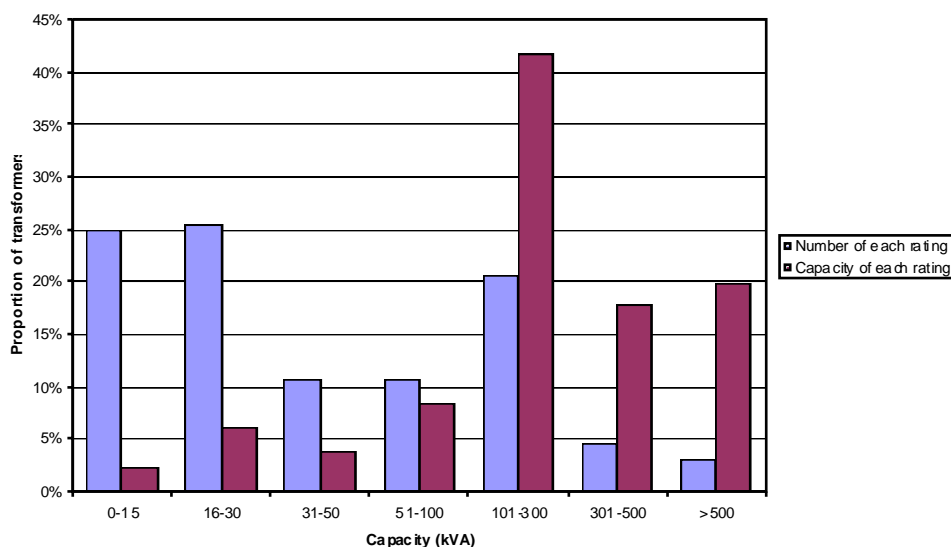
Figure 1: Age distribution of network company distribution transformers



As Figure 1 shows, there is a significant number of very old transformers still in service, well beyond the nominal life of 45 years. The oldest transformer identified was made in 1928. Some companies have plans for accelerated replacement of these over-aged transformers.

The estimated capacity distribution of these transformers is shown in Figure 2.

Figure 2: Capacity distribution of network company distribution transformers



It is notable that although transformers of 30 kVA or smaller account for 50% of the total number, these account for only 8% of the total kVA.

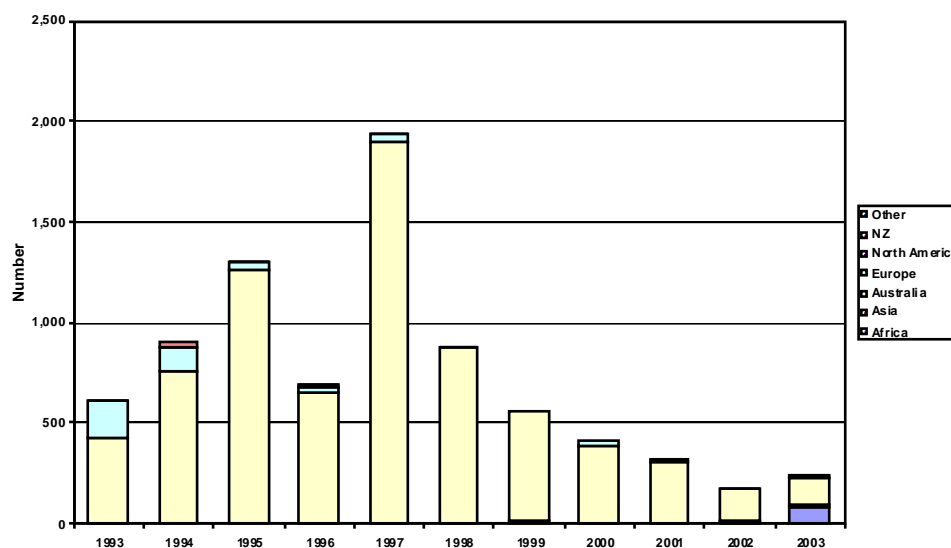
The future rate of transformer purchases will depend, in part, on the life expectancy of the existing ones. Historically, distribution transformers have lasted for some 45 to 55 years. There is considerable variation of opinion regarding the life to be expected of modern transformers. These are considerably smaller and lighter than those now old enough to require replacement. The standard life expectancy for distribution transformers, set in the ODV guidelines, is 45 years, consistent with historic life expectancy. The most common assumption is that a life of 45 to 50 years will be sustained, but other opinion is that their life will be substantially shorter, possibly as low as 25 years.

2.2. Transformer supply

Most of the transformers sold into the New Zealand market are made in New Zealand. There are two main manufacturers, ABB in New Plymouth and ETEL in Auckland. The number of distribution transformers being imported cannot be accurately determined, as the categorisation of transformers for customs purposes does not match the definition of a distribution transformer.

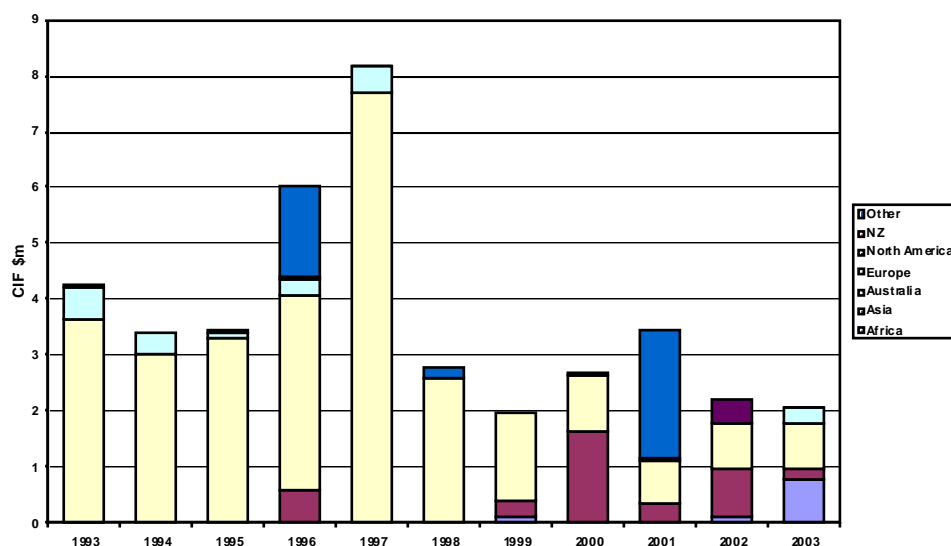
The imports of oil-cooled transformers were estimated as those having a liquid dielectric, and a power handling capacity not exceeding 10,000kVA. The numbers of these are shown in Figure 3.

Figure 3: Imports of oil-cooled distribution transformers



The value of these is shown in Figure 4.

Figure 4: Value of imports of oil-cooled distribution transformers



The classification includes transformers both smaller and larger than distribution transformers. The number and value of the very small ones would be insignificant. However the larger transformers included are clearly substantial in value, although probably minor in numbers. This is shown by the imports from Asia and “Other” countries (mainly Brazil), which are trivial in numbers but of substantial value. The recent imports from Africa (mainly South Africa) may well be genuine distribution transformers. The spike in imports from Australia in 1997 appears to be related to the marketing of a batch of low efficiency transformers that had been rejected in Australia.

A similar, but more severe, situation applies to the categorisation of dry-type transformers. Those under 16 kVA can be excluded, but the voltages are unknown. Consequently both numbers and value of imports are inflated by the inclusion of non-distribution transformers. The numbers (with that proviso) of dry-type imports are shown in Figure 5, and in value terms in Figure 6.

