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MODELLING THE IMPACT OF AIR QUALITY PLANS ON ENERGY DEMAND IN CHRISTCHURCH CITY AND NELSON CITY

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BACKGROUND

The national air quality standards published on 15 July 2004 require Regional Councils to develop plans to reduce the level of particulate matter of less than 10 microns in diameter (PM₁₀), to be less than 50 µg/m³ of air by 2013. Since most of the particulate matter originates from residential solid fuel heating, the standards also specify that freestanding wood burners sold from September 2005 must meet an emission limit of 1.5g of PM₁₀/kg of wood burnt, and have an efficiency rating of 65%.

Although air quality is a problem to the Regional Councils of Canterbury, Nelson, Marlborough and West Coast, the standards are of particular importance to Christchurch, Timaru and Nelson, where PM₁₀ emissions from mostly residential solid fuel heating in winter regularly exceed the permissible national level.

In response to this problem the Regional Councils of Canterbury, Nelson, Marlborough and West Coast are developing more stringent Air Quality Plans that are designed to provide pathways for reaching the air quality target within the period specified by the national regulations. In areas such as Christchurch, the particulate emission problem requires an even stricter wood burner specification of 1g of PM₁₀/kg of wood burnt.

The Air Quality Plans will affect the energy and, particularly, electricity demand in the Canterbury, Nelson, Marlborough and West Coast regions. The impact of these plans on the electricity transmission grid supplying these regions is especially important to the Electricity Commission and Transpower New Zealand, and requires investigation.

According to a 2001 study [2], the residential sector contributed 78% of Christchurch particulate emissions, of which the space and water heating contributions were respectively 41% and 30% [1]. The contributions of the industrial and transport sectors to the particulate emissions in Christchurch in 1999 were 10% and 12% respectively.

In the residential sector the Air Quality Plans will target solid fuel space and water heaters. More stringent Air Quality Plans would therefore replace solid fuel by gas, liquid fuel and electrical appliances through a phased banning of the installation and operation of solid fuel appliances.

Air Quality Plans prohibit the sale and use of residential solid fuel heaters under certain circumstances, and the type of replacement heating depends on a number of market factors. A Christchurch survey of 2001 [3], found that other than legislation, the cost of fuel was the most important factor in choosing the form of replacement heating. According to the survey, uncertainty in the price of electricity is an obstacle to switching to electrical replacement heating.

Studies on the effectiveness of management options to reduce particulate emissions in Christchurch [4, 5] used projected appliance stock ratios, based on historic trends, to generate a series of management options. The options model the replacement of solid fuel burning as a result of the continuation of these trends, changes in lifestyle and the successful implementation of education and incentives programmes to reduce the number of burners in use in Christchurch. These studies are likely to be updated to achieve the more stringent national environmental standard on ambient particulate concentration by 2013.

In the study by Wilton [5] the options assumed that up to 44% of the solid fuel burners and 58% of the open fires being replaced are being replaced by non-solid fuel forms of heating. This study also reported the results of open fire replacement options selected by participants in the "Helping Hands" incentives scheme implemented by Christchurch City Council up to 2001. Open fires were

replaced by solid fuel burners (53%), by gas (30.5%), by heat pumps (7.2%), by other fixed electric methods (6.3%), by kerosene burners (1.4%), and by non-fixed heating methods (2.3%).

Although the result of the “Helping Hands” programme indicated a 13.5% uptake of electrical replacement options, it is worth noting that the Christchurch City Council is actively promoting non-solid fuel replacement options that could increase this percentage appreciably.

DESCRIPTION

The purpose of the project is to quantify the impact on energy demand, and more specifically electricity demand, of more stringent Air Quality Plans that are being developed and implemented by Environment Canterbury (ECAN) in Christchurch City and by the Nelson City Council in Nelson City. For the rest of the report, Christchurch City will be referred to as Christchurch and Nelson City as Nelson.

The project involved the construction and comparison of three energy-use scenarios which are designed to demonstrate the impact of these more stringent Air Quality Plans on the residential sector. The EERA model and database [1] is used for constructing and comparing the scenarios.

The reference scenario (Scenario 1: Historic Trends) refers to a situation without the implementation of Air Quality Plans, where the residential appliance stocks and energy consumption grow according to historic trends.

The second scenario (Scenario 2: Open Fire Ban) refers to a situation without the implementation of more stringent Air Quality Plans but with total removal of open fires by 2006. This scenario estimates the appliance stock numbers and energy use that would result if just one of the key measures had been undertaken before the National Environmental Standard required greater urgency in air quality improvement.

The third scenario (Scenario 3: 2013 Target Achievement) is based on replacing high particle-emission solid fuel heating by low particle-emission solid fuel heating or heating with different energy types. In this scenario the likely regulations of the more stringent Air Quality Plans are used in conjunction with the projected growth of households and heating appliances, as obtained from Statistics New Zealand and Regional Council surveys.

Scenario 1: Historic Trends (Reference)

The reference scenario is defined as Christchurch’s and Nelson's historic energy demand and appliance stock trends projected by the logistic growth and exponential decay functions described below.

For Christchurch, the historic residential energy demand for each energy type is obtained from the ECAN Regional Energy Survey [6]. These totals are split into individual end-use demands per energy type with the EERA business-as-usual (BAU) end-use estimates for Canterbury. This allows the end-use energy demand per dwelling to be calculated.

These historic Christchurch end-use demands per dwelling are projected with logistic growth or exponential decay functions, and multiplied by the projected Christchurch dwelling stock obtained from Statistics New Zealand [9] to provide energy demands. The Household Economic Survey (HES) appliance stocks obtained from Statistics New Zealand [10] are also projected with logistic growth or exponential decay functions.

The Ministry for Economic Development's Electricity Enterprise Statistics [8] are used with Statistics New Zealand dwelling stock [9] and logistic functions to project the total residential electricity demand for Nelson-Marlborough. EERA and Statistics New Zealand dwelling stock are subsequently used to split the Nelson-Marlborough electricity demand into end-use electricity demands for Nelson.

The Christchurch non-electricity end-use energy demands are used with the Nelson/Christchurch dwelling stock ratio to determine the non-electricity end-use energy demands for Nelson. However, the space heating energy for Nelson is less than that of Christchurch due to Nelson's warmer climate. To compensate for this, the Christchurch space heating energy demand is multiplied with the Nelson/Christchurch space heating ratio as determined with the Building Research Association for New Zealand's (BRANZ) Annual Loss Factor (ALF) procedure [7].

Scenario 2: Open Fire Ban

This scenario estimates the appliance stock numbers and energy use that would result if just an open fire ban was implemented as the key policy to achieve PM10 emission reduction.

Scenario 3: 2013 Target Achievement

To achieve the stringent PM10 target by 2013, open fires are banned by 2006, non-complying enclosed burners are banned by 2015 and no burners are installed in new homes from 2005. Retiring solid fuel space and water heating appliances are replaced by solid fuel, LPG, kerosene or electrical space and water heating appliances complying with the national appliance emission standards. The type of replacement heater is based on the results of ECAN's Clean Heat Programme incentives scheme.

ASSUMPTIONS

In developing the scenarios for the Christchurch metropolitan area, particular note has been taken of the different quantities measured by the HES and by ECAN's emissions inventory household surveys. The HES estimates the total number of heating appliances installed in households while ECAN estimates the appliances used to heat the main living area in households. This is illustrated by the HES estimate of 19,402 open fires installed in 2001 in Christchurch compared with ECAN's estimate of approximately 10,000 open fires used to heat the main living area for this region.