Figure 5: Imports of dry-type transformers over 16 kVA

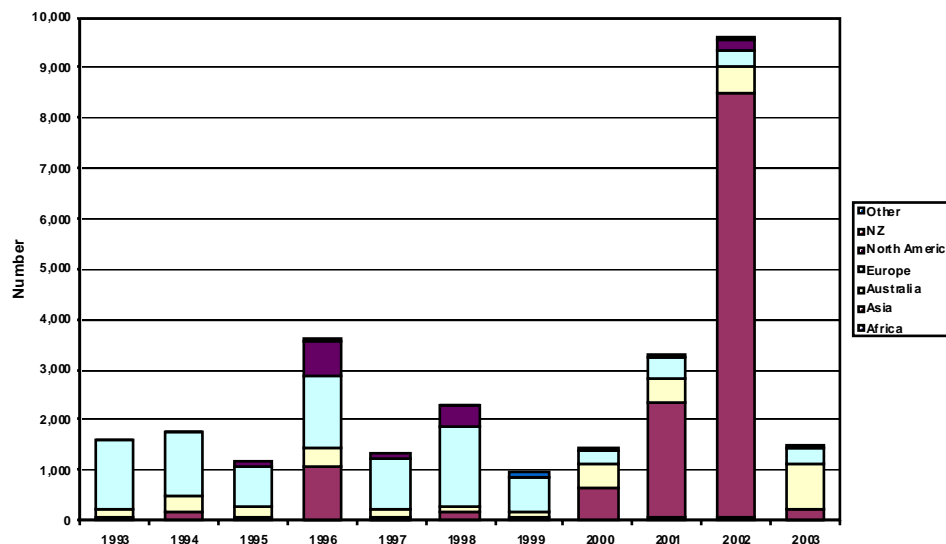
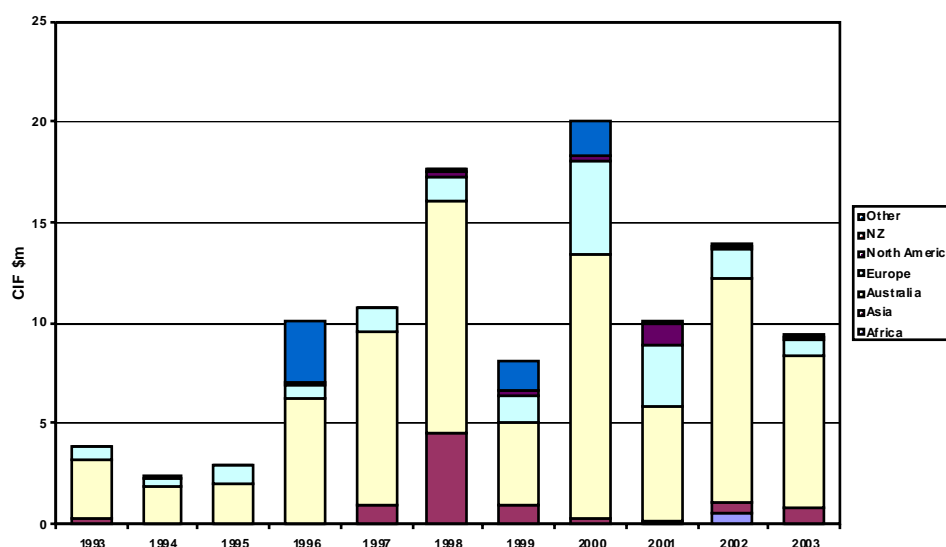


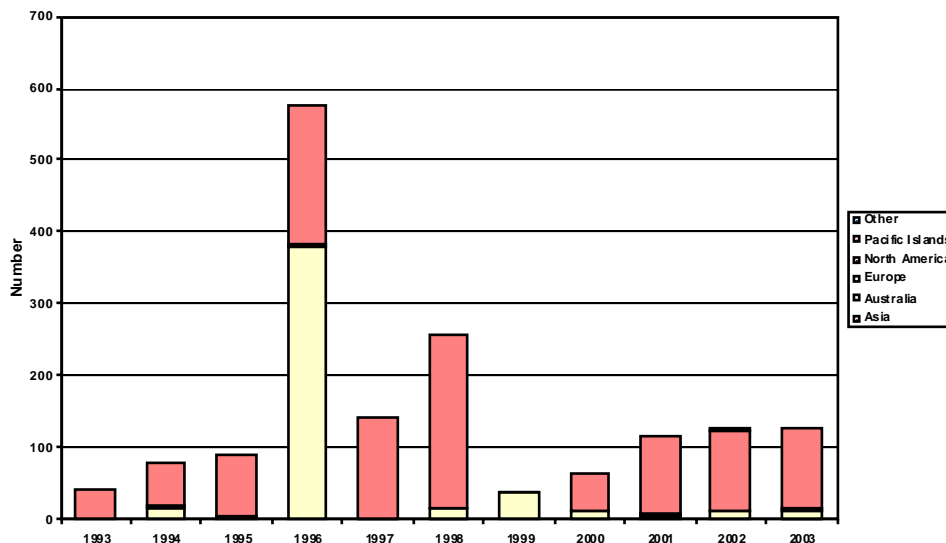
Figure 6: Value of imports of dry-type transformers over 16 kVA



The very different appearance of Figure 5 and Figure 6 indicates that the imports from different countries are in very different price brackets. An examination of the implied average prices shows variations from \$3 to \$3 million per transformer. Clearly the Trade Import Statistics need to be treated with some caution.

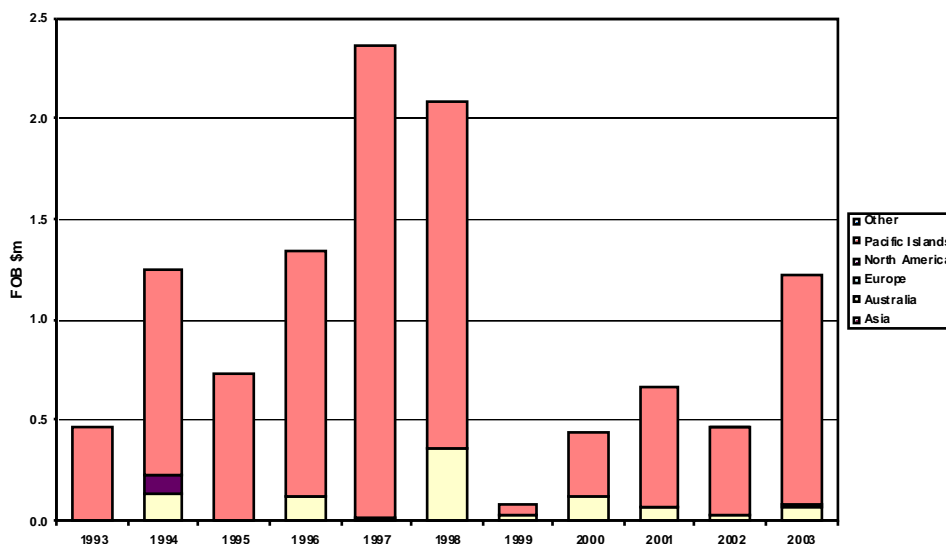
Transformer exports are on a somewhat smaller scale than imports, but are still appreciable, as shown in Figure 7.

Figure 7: Exports of oil-cooled distribution transformers



The value of these is shown in Figure 9.

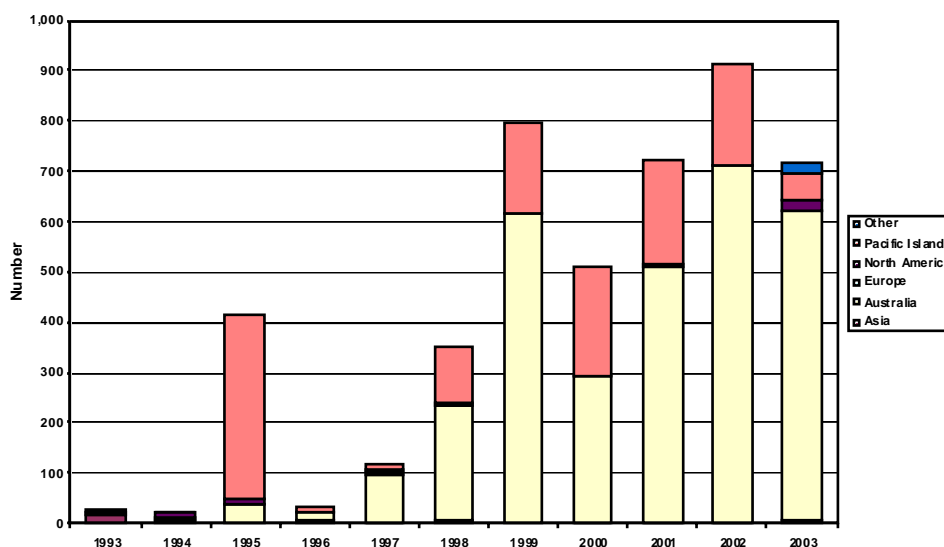
Figure 8: Value of exports of oil-cooled distribution transformers



The inclusion of some hundreds of transformers to Australia in 1996 may be something of an erratic, as the average value was only \$326, strongly suggesting that these were not distribution transformers.

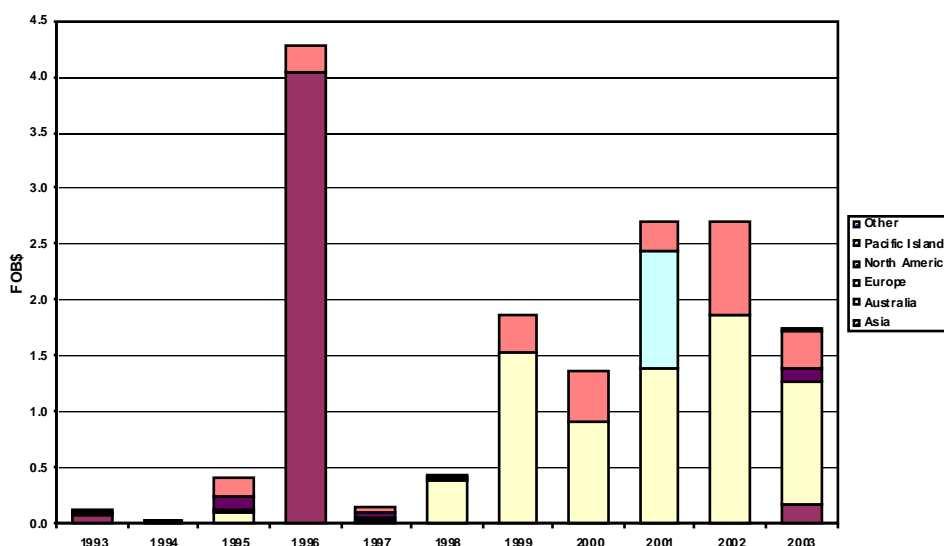
The export of dry transformers has grown from small beginnings over the last 10 years as shown in Figure 9. As with the import statistics, there is no assurance that these are in fact distribution transformers.

Figure 9: Exports of dry-type transformers over 16 kVA



The value of these is shown in Figure 10.

Figure 10: Value of imports of dry-type transformers over 16 kVA



The value spike in 1996 relates to the export of a single large transformer to Singapore.

2.3. Efficiencies

Transformers are available on a world market that can supply them to almost any specification. Those readily available range from ones that will meet the MEPS “High efficiency” standard, even if the manufacturer is using the tolerance allowance to exaggerate the transformer’s actual efficiency, to those that fall well below the MEPS minimum, but are cheap enough to be financially attractive.

2.4. Prices

Distribution transformers are sold in confidential contracts and prices are not published. Prices can vary over a wide range depending on the buying strength of the purchaser. There are strong economies of scale in both manufacturing volume and in the capacity of specific transformers.

2.5. Technological development

Transformers are a very mature technology, but there are still options for substantial reductions in losses, especially in the core. There are options within conventional technology with both improved materials and reduced sheet thicknesses. A major reduction in core losses (in the order of 70%) is possible through the use of amorphous iron alloy. It comes with some constraints on transformer construction⁵ and an increase in cost. To date amorphous iron alloy cores are made in significant quantities but are not yet mainstream. Economics, rather than a need for further technological development, is the obstruction to these options being adopted. Amorphous iron may become more common once the Allied Signal (now merged into Honeywell) patents expire.

Further improvements will become available through the use of nanocrystalline alloys. These are now in the technology development stage, and promise not only further reduction in losses but some amelioration of the increased core mass associated with amorphous metal.

Reduced losses in the windings are possible by using increased conductor cross-sections of low resistivity, and copper rather than aluminium. The increased material quantity increases cost, bulk and weight. Further loss reductions are possible by reducing the conductor temperature. The ultimate will be the use of super-conducting materials. This requires cooling to liquid nitrogen temperatures. Such transformers have been made and trialled in full-scale applications.

2.6. Options for maintaining efficiencies

There are a variety of mechanisms that could be used to encourage a greater preference for efficient transformers. These include:

Regulatory measures

1. adopt the Australian AS 2374.1.2 regulatory MEPS, as far as possible in to;
2. adopt the Australian AS 2374.1.2 regulatory MEPS, but with the minimum set at the “High efficiency” level; and
3. place a tax on distribution transformers in proportion to, or otherwise dependent on, the level of their losses.

Non-regulatory measures

1. adopt the Australian AS 2374.1.2, or similar criteria, but make compliance voluntary;
2. subsidise distribution transformers in proportion to, or otherwise dependent on, the level of their efficiency.

The taxation option has an attractive element in that it could directly counter the problem of network companies not having a commercial incentive to incorporate the value of losses into purchase decisions. A subsidy for more efficient transformers could have a similar effect, but would be open to criticism as a windfall gain to the network companies. However there are severe practical difficulties associated with a tax that would need to be individually calculated from the characteristics of each unit purchased or imported. Lesser administration would be incurred if taxes or subsidies were related to broad efficiency bands, but at a cost in terms of reduced effectiveness of the measure.

In practice, the existence of the CER agreements with Australia, and especially the operation of the TTRMA, when Australia is implementing a MEPS, makes adoption of alternatives to MEPS severely problematical. Hence the other options will not be considered further.

⁵ Amorphous iron alloy is made in narrow and very thin ribbons.

2.7. Regulatory activity and experience in other countries

Regulatory MEPS-type requirements for distribution transformers have to date been imposed only in Mexico and China. Formal consideration is being given to introducing them in Canada, Australia and the USA. Japan was to have added distribution transformers to its Top-Runner scheme in 2002, but for transformers in commercial premises only.

Mexico was the first country to take this action, and their standard took effect in 1999, for oil-filled transformers only (there is a voluntary standard for dry-type transformers). This imposes limits on both minimum efficiency and maximum losses. The transferability of the Mexican regulation to New Zealand is reduced by the 60 Hz standard applying there.

China also acted in 1999, and banned the low efficiency S-7 transformers. This was a radical step, as the S-7 comprised 90% of the market up until the announcement of the regulation. Even the now almost universal S-9 grade of transformers are not highly efficient by western standards. This is not a true MEPS in that there is no clearly specified minimum acceptable efficiency.

Canada now plans to introduce a MEPS in January 2005 for dry-type transformers only. This programme seems to have been considerably delayed from earlier intentions. A separate process considering a MEPS for oil-filled transformers is at an earlier stage. The proposal was to employ the USA's TP1 standard.

The USA has a voluntary programme under Energy Star since 1995, with the qualifying level set at the National Electrical Manufacturers Association (NEMA) standard of TP 1-1996. Under this about 35% of total distribution transformers production qualifies. The introduction of a MEPS was planned for mid-2003, but this timing seems to be slipping. No firm implementation commitment has been made to this so far. However, industry-wide consultations are being carried out and test procedures are being developed.

Australia has now reached a firm intention to introduce MEPS for distribution transformers in October 2004. If New Zealand is to introduce a compatible MEPS it would be desirable, in terms of minimising difficulties under TTMRA, for this to be brought in at much the same time.

In Europe CENELEC has, for more than ten years, applied a voluntary standard for transformer losses for each of the harmonised distribution transformer sizes. These have been formalised in harmonisation documents: HD428 for oil-cooled transformers, and HD538 for dry-type transformers. These are not MEPS requirements, indeed HD428 allows for three different levels of efficiency each for the core and windings, none of which are technically challenging. Purchasers are also allowed to choose their own loss evaluation techniques, effectively determining their own standard. The current national standards of European Union countries and major utilities are based upon HD428.

There are no plans to create a European Standard (EN) from HD428. However, discussions have already taken place between the European Commission, COTREL (representing the transformer manufacturers) and EURELECTRIC to discuss the possibility of voluntary agreements or a European Directive on reducing losses from distribution transformers through a minimum standard.

The EU standards, which relate to three phase transformers from 50 kVA upward only, are expressed in terms of load and no-load losses. Converting these to an efficiency at 50% load enables a selection of them to be compared with the proposed Australian MEPS. The comparison for oil-filled transformers is shown in Figure 11, and for dry-type transformers in Figure 12.

Figure 11: EU and Australian efficiency specifications for oil-filled transformers

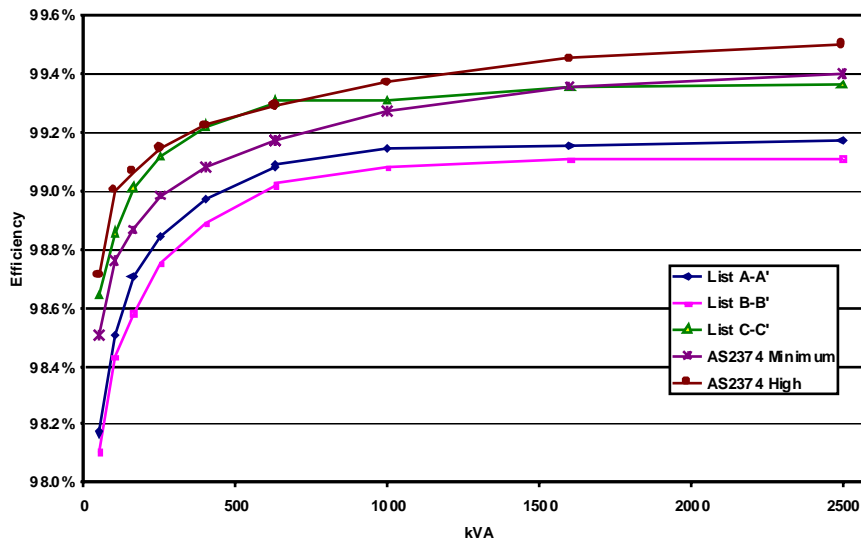
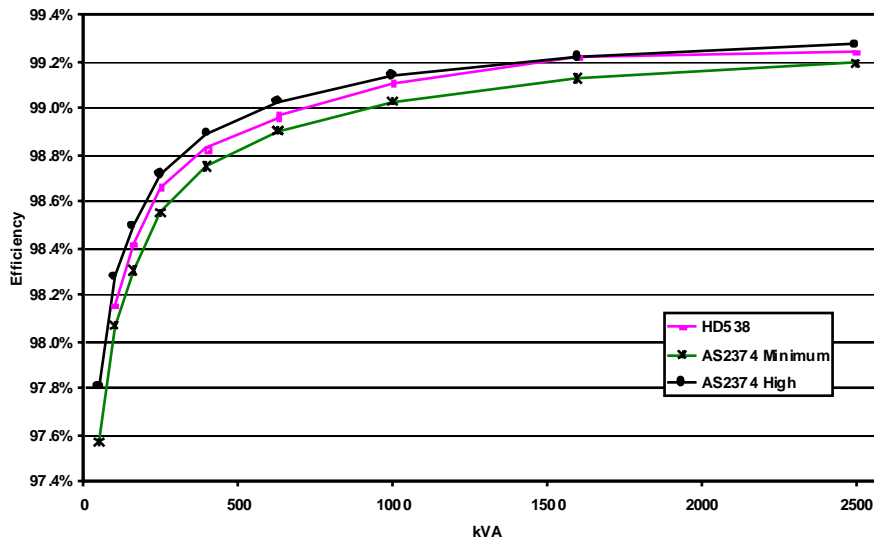