The Christchurch estimates for this report were adjusted to be consistent with the provisional ECAN scenario projections. The ECAN scenarios were developed using the historic and targeted solid fuel burner replacement rates resulting from ECAN's Clean Heat Programme incentives scheme. Information from Orion New Zealand Ltd about the development of peak electrical load for Christchurch for similar air quality scenarios was also used in the scenario development.

Portable kerosene heaters are assumed to act as minor supplementary heating appliances in around 2% of households from 2001 to 2020. Wetback water heating is in general assumed to be associated with slow combustion fires and, to a lesser extent, open fires. The number of electrical water heating installations is estimated to remain at around 99% of dwellings from 2001 to 2020.

As open fires and older slow combustion burners are replaced in the various scenarios, a check has been made that the decrease in total solid fuel appliances is approximately the same as the increase

in other fixed electrical, gas and central heating appliances (while allowing for the installations in new dwellings).

The historic and projected stocks of dwellings and appliances for Christchurch and Nelson are given in Tables 1 and 2 respectively.

Historic Trends scenario

Christchurch

Based on historic trends, open fires are projected to decrease to around 9% of dwellings by 2005, less than 5% by 2010 and only 1% by 2020 as they phase out naturally in favour of more efficient alternatives. This leads to the HES estimate of 19,447 open fires installed in 2001 compared with ECAN's estimate of approximately 10,000 open fires used to heat the main living area.

In contrast, slow combustion burners are projected to rise from 42.5% of dwellings in 2005 to 43.1% in 2010 and 43.7% in 2020. Electric night-store heaters remain at around 20% of dwellings from 2001 to 2020 while the average number of other fixed and portable electrical appliances is projected to drop slightly from 1.36 per household in 2001 to 1.29 in 2020. Central heating systems, portable gas heaters and fixed gas heaters are projected to remain at around 10%, 35% and 4% respectively of dwellings from 2001 to 2020.

Nelson

Based on historic trends, open fires are projected to decrease to around 5% of dwellings by 2005, 2% by 2010 and less than 1% by 2020 as they phase out naturally in favour of more efficient alternatives.

Slow combustion burners are projected to rise to a maximum of 49% of dwellings by 2001 and to remain at this level to 2020. Electric night-store heaters decline from 8% in 2001 to less than 1% in 2020 while the average number of other fixed and portable electrical appliances is projected to rise slightly from 1.38 per household in 2001 to 1.40 in 2020. Central heating systems, portable gas heaters and fixed gas heaters are projected to remain at around 10%, 32% and 3% respectively of dwellings from 2001 to 2020.

Open Fire Ban scenario

Christchurch

This scenario is based on the assumption that the only major policy change is an open fire ban by 2006 but there are no regulations on phasing out older slow combustion burners. Open fires therefore drop markedly to 3.0% of dwellings by 2005 and 0.5% by 2010 for dwellings outside the Christchurch clean air zone (declining to 0.3% by 2020). Slow combustion burners are projected to rise to 42% of dwellings in 2010 and decline slightly to 41% by 2020.

Electric night-store heaters remain at around 20% of dwellings from 2001 to 2020 while the average number of other fixed and portable electrical appliances is projected to remain constant at 1.36 per household from 2001 to 2020. Central heating systems are projected to remain at around 10% of dwellings from 2001 to 2020 while fixed and portable gas heaters are assumed to increase from 4% and 33% respectively in 2001 to 5% and 36% in 2010 and beyond.

Nelson

Open fires decline rapidly to 1.2% of dwellings by 2005 and unlike Christchurch it is assumed that all are gone by 2010 and beyond. Slow combustion burners are projected to remain at 49% of dwellings from 2001 onward. Electric night-store heaters remain at around 8% of dwellings from 2001 to 2020 while the average number of other fixed and portable electrical appliances remains at

1.41 per household from 2005 onward. Central heating systems are projected to remain at 12% of dwellings from 2005 onward. Portable gas heaters are assumed to increase from 32% respectively in 2001 to 34% in 2005 and beyond, and fixed gas heaters to increase from 3% in 2001 to 4% in 2005 and beyond.

2013 Target Achievement scenario

Christchurch

This scenario is based on the assumption that to achieve the PM10 target by 2013, the following policies will be required: banning open fires by 2006 and non-complying slow combustion burners by 2015 and no burners allowed in new homes from 2005. Open fires decline as quickly as in the Open Fire Ban scenario and slow combustion burners are also assumed to decline markedly from 42% of dwellings in 2001 to 31% in 2005, 22% in 2010 and 12% by 2020. Electric night-store heaters are assumed to rise from 20% of dwellings in 2001 to 23% in 2005, 25% in 2010 and 26% in 2020 while the average number of other fixed and portable electrical appliances is projected to rise from 1.36 per household in 2001 to 1.47 in 2005, 1.48 in 2010 and 1.50 in 2020. Central heating systems are projected to rise from 10% of dwellings in 2001 to 12% in 2005, 15% in 2010 and 17% in 2020. Fixed and portable gas heaters are assumed to increase from 4% and 33% respectively in 2001 to 6% and 42% in 2005, 10% and 44% in 2010 and 14% and 45% in 2020.

Nelson

Open fires decline at the same rate as for the Open Fire Ban scenario. Slow combustion burners are assumed to decline markedly from 49% of dwellings in 2001 to 29% in 2005, to 22% in 2010 and to 17% by 2020. Electric night-store heaters are assumed to rise to around 11% of dwellings in 2005 and beyond. The average number of other fixed and portable electrical appliances is projected to rise from 1.38 per household in 2001 to 1.56 in 2005 and to around 1.60 in 2010 and beyond. Central heating systems are projected to rise from 10% of dwellings in 2001 to 14% in 2005, and 16% in 2010 and beyond. Fixed and portable gas heaters are assumed to increase from 3% and 32% respectively in 2001 to 7% and 36% in 2005 and around 9% and 37% in 2015 and beyond.

COMPARISON OF SCENARIOS

Using the appliance stocks of Tables 1 and 2 with the EERA model [1], the historic and projected residential energy demand for each energy type for Christchurch (Table 3) and Nelson (Table 4) were determined for the different scenarios. These energy demands are illustrated in Figures 1 to 10.

The change in energy demand by energy type, with reference to the Historic Trends and Open Fire Ban scenarios, are shown in Tables 5 and 6 for Christchurch and Nelson respectively. Tables 7 and 8 give the same change as a percentage. These tables show that in Christchurch City an open fire ban only requires 6.1% less electricity by 2010 than complying to air quality standards by 2013. By 2020, 7.8% less electricity would be required by the open fire ban only.

Tables 3 and 4 show that by 2010, 1402 GWh/yr of electricity could be required for Christchurch (7.1% higher than the reference case) and 208 GWh/yr for Nelson (10.3% higher than the reference case) to achieve the 2013 national air standard target. By 2020 this could have increased to 1566 GWh/yr (9.6% higher than the reference case) and 220 GWh/yr respectively (11.2% higher than the reference case).

The following comparison can be made between the Historic Trends and 2013 Target Achievement scenarios, and the energy demand growth scenarios of Orion New Zealand and Marlborough Lines, as recorded in their Asset Management Plans:

The annual growth in the Historic Trends scenario residential electricity demand for Christchurch (Table 3) over the 2004 to 2014 period is 2.2%, and for the 2013 Target Achievement scenario 3.1%. The

average annual growth rate in the total electricity demand of the Orion New Zealand 10-year growth trend scenario is 1.9%. For the air plan implementation scenario it is 3.1% [11].