Figure 12: EU and Australian efficiency specifications for dry-type transformers



For the oil-filled transformers the C-C' level is proposed to be designated “energy-efficient”. By comparison, over the 50 to 1000 kVA range that covers near all distribution transformers, the Australian MEPS lies about half-way (a bit higher at the smallest end) between the A-A' and C-C' levels. The “High efficiency” level, however, is at or above the C-C level.

For dry-type transformers, the proposed MEPS is well below the EU level, while the “High efficiency” level is at or above it except for the largest sizes.

2.8. Measures in place

New Zealand does not at present have any specific regulatory programme for distribution transformers. The Electrical Engineers Association (EEA) has a recommended method for taking losses into account, but this is purely advisory.

2.9. Technical considerations

New Zealand power systems operate at 50 Hz, which is common in Europe, much of Asia, and Australia, but not in North or South America. Climate is not significant a factors, however New Zealand has a much larger proportion of small distribution transformers, mostly serving farms, than are used in more densely populated countries.

2.10. Trade issues

Adopting the Australian MEPS standard AS 2374.1.2 will require that New Zealand adopt the underlying Australian standards for distribution transformers, AS 2374 and AS 2375. These standards are closely based on the corresponding international standard IEC 60076. At present New Zealand has no standard of its own and general practice is to use the UK standard BS 171, which is also a clone of IEC 60076. Hence the adoption of the Australian standard will not cause any particular issues under the General Agreement on Tariffs and Trade (GATT) *Technical Barriers to Trade* (GTBT) Agreement. The regulations would apply equally to imports and locally manufactured products, and so do not discriminate against imports.

The MEPS requirements are based on an addition to AS 2374 that is not part of IEC 60076. It also requires that energy losses be reported to a high level of precision, based on measurements with an accuracy generally of $\pm 0.5\%$. Consequently all products will need to be tested to the Australian Standard. The results of tests carried out to the IEC standard, or other national standards based on the IEC standard, will not be acceptable. The Mexican transformer MEPS regime has a similar requirement. Beyond October 2004 the testing laboratory will also be required to be accredited by the Australian National Association of Testing Authorities (NATA) (or a laboratory that has been accredited by a body with a mutual recognition agreement with NATA). This procedure is not inconsistent with the GTBT agreement. This will, however, act as an appreciable barrier to imports from other countries.

An issue that will need to be dealt with in adopting the Australian MEPS standard AS 2374.1.2 is that it makes several references that are Australian specific. Negotiating a joint Australian/New Zealand standard would be difficult in the time available before the Australian MEPS goes into effect. Hence either a localised version of it will need to be created and adopted by New Zealand as a New Zealand standard, or the regulation implementing a New Zealand MEPS will need to include suitable provisions to modify AS 2374.1.2 as it is to be applied in New Zealand.

If New Zealand does not move in reasonably close harmony with Australia in implementing a MEPS for distribution transformers, Australia will need to protect its own MEPS by introducing a temporary exemption under TTMRA to exclude non-complying transformers. If New Zealand did not introduce a compatible MEPS within a few years the temporary exemption provisions would come under some strain.

3. Analysis and results

3.1. Energy consumption changes

The majority of transformers presently being purchased in New Zealand already comply with the MEPS proposed in Australia, at least after allowing for the permissible tolerances. Those that do not comply are concentrated in the smaller sizes that account for half the transformers by number, but less than 10 percent of the capacity. Consequently the reduction in energy consumption from introducing a MEPS at the same levels as Australia will be very small, even when accumulated over several years.

The major benefit from introducing such a MEPS comes from preventing a decline in efficiencies. Efficiencies will be frozen at a level marginally above their present level, and the effects of a loss of incentive to sustain efficiencies avoided.

A MEPS set at the “high efficiency” of the Australian proposal would have more rapid and substantial impacts on energy production. Since some network companies already purchase transformers that meet the high efficiency level the immediate effect would be less than the total difference in efficiency levels might suggest, but over time it could approach that.

The energy consumed by the existing transformers is not measured or otherwise known. It can only be rather roughly estimated on the basis of the demographics of the transformer population, and the loadings on them. The demographics are described in Section 2. Average loadings on

New Zealand's distribution transformers seem to be in the 30% to 35% range. However transformer losses are non-linear with loading, so that the average losses will be higher than the losses at the average loading. To allow for this, the average load losses have been assumed to be 15% of the losses at full load, which is approximately the loss at a 40% loading.

The total losses in transformers owned by network companies are estimated on the basis of currently available transformers as set out in Table 1.

Table 1: Estimated energy losses in network distribution transformers at 2002 efficiencies

	Number	Losses per transformer				Total losses	
		No load loss	Load loss	Load loss @ 40%	Total @ 40%	GWh	PJ
kVA		watts	watts	watts	watts		
0-15	43,812	40	310	50	90	34	0.1
16-30	44,642	85	590	94	179	70	0.3
31-50	18,685	120	800	128	248	41	0.1
51-100	18,820	175	1,300	208	383	63	0.2
101-300	36,273	400	2,700	432	832	264	1.0
301-500	8,091	700	5,300	848	1,548	110	0.4
>500	5,067	1,020	9,150	1,464	2,484	110	0.4
Total	175,390					693	2.5

Many of the older transformers now in use will not be as efficient as the new ones as there have been increases in the quality of materials. This applies mainly to core steel, which has improved very substantially, notably with the introduction of grain oriented silicon steel in the early 1960's. The pattern of conductor efficiency has been more mixed, with some backsliding due to an increase in the use of aluminium conductor in place of copper.

In the absence of any survey of the efficiency of existing transformers, which would be a major operation, an estimate must be based on limited information. This suggests that the average losses in the existing fleet of transformers is some 25% higher than those incurred by transformers now on the market. This implies that the annual losses in network distribution transformers is presently around 860 GWh (3.1 PJ). This is 2.2% of the total generation of some 39,000 GWh (140 PJ) last year.

Not included in these estimates are the transformers owned by consumers. There does not appear to have ever been a survey of these, or any other assessment of their numbers, characteristics or loading. An estimate in Australia is that private transformers account for about 15% of the total distribution transformer stock⁶. Practices in New Zealand will have been different⁷, and other variations may result from differences in scale and economic structure. The overall effect of these is unknown, but seem likely to reduce the significance of private transformers. The average size of private transformers will undoubtedly be considerably higher than the network owned ones. There is some argument that the average loading on the private transformers will be higher than on network ones. No evidence is available to validate this suggestion. As applied in the Australian RIS for distribution transformers⁸, the 15% has been interpreted as implying that

⁶ Ellis, M., 2001. "National Appliance and Equipment Energy Efficiency Program Analysis of Potential for Minimum Energy Performance Standards for Distribution Transformers".

⁷ For example the transformers within the CHH mill at Kinleith belong to the network company.

⁸ George Wilkenfeld and Associates, May 2002. "Regulatory Impact Statement: Minimum Energy Performance Standards and Alternative Strategies for Electricity Distribution Transformers".

losses in private transformers are 20% of those in utility transformers. In view of the likelihood that private transformers are a little less significant in New Zealand an additional 15% is assumed here. This implies additional losses of 130 GWh (0.5 PJ). Total distribution transformer losses are therefore likely to be close to 1000 GWh (3.6 PJ) per year.

A difficulty in assessing the effects of implementing a MEPS, using the proposed Australian standard is that this does not specify the required efficiency levels for single-phase transformers of over 50 kVA, or three-phase transformers of under 25 kVA. New Zealand has thousands of three-phase transformers of 15 kVA or smaller, and these are still being purchased. There are also a significant number of large single-phase transformers, usually installed as banks of three to provide three phase service. There are probably few of these still being installed. However single-phase 75 kVA transformers are still being purchased in appreciable numbers. Since these transformers are defined as falling with the scope of the standard, they are subject to an undefined requirement. The applicable efficiency level cannot be determined by extrapolation from the levels specified, since the relationship is non-linear.

A further difficulty results from the tolerances that are permitted for the losses in any particular transformer. The MEPS requirement applies to “transformer designs” rather than actual transformers. AS 2374.1 (in common with IEC 76-1, of which it is a clone) specifies tolerances of +15% on each of the no load and load losses, but +10% on the sum of these. However the load losses are measured at 100% of full load, whereas the efficiency requirement is specified at 50% of full load. As a result, the minimum efficiency requirement for a specific transformer is appreciably lower than the nominal requirement in the standard, by an amount that cannot be clearly specified as it depends on the construction of each transformer.

The permissible tolerances are considerably wider than can be achieved by an efficient manufacturer. Hence manufacturers can, and clearly do, claim efficiencies for their models which are higher than their actual products, but by an amount that keeps all but a small proportion within the tolerance requirements. This practice must be expected to continue after a MEPS regime is in place.

If network companies trend toward cost minimisation, as they are now pressured to do by the Commerce Commission decision, their suppliers will need to provide transformers which only just meet the proposed MEPS, including the opportunities provided by the tolerances. The introduction of the MEPS in this situation will not result in any reduction in losses. Indeed there is room for some backsliding from the present mix of purchases, although this will not necessarily actually occur. A small number of imported low efficiency transformers may be excluded. However the benefits of this could be offset by the introduction of less efficient dry transformers into networks. The average efficiency of the stock of distribution transformers will still improve slowly due to the lower efficiency of the oldest transformers which are the ones that will be replaced.

A MEPS will put a floor under the backsliding, which will not otherwise be there. How rapidly the average efficiency of new transformers might decline without a MEPS is necessarily rather speculative. The Australian study⁹ appears to have assumed a slow uniform decline of 0.005% per annum for 30 years for the operating efficiency of newly purchased utility owned transformers, and of 0.01% per annum for privately owned ones. The pressures to minimise costs are much more direct and immediate in New Zealand. Hence a more rapid decline in efficiencies should be anticipated, at least at first, and there is no reason why network owned transformers should decline in efficiency any less rapidly than privately owned ones. Indeed, since the only prospective change in incentives for the private owners is a recent or anticipated increase in electricity costs, a slight tendency toward increased efficiency is possible.

⁹ Wilkenfeld, 2002 op cit

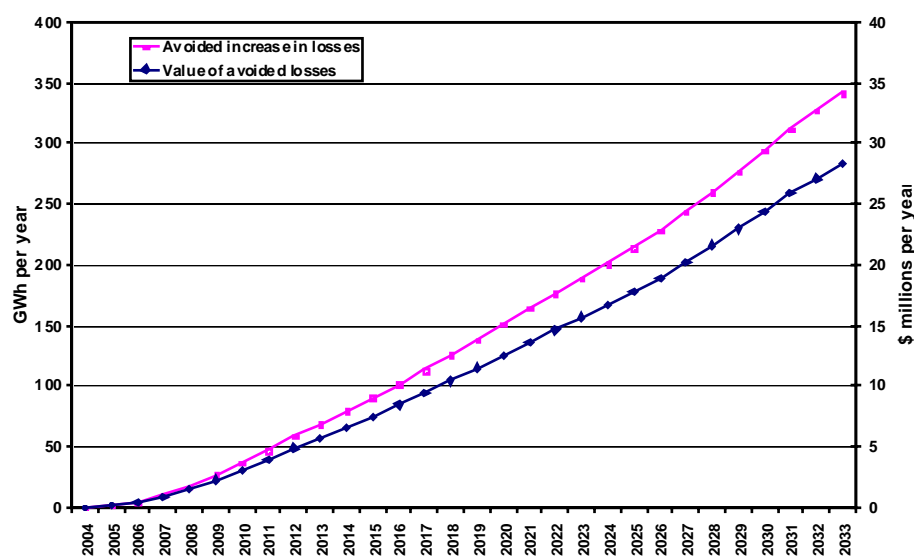
For evaluation purposes a decline (in the absence of MEPS) in the efficiency of transformers purchased by network companies is assumed of 0.05% per annum for five years, followed by 0.01% per annum for the following 25 years.

The private owners of distribution transformers will be under no change in incentives from those at present, so there is no reason to anticipate a decline in efficiencies in the absence of a MEPS. With the proposed MEPS, the less efficient and lower cost oil filled transformers presently sold into the private market by some suppliers will no longer be available. Whether the private buyers will respond by purchasing the higher efficiency utility grade oil filled transformers, or the cheaper and less efficient dry-type transformers, cannot yet be determined. A mixture of the two could well leave average efficiencies unchanged.

Private transformer buyers already preferring the dry-type transformers will not be significantly affected by the introduction of MEPS, since nearly all presently existing models meet the MEPS standard, after allowing for the permissible tolerances. Overall, there seems to be no reason to anticipate any significant change in the efficiency of privately owned transformers due to the introduction of the proposed MEPS. This conclusion could usefully be revisited if further information on private transformers becomes available.

The pattern of build-up in the losses that a MEPS could avoid, and their value, are shown in Figure 13. The slight irregularities in the slope of the lines are due to the age distribution of the existing transformer stock, resulting in variations in the rate of replacement.

Figure 13: Quantity and value of avoided increase in transformer losses



3.2. Economic impact

The introduction of MEPS at the proposed Australian level will have a minimal economic impact, since it requires very little change from the present situation. Change, and resulting impact, is likely if a MEPS is not introduced. This will occur through a reduction in the value of the output of the transformer manufacturing industry, an increase in transformer imports, and a gradual addition to electricity generation. The costs of the electricity network companies will fall, while the costs to electricity consumers are likely to rise.

National level economic value depends on the trade-off between the opportunity to reduce capital expenditures on distribution transformers, and the cost of the resulting increased electricity generation in subsequent years. There is no reason to anticipate that any other costs and benefits will change by more than trivial amounts.

Establishing the generation consequences of a change in efficiency is straightforward. Establishing the effect on transformer prices, when there are only two significant manufacturers

and no reporting requirement is more difficult. Some information is provided by a study by the European Communities¹⁰ that provides prices for alternative efficiencies for some sizes of distribution transformers.

The relationship between the European standards, converted to a 50% loading basis, and those proposed in the Australian MEPS is shown in Table 2.

Table 2: Comparison of efficiency requirements at 50% loading

Rated Power kVA	Europe				AS 2374			
	Oil filled HD 428			Dry	Oil filled		Dry, 11kV	
	List A-A'	List B-B'	List C-C'	HD538	Minimum	High	Minimum	High
50	98.17%	98.11%	98.64%	N/A	98.50%	98.71%	97.57%	97.81%
100	98.51%	98.43%	98.86%	98.15%	98.76%	99.00%	98.07%	98.28%
160	98.71%	98.58%	99.01%	98.42%	98.87%	99.07%	98.30%	98.50%
250	98.84%	98.75%	99.12%	98.66%	98.98%	99.14%	98.55%	98.72%
400	98.97%	98.89%	99.22%	98.83%	99.08%	99.22%	98.75%	98.89%
630/4% I ¹¹	99.08%	99.02%	99.30%	98.96%	99.17%	99.29%	98.90%	99.03%
630/6% I	99.09%	99.02%	99.31%	98.97%	99.17%	99.29%	98.90%	99.03%
1000	99.14%	99.08%	99.31%	99.11%	99.27%	99.37%	99.03%	99.14%
1600	99.15%	99.11%	99.35%	99.22%	99.36%	99.45%	99.13%	99.22%
2500	99.17%	99.11%	99.36%	99.24%	99.40%	99.50%	99.19%	99.27%

The economic comparison in the EU study is between transformers meeting the A-A' specification with those meeting the C-C' level. This is not quite the same range as between those meeting the MEPS and alternative ones that would be purchased in the absence of a MEPS. Since the cost to improve efficiency generally rises as the level approaches 100%, this should provide a slightly conservative assessment.

Table 3: Cost effectiveness of improved efficiency

Rated Power kVA	Cost		Increase		Losses at 40%		Reduction
	List A-A'	List C-C'			List A-A'	List C-C'	
	Euros	Euros	Euros	NZ\$	kWh/yr	kWh/yr	kWh/yr
100	2,538	2,799	261	517	5,256	3,907	1,349
400	4,307	4,762	455	901	14,594	10,740	3,854
1600	9,434	10,147	713	1,412	46,603	34,514	12,089

The cost and loss changes between the two efficiency levels are shown in Table 3 (Euros are converted to NZ\$ at 1NZ\$ = 0.505 Euro).