The annual growth in the Historic Trends scenario residential electricity demand for Nelson (Table 4) over the 2004 to 2014 period is 1.2%, and for the 2013 Target Achievement scenario 1.9%. The average annual growth rate in the total electricity demand of the Marlborough Lines low growth scenario is 1%. For the base case it is 2.5% and for the high growth scenario 5% [12].

CONCLUSIONS

This study has indicated that the more stringent Air Quality Plans being developed and implemented by Environment Canterbury in Christchurch and by the Nelson City Council in Nelson could have an appreciable impact on the present and projected electricity demand for these regions. This impact compares well with that forecast by the Asset Management Plans of Orion New Zealand and Marlborough Lines.

The impact estimated by the Open Fire Ban and 2013 Target Achievement scenarios arises from the one-to-one replacement of solid fuel space and water heating appliances with electrical, LPG and kerosene appliances according to replacement preferences established in ECAN's Clean Heat Programme incentives scheme. The thermal efficiencies of the replaced appliances differ from that of the appliances being replaced. Consequently the before and after replacement energy demand ratios of the affected energy types are not the same as the before and after appliance stock ratios.

The projected energy demands of the three scenarios developed in this study should not be regarded as predictions of future energy demands for the Christchurch City and Nelson City regions. They represent possible energy demand outcomes based on the assumptions used in the study. However, these assumptions are specifically designed to investigate the impact of the Air Quality Plans for Christchurch City and Nelson City. The scenarios are therefore useful indicators of the quantitative impact of the Air Quality Plans on any possible projected energy demand scenario for Canterbury and Nelson-Marlborough regions.

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CRL Energy Ltd is also grateful to Glenn Coates from Orion NZ Ltd who has provided comments based on his development of peak electrical load for Christchurch for similar air quality scenarios.

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TABLES

End use	Appliance type	Scenario	1996	2001	2005	2010	2015	2020
			Dwelling stock [9]					
			116,187	122,777	128,846	134,462	139,674	144,755
			Appliance stock					
Space heating	Electric Night-store Heaters	Historic trends	20,286	24,121	25,682	26,881	27,933	28,951
Space heating	Electric Night-store Heaters	Open Fire Ban	20,286	24,121	25,521	26,634	27,666	28,000
Space heating	Electric Night-store Heaters	2013 Target Achievement	20,286	24,121	30,000	33,000	36,000	38,000
Space heating	Fixed & Portable Electric Heaters	Historic trends	160,104	166,840	173,118	178,095	182,332	186,200
Space heating	Fixed & Portable Electric Heaters	Open Fire Ban	160,104	166,840	175,321	182,963	190,055	196,144
Space heating	Fixed & Portable Electric Heaters	2013 Target Achievement	160,104	166,840	189,000	199,500	209,500	216,500
Space heating	Fixed & Portable Electric Heaters	ECAN			92,972	105,904	114,485	118,723
Space heating	Central Heating of Any Kind	Historic trends	9,589	12,028	12,622	13,172	13,683	14,181
Space heating	Central Heating of Any Kind	Open Fire Ban	9,589	12,028	12,622	13,172	13,683	14,181
Space heating	Central Heating of Any Kind	2013 Target Achievement	9,589	12,028	15,000	19,500	22,500	24,500
Space heating	Fixed Gas Heaters	Historic trends	1,828	4,525	5,574	6,022	6,282	6,514
Space heating	Fixed Gas Heaters	Open Fire Ban	1,828	4,525	5,500	6,300	6,600	6,900
Space heating	Fixed Gas Heaters	2013 Target Achievement	1,828	4,525	7,500	14,000	18,000	20,000
Space heating	Portable Gas Heaters	Historic trends	26,883	40,858	44,727	47,022	48,882	50,664
Space heating	Portable Gas Heaters	Open Fire Ban	26,883	40,858	46,000	48,000	50,000	52,000
Space heating	Portable Gas Heaters	2013 Target Achievement	26,883	40,858	53,500	59,500	62,500	65,500
Space heating	Portable Gas Heaters	ECAN			44,540	53,684	62,281	67,925
Space heating	Portable Kerosene Heaters	Historic trends	3,443	2,911	2,556	2,134	1,773	1,470
Space heating	Portable Kerosene Heaters	Open Fire Ban	3,443	2,911	2,200	2,400	2,500	2,600
Space heating	Portable Kerosene Heaters	2013 Target Achievement	3,443	2,911	2,350	2,800	3,200	3,400
Space heating	Portable Kerosene Heaters	ECAN			2,277	2,808	3,223	3,419
Space heating	Open Fires	Historic trends	31,342	19,447	11,902	6,331	3,352	1,770
Space heating	Open Fires	Open Fire Ban	31,342	19,447	3,902	700	600	500
Space heating	Open Fires	2013 Target Achievement	31,342	19,447	3,902	700	600	500
Space heating	Open Fires	ECAN	15,357		3,902	700	600	500
Space heating	Slow Combustion Fires	Historic trends	46,323	51,074	54,715	57,996	60,775	63,297
Space heating	Slow Combustion Fires	Open Fire Ban	46,323	51,074	53,000	57,000	58,500	60,000
Space heating	Slow Combustion Fires	2013 Target Achievement	46,323	51,074	40,000	29,000	19,500	17,500
Space heating	Slow Combustion Fires	ECAN	34,483		39,405	28,714	19,365	17,531
Water heating	Wet-back Fires of Any Kind	Historic trends	40,410	30,531	27,000	25,000	25,000	25,000
Water heating	Wet-back Fires of Any Kind	Open Fire Ban	40,410	30,531	27,000	25,000	25,000	25,000
Water heating	Wet-back Fires of Any Kind	2013 Target Achievement	40,410	30,531	18,000	14,000	17,000	17,000
Water heating	Electric Water Heaters	Historic trends	113,280	120,411	126,833	132,847	138,386	143,731
Water heating	Electric Water Heaters	Open Fire Ban	113,280	120,411	126,833	132,847	138,386	143,731
Water heating	Electric Water Heaters	2013 Target Achievement	113,280	120,411	126,833	132,847	138,386	143,731

Table 1: Historic and projected stocks of dwellings and residential appliances for Christchurch City, as estimated by CRL Energy Ltd and Environment Canterbury (ECAN) (see heading: *Assumptions*)

End use	Appliance type	Scenario	1996	2001	2005	2010	2015	2020
			Dwelling stock					
			15,282	16,125	17,242	18,388	19,541	20,642
			Appliance stock					
Space heating	Electric Night-store Heaters (Fixed in Place)	Historic trends	3,074	1,336	657	265	107	43
Space heating	Electric Night-store Heaters (Fixed in Place)	Open Fire Ban	3,074	1,336	1,419	1,517	1,610	1,699
Space heating	Electric Night-store Heaters (Fixed in Place)	2013 Target Achievement	3,074	1,336	1,833	2,097	2,286	2,441
Space heating	Fixed & Portable Electric Heaters	Historic trends	20,542	22,272	24,005	25,696	27,341	28,894
Space heating	Fixed & Portable Electric Heaters	Open Fire Ban	20,542	22,272	24,250	25,889	27,498	29,034
Space heating	Fixed & Portable Electric Heaters	2013 Target Achievement	20,542	22,272	26,809	29,162	31,217	33,082
Space heating	Central Heating of Any Kind	Historic trends	1,324	1,554	1,759	1,963	2,143	2,301
Space heating	Central Heating of Any Kind	Open Fire Ban	1,324	1,554	2,069	2,207	2,345	2,477
Space heating	Central Heating of Any Kind	2013 Target Achievement	1,324	1,554	2,400	2,850	3,050	3,250
Space heating	Gas Heaters (Fixed in Place)	Historic trends	182	510	548	585	621	656
Space heating	Gas Heaters (Fixed in Place)	Open Fire Ban	182	510	690	736	782	826
Space heating	Gas Heaters (Fixed in Place)	2013 Target Achievement	182	510	1,164	1,505	1,740	1,926
Space heating	Portable Gas Heaters	Historic trends	3,951	5,187	5,642	6,030	6,409	6,771
Space heating	Portable Gas Heaters	Open Fire Ban	3,951	5,187	5,862	6,252	6,644	7,018
Space heating	Portable Gas Heaters	2013 Target Achievement	3,951	5,187	6,170	6,739	7,228	7,678
Space heating	Portable Kerosene Heaters	Historic trends	435	335	279	218	169	131
Space heating	Portable Kerosene Heaters	Open Fire Ban	435	335	200	250	300	350
Space heating	Portable Kerosene Heaters	2013 Target Achievement	435	335	285	335	385	435
Space heating	Open Fires	Historic trends	3,204	1,344	778	385	190	93
Space heating	Open Fires	Open Fire Ban	3,204	1,344	200	0	0	0
Space heating	Open Fires	2013 Target Achievement	3,204	1,344	200	0	0	0
Space heating	Open Fires	Nelson City Council	-	1,156	-	-	-	-
Space heating	Slow Combustion Fires	Historic trends	7,488	7,901	8,449	9,010	9,575	10,115
Space heating	Slow Combustion Fires	Open Fire Ban	7,488	7,901	8,333	8,982	9,494	9,984
Space heating	Slow Combustion Fires	2013 Target Achievement	7,488	7,901	4,929	4,086	3,658	3,475
Space heating	Slow Combustion Fires	Nelson City Council	-	7,901	-	-	-	-
Water heating	Wet-back Fires of Any Kind:	Historic trends	4,608	4,342	4,240	4,038	3,832	3,614
Water heating	Wet-back Fires of Any Kind:	Open Fire Ban	4,608	4,342	3,000	3,200	3,400	3,600
Water heating	Wet-back Fires of Any Kind:	2013 Target Achievement	4,608	4,342	2,050	1,750	1,650	1,550
Water heating	Water Heaters	Historic trends	14,981	15,938	17,112	18,306	19,491	20,611
Water heating	Water Heaters	Open Fire Ban	14,981	15,938	17,112	18,306	19,491	20,611
Water heating	Water Heaters	2013 Target Achievement	14,981	15,938	17,112	18,306	19,491	20,611

Table 2: Historic and projected stocks of dwellings and residential appliances for Nelson City, as estimated by CRL Energy Ltd (see heading: *Assumptions*)

Electricity (TJ/yr)

Scenario:	2000	2002	2004	2006	2008	2010	2012	2014	2016	2018	2020
Historic Trends	4,070	4,292	4,384	4,509	4,617	4,712	4,805	4,897	4,985	5,067	5,145
Open Fire Ban	4,070	4,301	4,400	4,531	4,648	4,756	4,861	4,964	5,059	5,146	5,228
2013 Target Achievement	4,070	4,346	4,558	4,773	4,924	5,048	5,180	5,316	5,439	5,543	5,638
ECAN Regional Energy Survey	4,070	4,292									

Electricity (GWh/yr)

Scenario:	2000	2002	2004	2006	2008	2010	2012	2014	2016	2018	2020
Historic Trends	1,131	1,192	1,218	1,252	1,283	1,309	1,335	1,360	1,385	1,407	1,429
Open Fire Ban	1,131	1,195	1,222	1,259	1,291	1,321	1,350	1,379	1,405	1,429	1,452
2013 Target Achievement	1,131	1,207	1,266	1,326	1,368	1,402	1,439	1,477	1,511	1,540	1,566
ECAN Regional Energy Survey	1,131	1,192	0	0	0	0	0	0	0	0	0

Coal (TJ/yr)

Scenario:	2000	2002	2004	2006	2008	2010	2012	2014	2016	2018	2020
Historic Trends	143	81	56	45	36	29	23	19	15	12	10
Open Fire Ban	143	76	40	23	15	13	11	8	7	5	5
2013 Target Achievement	143	74	36	17	10	8	6	5	3	3	3
ECAN Regional Energy Survey	143	81									

Kerosene (TJ/yr)

Scenario:	2000	2002	2004	2006	2008	2010	2012	2014	2016	2018	2020
Historic Trends	363	440	528	611	679	730	769	799	824	843	860
Open Fire Ban	363	435	512	595	676	743	793	829	858	882	903
2013 Target Achievement	363	436	517	605	691	764	818	859	890	914	933
ECAN Regional Energy Survey	363	440									

LPG (TJ/yr)

Scenario:	2000	2002	2004	2006	2008	2010	2012	2014	2016	2018	2020
Historic Trends	182	215	255	289	318	343	364	382	398	411	421
Open Fire Ban	182	216	260	296	326	351	373	392	408	422	434
2013 Target Achievement	182	224	295	362	423	474	518	554	584	609	631
ECAN Regional Energy Survey	187	219									

Wood (TJ/yr)

Scenario:	2000	2002	2004	2006	2008	2010	2012	2014	2016	2018	2020
Historic Trends	1,065	1,116	1,135	1,179	1,219	1,255	1,292	1,330	1,369	1,407	1,444
Open Fire Ban	1,065	1,059	902	817	861	973	1,069	1,138	1,199	1,262	1,324
2013 Target Achievement	1,065	1,028	772	569	507	526	536	528	525	536	554
ECAN Regional Energy Survey	1,065	1,116									

Table 3: Historic and projected residential energy demand for Christchurch City for different scenarios, as estimated by the EERA model from the appliance stocks of Table 1

Electricity (TJ/yr)

Scenario:	2000	2002	2004	2006	2008	2010	2012	2014	2016	2018	2020
Historic Trends	626	639	651	663	672	679	686	693	700	706	713
Open Fire Ban	626	655	671	678	689	701	710	717	724	731	738
2013 Target Achievement	626	663	699	720	736	749	759	768	777	785	793
Electricity Enterprise Statistics	626										

Electricity (GWh/yr)

Scenario:	2000	2002	2004	2006	2008	2010	2012	2014	2016	2018	2020
Historic Trends	174	177	181	184	187	189	190	192	194	196	198
Open Fire Ban	174	182	186	188	192	195	197	199	201	203	205
2013 Target Achievement	174	184	194	200	204	208	211	213	216	218	220
Electricity Enterprise Statistics	174										

Coal (TJ/yr)

Scenario:	2000	2002	2004	2006	2008	2010	2012	2014	2016	2018	2020
Historic Trends	15	8	6	5	4	3	3	2	2	1	1
Open Fire Ban	15	8	5	3	3	2	2	1	1	1	1
2013 Target Achievement	15	8	4	2	1	1	1	1	0	0	0

Kerosene (TJ/yr)