The economic assessment of these changes is shown in Table 4. The valuation of the increased generation is calculated at 8.3 c/kWh, as calculated in section 0 above. The NPV of the change in generation is calculated on the basis of a 10% discount rate and a 30 year life for the reductions.

¹⁰ The scope for energy saving in the EU through the use of energy-efficient electricity distribution transformers, Dec 1999

¹¹ 630/4% I and 630/6% I refer to 4% and 6% impedance. A feature of European Harmonised Directives 428 and 538

Table 4: Estimated costs and benefits of increased efficiency

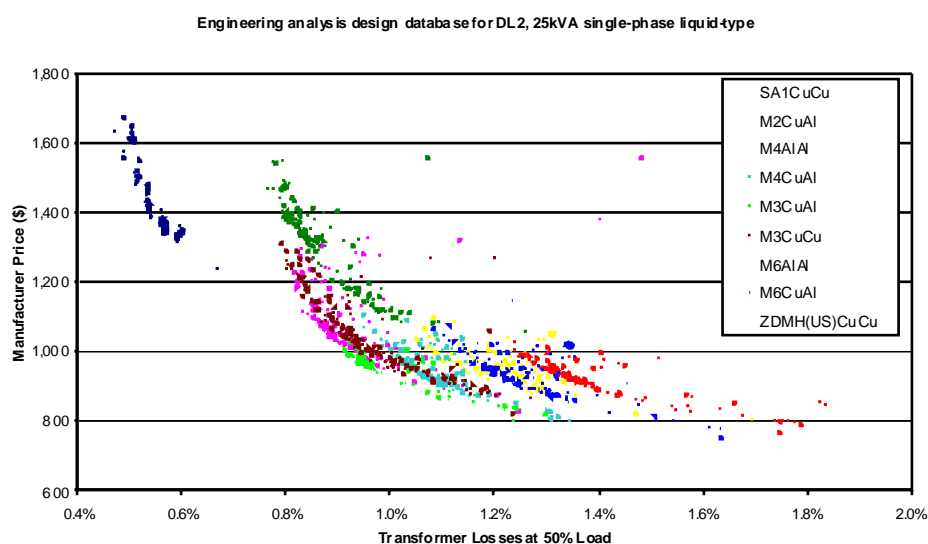
Rated Power kVA	Increased capital cost NZ\$	Value of reduction in generation NZ\$/yr	Payback years	NPV of reduced generation NZ\$	Benefit/cost ratio
100	517	111.97	4.62	1,056	2.0
400	901	319.92	2.82	3,016	3.4
1600	1,412	1003.37	1.41	9,459	6.7

The assessment shows that the increased efficiency is well worthwhile, within the range of sizes included. Changing to a lower discount rate would only increase the benefit/cost ratio. Changing to a 25-year life would barely alter the ratio, and any shorter life is not credible.

The trend in the results of this analysis does suggest that the case for increased efficiency may be weaker for small transformers, of sizes common in rural New Zealand, but not in Europe. Distribution transformers of less than 100 kVA comprise 61% of the total number, but only 13% of the total capacity. Since the proposed MEPS already allows for the small transformers to have a lower efficiency it is far from clear that imposing it would create any penalty.

One indicator of the effects at smaller sizes can be provided by work done in the USA. This cannot be directly related to New Zealand since it applies at 60 HZ, rather than 50, and the USA's 120/240V secondary voltage system.

A chart showing the results of surveying 2,100 models of 25 kVA, oil cooled distributed gap single phase pole mounted transformers is shown in Figure 14. This is adapted from a spreadsheet "liquid-type_engineering.xls", prepared by Optimized Program Service, Inc to provide standardised costings for the manufacture of a very wide variety of transformer designs. The work was undertaken for the US Department of Energy. Unfortunately the analysis was not undertaken for transformers as small as the 15 kVA ones common on rural networks in New Zealand.

Figure 14: Results of evaluation of 25 kVA oil filled transformers in USA

In the chart the various colours refer to different transformer technologies. Each code in the key defines the core steel in the first few characters, while the last four characters give the metal: aluminium or copper, used in the primary and secondary windings. Metal code SA1 indicates amorphous iron alloy, and provides the island of transformer designs with losses below 0.6%. ZDMH refers to domain-controlled grain oriented steel.

The proposed MEPS minimum efficiency for a transformer of this size and type is 98.7%, i.e. losses of 1.3%, while the High efficiency rating is at 98.8%, i.e. losses of 1.2%. These are to the right of the bulk of the designs in Figure 14, indeed 88% of the designs have losses below the MEPS, and 79% below the High efficiency mark.

Over this efficiency range the slope in the chart for a specific transformer technology is some US\$49 per 0.1% change in efficiency. This implies a relatively unattractive payback of 8.5 years, and a benefit/cost ratio of only 1.1. However, taking the lowest cost technology at each efficiency level (implying, in this case, a change from M4 to M3 steel, but retaining the copper primary and aluminium secondary) enables a more cost-effective improvement with a slope of US\$25 for the 0.1% change in efficiency. This yields a payback of 4.3 years and a benefit/cost ratio of 2.2. The difference in electrical specifications makes this analysis not fully transferable, but it does suggest that the MEPS requirements are not uneconomic for quite small transformers, and that this is true at least up to the “High efficiency” level.

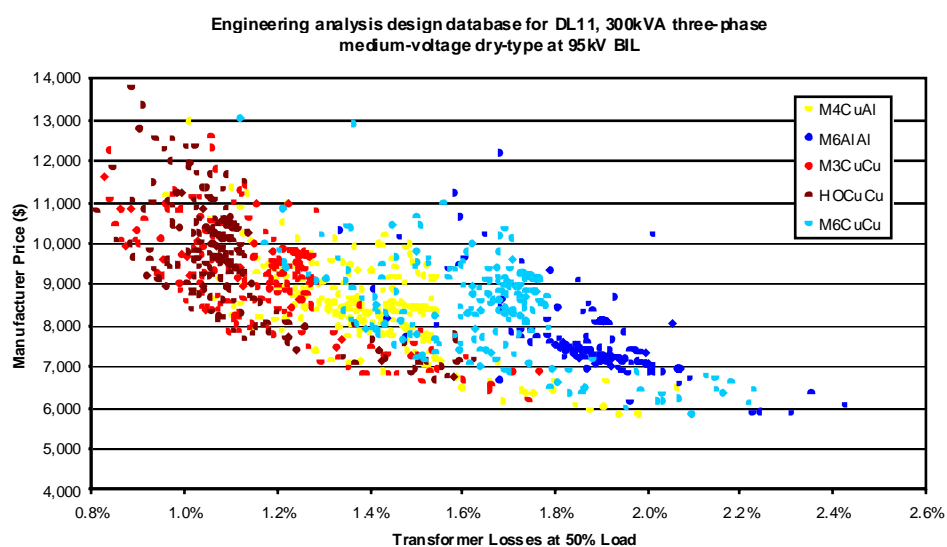
It is notable from this analysis that the most cost effective designs over a wide range of efficiencies used grain oriented steel cores (of varying lamination thickness), copper primary and aluminium secondary windings. Aluminium primaries were cost effective only at very low efficiencies, and copper secondaries only at the highest efficiencies.

Very substantially lower losses are possible with the use of amorphous metal cores. At the reported costs, changing to transformers using amorphous metal is marginally economic for this size of transformer. This situation could improve in a few years time when the key Allied Signal patents expire.

For dry-type transformers the EU has only the one efficiency level and provides no data on the cost of alternative efficiency levels. The work done in the USA provides the only available guide.

One result of the US work is shown in Figure 15, adapted from the engineering worksheet `dry_type_engineering.xls`, also prepared for the US Dept of Energy by Optimized Program Service, Inc. Figure 15 contains the results of an analysis of 1,375 designs. The code H0 refers to laser scribed steel. The other codes are as in Figure 14. This analysis did not include designs employing amorphous metal.

Figure 15: Results of evaluation of 300 kVA 3-phase dry-type transformers in USA



The minimum efficiency under the proposed Australian MEPS for this capacity of dry transformer is 98.64%, i.e. losses of 1.36%, which is bettered by 44% of the designs in the chart. The High efficiency level is 98.8%, i.e. losses of 1.2%. This is bettered by 28% of the designs.

The slope of the most efficient designs over the range from 98.5% to 98.6% is some US\$165 per 0.1% efficiency increase. This gives a payback of 2.6 years and a benefit/cost ratio of 3.6. Over the range from 98.6% to 98.9% the slope steepens to US\$319 per 0.1% efficiency increase. This gives a payback of 5.1 years and a benefit/cost ratio of 1.8. To the extent that these costs and efficiencies can be transferred to New Zealand conditions the MEPS minimum efficiency is easily justifiable, while the further increase to the high efficiency level is more marginal, but still readily justifiable.