Scenario:	2000	2002	2004	2006	2008	2010	2012	2014	2016	2018	2020
Historic Trends	44	54	67	79	89	97	104	109	114	118	121
Open Fire Ban	44	53	64	76	88	98	107	114	119	124	128
2013 Target Achievement	44	54	67	80	92	102	110	117	122	127	131

LPG (TJ/yr)

Scenario:	2000	2002	2004	2006	2008	2010	2012	2014	2016	2018	2020
Historic Trends	18	22	26	30	33	36	39	41	43	45	46
Open Fire Ban	18	22	27	32	35	38	41	43	45	47	49
2013 Target Achievement	18	23	30	36	41	45	49	52	55	58	60

Wood (TJ/yr)

Scenario:	2000	2002	2004	2006	2008	2010	2012	2014	2016	2018	2020
Historic Trends	115	121	125	132	137	142	148	154	159	165	170
Open Fire Ban	115	116	103	100	109	118	129	138	146	155	164
2013 Target Achievement	115	109	78	58	55	57	59	59	59	60	61

Table 4: Historic and projected residential energy demand for Nelson City for different scenarios as estimated by the EERA model from the appliance stocks of Table 2

Electricity (TJ/yr)

Scenario:	2000	2002	2004	2006	2008	2010	2012	2014	2016	2018	2020
Open Fire Ban - Historic Trends	0	9	16	22	31	43	57	67	74	79	83
2013 Target Achievement - Historic Trends	0	54	174	264	307	336	376	419	453	476	493
2013 Target Achievement - Open Fire Ban	0	45	158	242	276	292	319	352	379	397	410

Electricity (GWh/yr)

Scenario:	2000	2002	2004	2006	2008	2010	2012	2014	2016	2018	2020
Open Fire Ban - Historic Trends	0	2	4	6	9	12	16	19	21	22	23
2013 Target Achievement - Historic Trends	0	15	48	73	85	93	104	116	126	132	137
2013 Target Achievement - Open Fire Ban	0	12	44	67	77	81	89	98	105	110	114

Coal (TJ/yr)

Scenario:	2000	2002	2004	2006	2008	2010	2012	2014	2016	2018	2020
Open Fire Ban - Historic Trends	0	-5	-15	-22	-21	-16	-13	-10	-9	-7	-5
2013 Target Achievement - Historic Trends	0	-7	-19	-28	-27	-22	-17	-14	-12	-9	-7
2013 Target Achievement - Open Fire Ban	0	-2	-4	-6	-6	-5	-5	-4	-3	-2	-2

Kerosene (TJ/yr)

Scenario:	2000	2002	2004	2006	2008	2010	2012	2014	2016	2018	2020
Open Fire Ban - Historic Trends	0	-5	-16	-17	-3	14	24	30	34	39	43
2013 Target Achievement - Historic Trends	0	-4	-11	-6	12	34	50	60	66	70	73
2013 Target Achievement - Open Fire Ban	0	1	5	10	15	20	26	30	32	31	30

LPG (TJ/yr)

Scenario:	2000	2002	2004	2006	2008	2010	2012	2014	2016	2018	2020
Open Fire Ban - Historic Trends	0	2	5	7	8	8	9	10	11	12	13
2013 Target Achievement - Historic Trends	0	10	40	74	105	132	154	172	186	198	209
2013 Target Achievement - Open Fire Ban	0	8	35	67	97	124	145	162	176	187	197

Wood (TJ/yr)

Scenario:	2000	2002	2004	2006	2008	2010	2012	2014	2016	2018	2020
Open Fire Ban - Historic Trends	0	-57	-233	-362	-358	-282	-223	-192	-170	-145	-120
2013 Target Achievement - Historic Trends	0	-88	-363	-611	-712	-729	-756	-802	-844	-871	-890
2013 Target Achievement - Open Fire Ban	0	-31	-130	-249	-354	-447	-533	-610	-674	-726	-770

Table 5: Change in energy demand for Christchurch City by energy type, with reference to the Historic Trends and Open Fire Ban scenarios

Electricity (TJ/yr)

Scenario:	2000	2002	2004	2006	2008	2010	2012	2014	2016	2018	2020
Open Fire Ban - Historic Trends	0	16	20	16	18	23	25	25	24	25	25
2013 Target Achievement - Historic Trends	0	24	48	58	65	70	74	76	77	79	80
2013 Target Achievement - Open Fire Ban	0	8	28	42	47	48	49	51	53	54	55

Electricity (GWh/yr)

Scenario:	2000	2002	2004	2006	2008	2010	2012	2014	2016	2018	2020
Open Fire Ban - Historic Trends	0	4	6	4	5	6	7	7	7	7	7
2013 Target Achievement - Historic Trends	0	7	13	16	18	19	21	21	21	22	22
2013 Target Achievement - Open Fire Ban	0	2	8	12	13	13	14	14	15	15	15

Coal (TJ/yr)

Scenario:	2000	2002	2004	2006	2008	2010	2012	2014	2016	2018	2020
Open Fire Ban - Historic Trends	0	0	-1	-1	-1	-1	-1	-1	-1	-1	0
2013 Target Achievement - Historic Trends	0	-1	-2	-3	-2	-2	-2	-1	-1	-1	-1
2013 Target Achievement - Open Fire Ban	0	0	-1	-1	-1	-1	-1	-1	-1	0	0

Kerosene (TJ/yr)

Scenario:	2000	2002	2004	2006	2008	2010	2012	2014	2016	2018	2020
Open Fire Ban - Historic Trends	0	-1	-3	-3	-1	1	3	4	5	6	7
2013 Target Achievement - Historic Trends	0	0	0	1	3	5	6	7	8	9	9
2013 Target Achievement - Open Fire Ban	0	1	3	4	4	3	3	3	3	3	3

LPG (TJ/yr)

Scenario:	2000	2002	2004	2006	2008	2010	2012	2014	2016	2018	2020
Open Fire Ban - Historic Trends	0	0	1	2	2	2	2	2	2	3	3
2013 Target Achievement - Historic Trends	0	1	4	6	8	9	10	11	12	13	14
2013 Target Achievement - Open Fire Ban	0	1	3	4	6	7	8	9	10	10	11

Wood (TJ/yr)

Scenario:	2000	2002	2004	2006	2008	2010	2012	2014	2016	2018	2020
Open Fire Ban - Historic Trends	0	-6	-22	-31	-29	-24	-19	-16	-13	-10	-6
2013 Target Achievement - Historic Trends	0	-12	-47	-74	-82	-85	-88	-94	-100	-105	-109
2013 Target Achievement - Open Fire Ban	0	-6	-25	-42	-53	-61	-69	-78	-87	-95	-103

Table 6: Change in energy demand for Nelson City by energy type, with reference to the Historic Trends and Open Fire Ban scenarios

Electricity (%)

Scenario:	2000	2002	2004	2006	2008	2010	2012	2014	2016	2018	2020
Open Fire Ban - Historic Trends	0.0	0.2	0.4	0.5	0.7	0.9	1.2	1.4	1.5	1.6	1.6
2013 Target Achievement - Historic Trends	0.0	1.3	4.0	5.9	6.6	7.1	7.8	8.6	9.1	9.4	9.6
2013 Target Achievement - Open Fire Ban	0.0	1.0	3.6	5.3	5.9	6.1	6.6	7.1	7.5	7.7	7.8

Coal (%)