3.3. Environmental impact

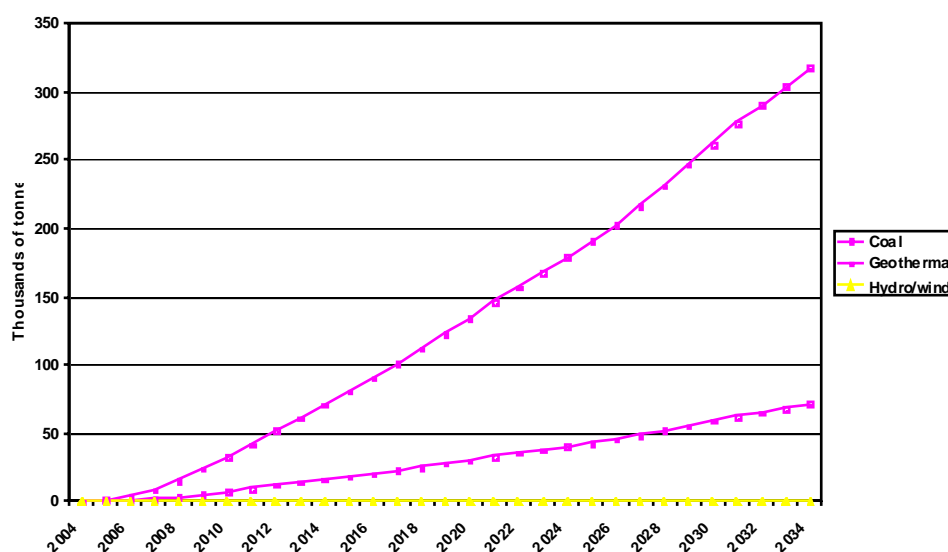
The environmental impacts of introducing a MEPS are modest. There will be no obvious appearance, bulk, location or pollution hazard changes. The only impacts will be on emissions.

3.3.1. Emissions reduction

Introducing a MEPS will, in itself, cause little change in manufacture or use from the present position. Hence environmental effects will be trivial. The consequences of not introducing a MEPS are likely to be more substantial. The increase in transformer losses that can be expected to accompany such a decision can be achieved by changing to thicker laminations in the core, and slightly thinner gauge wires in the windings. There is also likely to be a (potentially rapid) increase in imports. Most of the raw materials for transformer manufacture are imported, and the manufacturing process is not seriously polluting. Consequently the emissions effects of a small change in manufacturing procedure is likely to be insignificant. A more appreciable, but still modest, reduction in emissions from manufacturing could result from a switch to imported transformers.

Much more significant are the emissions consequences of not introducing a MEPS. This will result in increased generation. The emissions consequences of this will depend on the particular form of generation that increases, and this will change over time. As noted in section 1.9, this may be additional fossil fuel burn in the early years, but could be additional or earlier generation by new hydro, geothermal or wind in the longer term. In the former case the GHG emissions are likely to be in the range of 850 to 900 tCO₂e/GWh. In the latter case they could be up to 200 tCO₂e/GWh if all additional generation was at a geothermal station supplied by a field with a high CO₂ content, or zero if was from hydro or wind. The range of possible outcomes is shown in Figure 16.

Figure 16: Potential additional annual emissions from not having a MEPS



3.4. Uncertainty analysis

There are several sources of uncertainty in this analysis. The most notable is that relating to the emissions, especially of greenhouse gases, consequences of small changes in electricity generation. This depends on the future sources of additional electricity, and cannot yet be reliably determined. This does not alter the conclusions, since these do not depend on a valuation of the emissions.

In the absence of adequate information from other sources, some reliance has been placed on cost-efficiency relationships from the USA. These are based on a very comprehensive study, but do transfer directly to New Zealand since the electrical systems differ.

The demographics of the New Zealand distribution transformer population are not fully known, and neither is the future life or rate of replacement of them. This impacts on the annual value and NPV of having a MEPS, but is basically a scaling factor on both costs and benefits. It has little effect on the desirability of introducing a MEPS.

Some uncertainty attaches to future electricity prices. However it would take a major, beyond credibility, reduction to alter the conclusions. Somewhat greater attention would need to be paid to electricity values if higher minimum efficiency levels were to be proposed.

3.5. Administration costs

The administration of a distribution transformer MEPS will follow the some pattern as those for consumer products. Since the systems are well established the marginal cost of adding an additional product is modest (if not zero as claimed in the Australian RIS¹²). The paper-work involved in maintaining a register of compliant transformer types will be modest, no more than a part-time task for one person. This should cost less than \$20,000 per year.

More substantial costs will be involved in maintaining the credibility of the MEPS through systematic check testing. The work will need to be carried out in a laboratory with an acceptable accreditation. What this will involve will need to be specified in the process of adapting the proposed Australian MEPS as specified in AS 2374.1.2 to New Zealand and identifying facilities to carry out the tests. The fees and costs for this cannot yet be determined. Including the associated logistics, costs per test can be expected to be several thousand dollars. How many check tests will be carried out is an administrative decision yet to be made, and is likely to depend, in part, on the results of the early tests.

4. Business compliance cost statement

4.1. Sources of compliance costs

Compliance costs will derive from:

- modifications to enable all models comply;
- satisfying administrative requirements for registration and annual reporting; and
- correction of any cases of check-test failure.

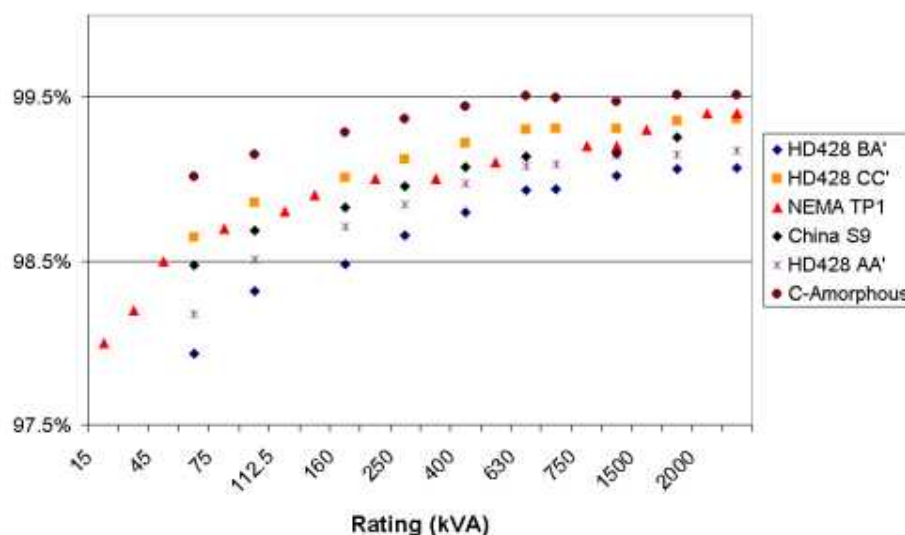
4.2. Parties affected

The companies that will be most affected by the introduction of a MEPS are the two distribution transformer manufacturers in New Zealand - ABB Limited, the local branch of ABB, a multinational company with a very wide product range based in Sweden and Switzerland, and ETEL Limited, a New Zealand company specialising in distribution transformers.

¹² Wilkenfeld, 2002 op cit, pg 5.

The major effect on these companies, and to a lesser extent those companies importing distribution transformers from Australia, is to reduce competition from low priced, but somewhat less efficient, imports from China. It is not clear that this protection will be long lived. China's reputation for low efficiency products may result from selling off transformers built to the old S-7 standard. With the introduction of its own MEPS in 1999, China's S-9 transformer standard is now between the EU's A-A' and C-C' levels, as can be seen from the comparison in Figure 17¹³.

Figure 17: Comparison of transformer efficiency standards



A Chinese manufacturer that is currently producing to S-9 would need to do a bit of work to meet the proposed Australian MEPS, but not such that major redesign would be likely to be required. Beyond that the Chinese would seem to face little more than compliance and marketing difficulties in selling to Australia and New Zealand. If and when Australia and New Zealand move to make the “High efficiency” level the minimum, the barrier to Chinese imports will become considerably more substantial.

Affected to a much lesser degree will be the 28 electricity distribution network companies. These cover a wide range of sizes from Buller Network (supplying 4,100 consumers) to Vector (supplying 580,000 consumers). These will lose the opportunity to purchase cheaper transformers.

4.3. Estimates of compliance costs

Compliance costs result from the need for manufacturers to make changes to their products to enable them to comply, and from the testing and administrative efforts they must make to obtain clearance.