Scenario:	2000	2002	2004	2006	2008	2010	2012	2014	2016	2018	2020
Open Fire Ban - Historic Trends	0.0	0.2	0.4	0.5	0.7	0.9	1.2	1.4	1.5	1.6	1.6
2013 Target Achievement - Historic Trends	0.0	1.3	4.0	5.9	6.6	7.1	7.8	8.6	9.1	9.4	9.6
2013 Target Achievement - Open Fire Ban	0.0	1.0	3.6	5.3	5.9	6.1	6.6	7.1	7.5	7.7	7.8

Kerosene (%)

Scenario:	2000	2002	2004	2006	2008	2010	2012	2014	2016	2018	2020
Open Fire Ban - Historic Trends	0.0	-6.2	-27.3	-49.2	-58.1	-55.9	-53.8	-55.0	-56.9	-56.1	-52.3
2013 Target Achievement - Historic Trends	0.0	-8.2	-34.8	-61.5	-73.7	-73.9	-73.5	-75.6	-77.3	-75.6	-70.5
2013 Target Achievement - Open Fire Ban	0.0	-2.1	-10.3	-24.1	-37.2	-40.7	-42.6	-45.7	-47.3	-44.4	-38.1

LPG (%)

Scenario:	2000	2002	2004	2006	2008	2010	2012	2014	2016	2018	2020
Open Fire Ban - Historic Trends	0.0	-1.1	-3.1	-2.7	-0.4	1.9	3.1	3.7	4.2	4.6	5.0
2013 Target Achievement - Historic Trends	0.0	-0.8	-2.1	-1.0	1.8	4.6	6.5	7.5	8.0	8.3	8.5
2013 Target Achievement - Open Fire Ban	0.0	0.3	1.1	1.7	2.3	2.7	3.2	3.6	3.7	3.6	3.4

Wood (%)

Scenario:	2000	2002	2004	2006	2008	2010	2012	2014	2016	2018	2020
Open Fire Ban - Historic Trends	0.0	0.7	2.1	2.4	2.4	2.4	2.4	2.5	2.7	2.8	3.0
2013 Target Achievement - Historic Trends	0.0	4.5	15.8	25.6	33.0	38.4	42.3	44.9	46.8	48.3	49.7
2013 Target Achievement - Open Fire Ban	0.0	3.8	13.4	22.6	29.8	35.2	38.9	41.3	43.0	44.3	45.3

Table 7: Percentage change in energy demand for Christchurch City by energy type, with reference to the Historic Trends and Open Fire Ban scenarios

Electricity (%)

Scenario:	2000	2002	2004	2006	2008	2010	2012	2014	2016	2018	2020
Open Fire Ban - Historic Trends	0.0	2.5	3.1	2.3	2.7	3.3	3.6	3.6	3.5	3.5	3.6
2013 Target Achievement - Historic Trends	0.0	3.8	7.4	8.7	9.6	10.3	10.8	11.0	11.0	11.1	11.2
2013 Target Achievement - Open Fire Ban	0.0	1.2	4.2	6.2	6.8	6.8	6.9	7.1	7.3	7.4	7.4

Coal (%)

Scenario:	2000	2002	2004	2006	2008	2010	2012	2014	2016	2018	2020
Open Fire Ban - Historic Trends	0.0	-3.7	-16.4	-28.0	-31.5	-37.8	-38.7	-39.5	-40.2	-40.2	-38.6
2013 Target Achievement - Historic Trends	0.0	-9.0	-35.5	-56.1	-62.3	-68.8	-70.1	-71.4	-71.9	-70.7	-66.8
2013 Target Achievement - Open Fire Ban	0.0	-5.5	-22.9	-39.1	-44.9	-49.9	-51.2	-52.8	-53.0	-51.0	-45.9

Kerosene (%)

Scenario:	2000	2002	2004	2006	2008	2010	2012	2014	2016	2018	2020
Open Fire Ban - Historic Trends	0.0	-1.5	-4.2	-4.0	-1.3	1.3	2.9	3.8	4.4	5.0	5.5
2013 Target Achievement - Historic Trends	0.0	-0.2	-0.1	1.1	3.1	4.9	6.0	6.6	7.0	7.3	7.6
2013 Target Achievement - Open Fire Ban	0.0	1.4	4.3	5.3	4.5	3.5	2.9	2.7	2.5	2.2	2.0

LPG (%)

Scenario:	2000	2002	2004	2006	2008	2010	2012	2014	2016	2018	2020
Open Fire Ban - Historic Trends	0.0	2.3	5.2	6.1	5.9	5.7	5.7	5.7	5.6	5.6	5.6
2013 Target Achievement - Historic Trends	0.0	5.0	14.9	21.1	23.6	24.8	26.1	27.2	28.1	28.8	29.5
2013 Target Achievement - Open Fire Ban	0.0	2.7	9.2	14.1	16.7	18.1	19.3	20.4	21.3	22.0	22.6

Wood (%)

Scenario:	2000	2002	2004	2006	2008	2010	2012	2014	2016	2018	2020
Open Fire Ban - Historic Trends	0.0	-4.7	-17.6	-23.9	-20.9	-17.2	-13.0	-10.4	-8.2	-5.9	-3.5
2013 Target Achievement - Historic Trends	0.0	-9.9	-37.4	-56.2	-59.9	-60.0	-59.9	-61.4	-63.0	-63.7	-63.9
2013 Target Achievement - Open Fire Ban	0.0	-5.5	-24.1	-42.4	-49.3	-51.7	-53.9	-57.0	-59.6	-61.4	-62.6

Table 8: Percentage change in energy demand for Nelson City by energy type, with reference to the Historic Trends and Open Fire Ban scenarios

FIGURES

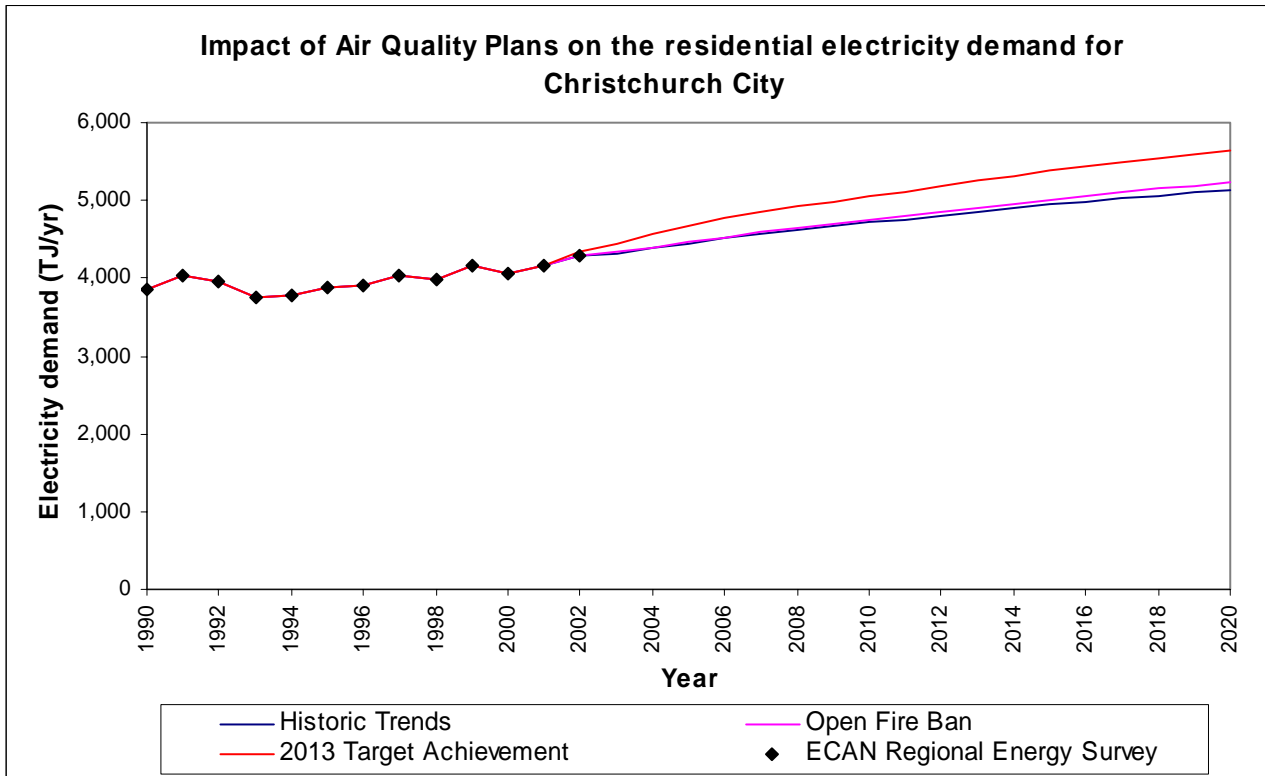


Figure 1: Impact of Air Quality Plans, as expressed by different scenarios, on the electricity demand for Christchurch City

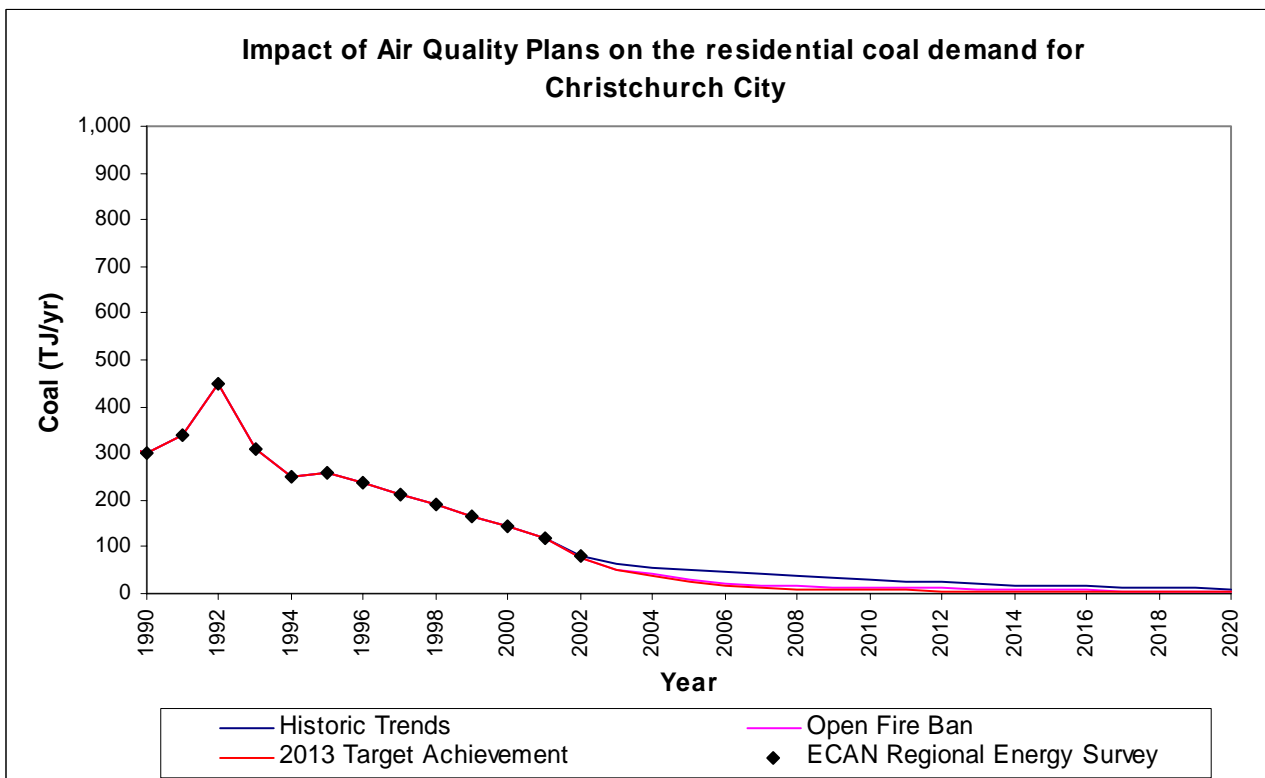


Figure 2: Impact of Air Quality Plans, as expressed by different scenarios, on the coal demand for Christchurch City

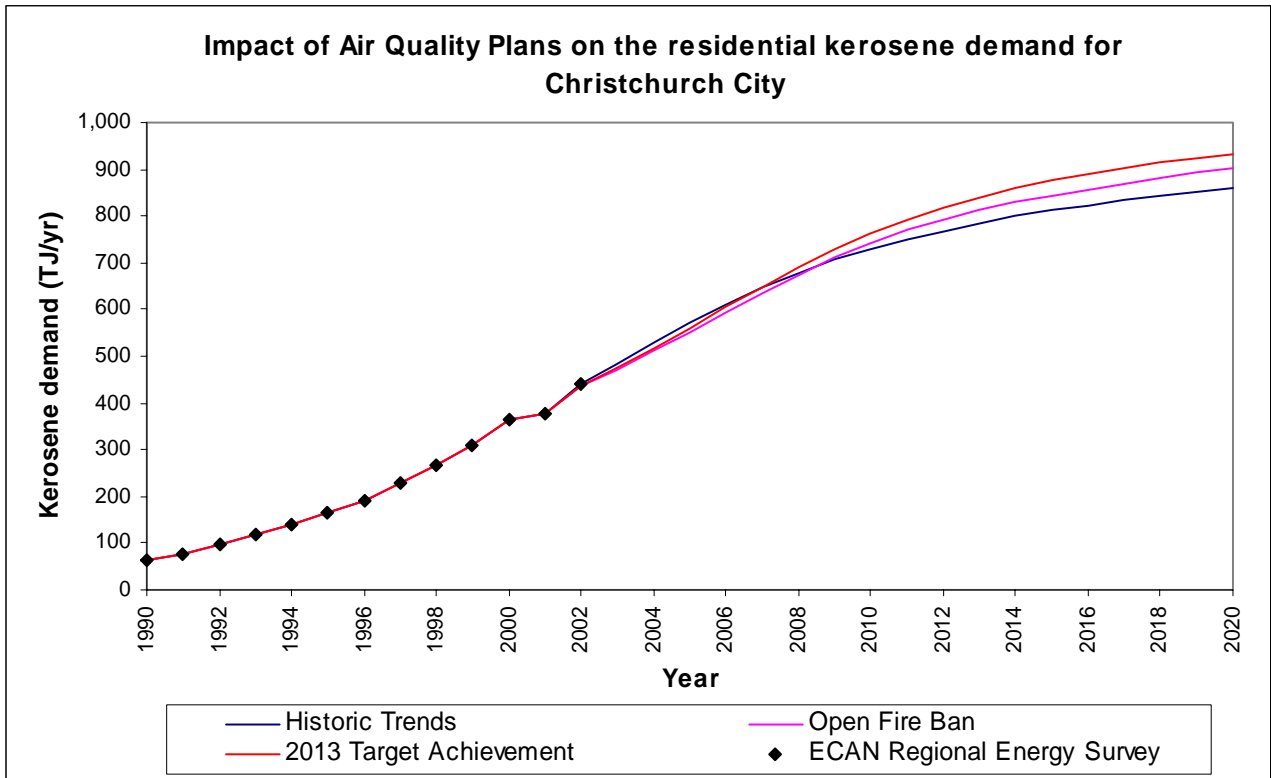


Figure 3: Impact of Air Quality Plans, as expressed by different scenarios, on the kerosene demand for Christchurch City