The local manufacturers do not anticipate significant costs in modifying their designs to achieve compliance with AS 2374.1.2. The Australian manufacturers will be bringing their designs into compliance to meet Australian MEPS requirements. Any additional work to bring the models exported to New Zealand into compliance is unlikely to be substantial.

Establishing compliance will require that the efficiency of each transformer be determined by testing in accordance with the requirements of AS 2374.1 (oil filled) or AS 2735 (dry type). Manufacturers already do this, but do the testing themselves. It is assumed that the requirements for testing for a New Zealand MEPS will closely parallel those proposed to be required in Australia.

¹³ From “Introduction to transformer efficiency” by the European Copper Institute.

These will require (after October 2004) that testing be carried out by a laboratory accredited by Australia's National Analytical Testing Authority (NATA), or a laboratory that has been accredited by a body with a mutual recognition agreement with NATA. Manufacturers will likely decide to seek accreditation for their in-house laboratories. This will have an offsetting benefit in improving the credibility of the manufacturers test certificates on all aspects of transformer performance.

Check testing will be undertaken as a quality assurance measure. This will require testing by an independent laboratory. Costs will depend on the administering agency's level of disbelief in the accuracy of the test results being supplied by manufacturers and importers. It is not clear where transformers will need to be sent for check testing. This may require units to be sent to an Australian laboratory. Procedures will need to be developed for the selection of units for check testing, as those specified for consumer appliances will not be applicable.

A failed check test will trigger further expenditures on checking for defects, correction of defects and/or enhancement of the design, and further testing.

The great majority of the testing required by the MEPS is being carried out anyway, and to the same level of accuracy. The only additional requirement is that the laboratories be accredited. Additional costs, beyond the accreditation fees, will be incurred only to the extent that manufacturers and importers attempt to, or are suspected of attempting to, operate their manufacturing and/or testing close to the edge of compliance.

In Australia fees are charged for the registration of models under MEPS. No such fees are charged in New Zealand.

Some additional work will be required of manufacturers and importers to enable them to meet the reporting requirements of a MEPS. This does not require the collection of any information not likely to be already available, but will require that information to be organised in such a way that the required reports can be generated. All Australian manufacturers, and businesses importing transformers into Australia, will need to do this anyway to meet the Australian MEPS requirements, and hence will not incur any additional set-up cost. This will include New Zealand manufacturers who export to Australia. Hence it is doubtful that any additional set-up costs will be imposed by the introduction of MEPS for distribution transformers in New Zealand.

Some on-going costs will be incurred in submitting the required annual reports. These are unlikely to amount to more than a few thousand dollars per annum per manufacturer and importer. These will be inconsequential for substantial manufacturers and importers, but will comprise some barrier for the producers and importers of small numbers of units of a given model. The simplified reporting requirements for low volume models, which are used for consumer products, are not available for distribution transformers. This will create a disincentive to introduce models of designs where only small numbers are likely to be sold. It will act as a barrier to entry for importers without an established market position.

4.4. Overlapping compliance requirements with other agencies

No overlap of compliance requirements with other agencies is known. Other compliance requirements, such as for electrical safety, involve quite different information.

4.5. Compliance cost minimisation

The compliance process will be closely modelled on those already operating for other appliances. Efficient procedures have been developed for this purpose.

4.6. Risk assessment

The risks faced in implementing a MEPS for distribution transformers are few. The obvious risk, that the future trend for network companies to purchase cheap and low efficiency distribution

transformers has been seriously over-estimated, does not invalidate the programme. Both its costs and benefits will be reduced in equal measure, leaving the assessment scaled down in total value, but not reversed.

The other potential error, that the cost saving from reducing the efficiency of distribution transformers is much greater than estimated here, is highly unlikely, given that the MEPS is consistent with present practice for those network companies that take losses into account in their purchase decisions.

4.7. Intangible factors

The intangible effects of the less efficient transformers that are likely to be introduced in the absence of a MEPS are likely to be very modest. They will not look any different from those now in use. Their higher losses will result in a small increase in heat released from them, and possibly some increase in noise.

More significant intangible effects may result from the increased generation that will be required without a MEPS. The nature of these will be entirely dependent on the form the increased generation takes. It could be increased emissions from a coal fired station, or the visual impact of additional wind turbines.

4.8. Key issues

Some key issues that have arisen during the investigation are:

- the Australian standard does not specify efficiency requirements for some types of distribution transformers commonly used in New Zealand;
- the tolerance allowances in AS 2374.1 create uncertainty as to what the minimum efficiency requirement actually is;
- the emissions consequences of the MEPS depends on the mix of future generation plant, which is unknown;
- the benefits from introducing a MEPS depend on the rate at which network companies would regress to cheap but inefficient distribution transformers. These are readily available, notably from China; and
- the arguments applied here to distribution transformers apply equally to power transformers, but no MEPS, or other control instrument, is proposed for these.

5. Conclusions

From the analysis presented here it is concluded that:

- Australia, and New Zealand if it acts jointly, will be the first countries in the 50 Hz world, and the second in the world as a whole, to introduce MEPS for distribution transformers, although other countries are considering it;
- introducing a MEPS for distribution transformers in common with Australia will prevent a significant disbenefit developing;
- in the absence of a MEPS the competitive position of the New Zealand and Australian transformer manufacturers will be threatened by low priced imports from China;
- New Zealand and Australian manufacturers are already producing distribution transformers that meet the “Minimum” efficiency level in AS 2374 1.2. Consequently introducing a MEPS with that requirement will not result in a loss of competition in the distribution transformer market;

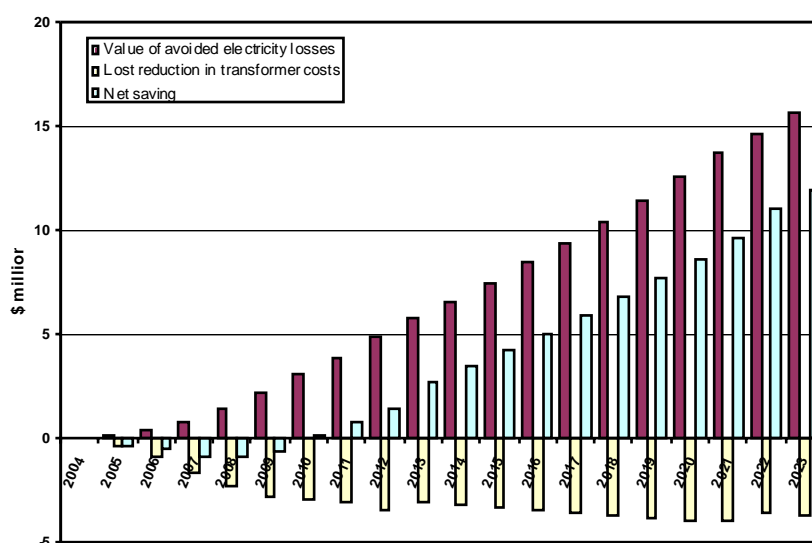
- introducing a MEPS at short notice with the minimum set at the “High efficiency” level of AS 2374 1.2 would result in a significant loss of competition in the distribution transformer market;
- not introducing a MEPS for distribution transformers would create difficulties under TTMRA;
- the value of the avoided increase in generation outweighs the lost savings in transformer manufacturing costs that would result from the proposed MEPS for all sizes and types of distribution transformers within the MEPS’ coverage;
- to minimise TTMRA issues the timing of the introduction of the proposed MEPS should preferably be aligned with that in Australia.

5.1. Net benefit of the proposal

There will be little, if any, benefit from introducing a MEPS, using the proposed Australian MEPS standards, relative to the present situation. Significant benefit may well arise by preventing a regression from existing efficiency standards. This will be offset by a loss of opportunity to lower expenditures on transformer purchases.

The relationship between the additional capital cost of a more efficient transformer and the reduction in losses varied appreciably between the cases examined, as described in section 3.1 above. There is no clear trend with transformer size, or between oil-filled and dry-type transformers. The cases examined average around \$300 per MWh per annum of electricity losses avoided. Assuming this rate, the manner in which the net benefit may build up over time is shown in Figure 18.

Figure 18: Net benefit of transformer MEPS



The net benefit is negative in the initial years, as the added cost of the more efficient transformers is immediate, whereas the value of the avoided electricity losses accumulates over time.

The NPV of the net benefit with a 10% discount rate over 30 years is \$32.6 million. This is the total of NPV’s of \$56.1 million for the benefits and \$23.5 million for the costs.

6. Recommendations

It is recommended that:

1. New Zealand should proceed to implement a MEPS for distribution transformers;
2. New Zealand should adopt the Australian standard AS 2374, and the proposed part AS 2374.1.2, as a New Zealand standard for distribution transformers;
3. the timing of the commencement of the MEPS should be aligned with that of the corresponding MEPS in Australia.