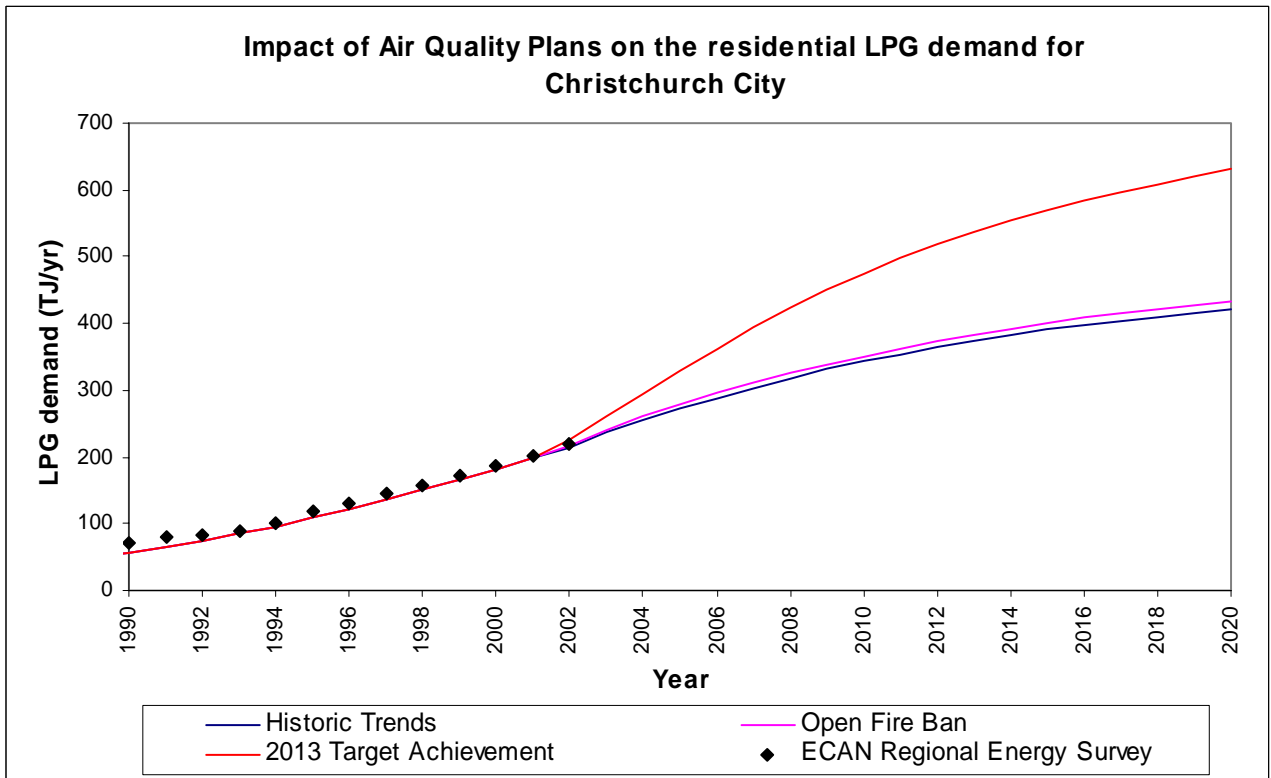


Figure 4: Impact of Air Quality Plans, as expressed by different scenarios, on the LPG demand for Christchurch City

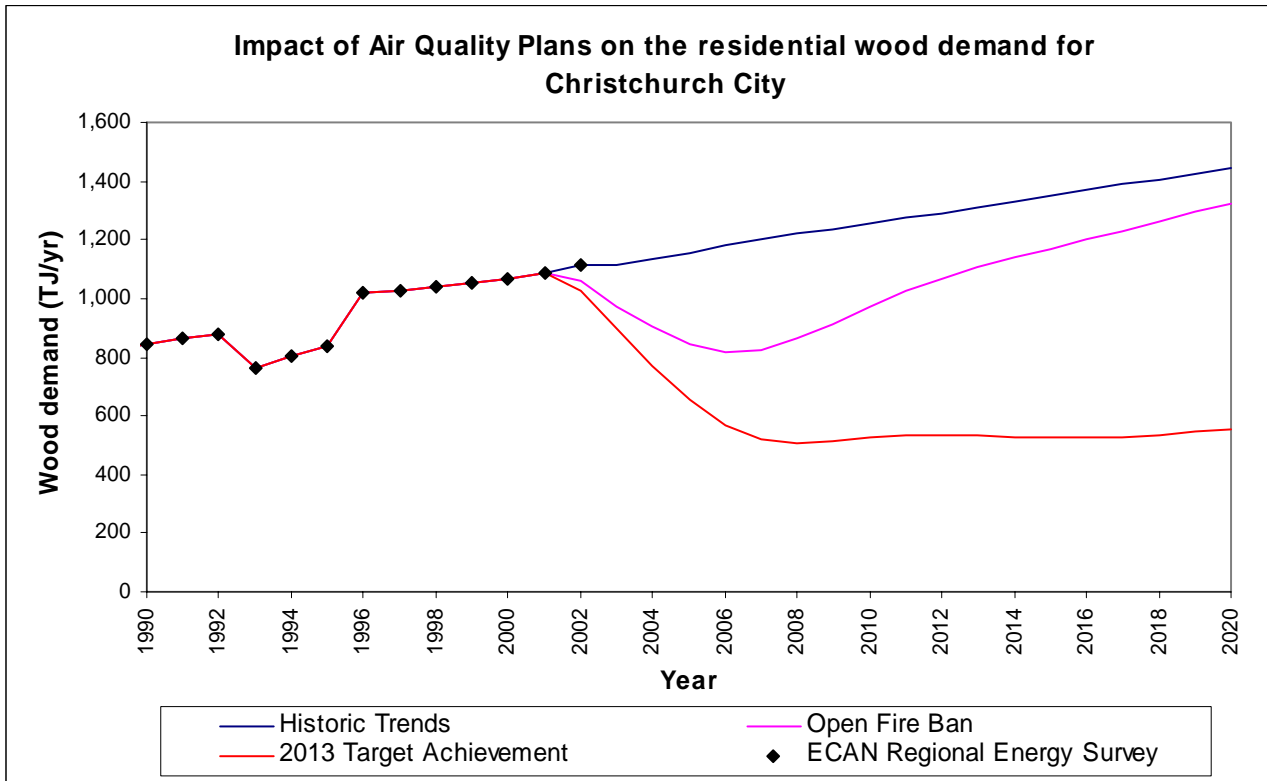


Figure 5: Impact of Air Quality Plans, as expressed by different scenarios, on the wood demand for Christchurch City

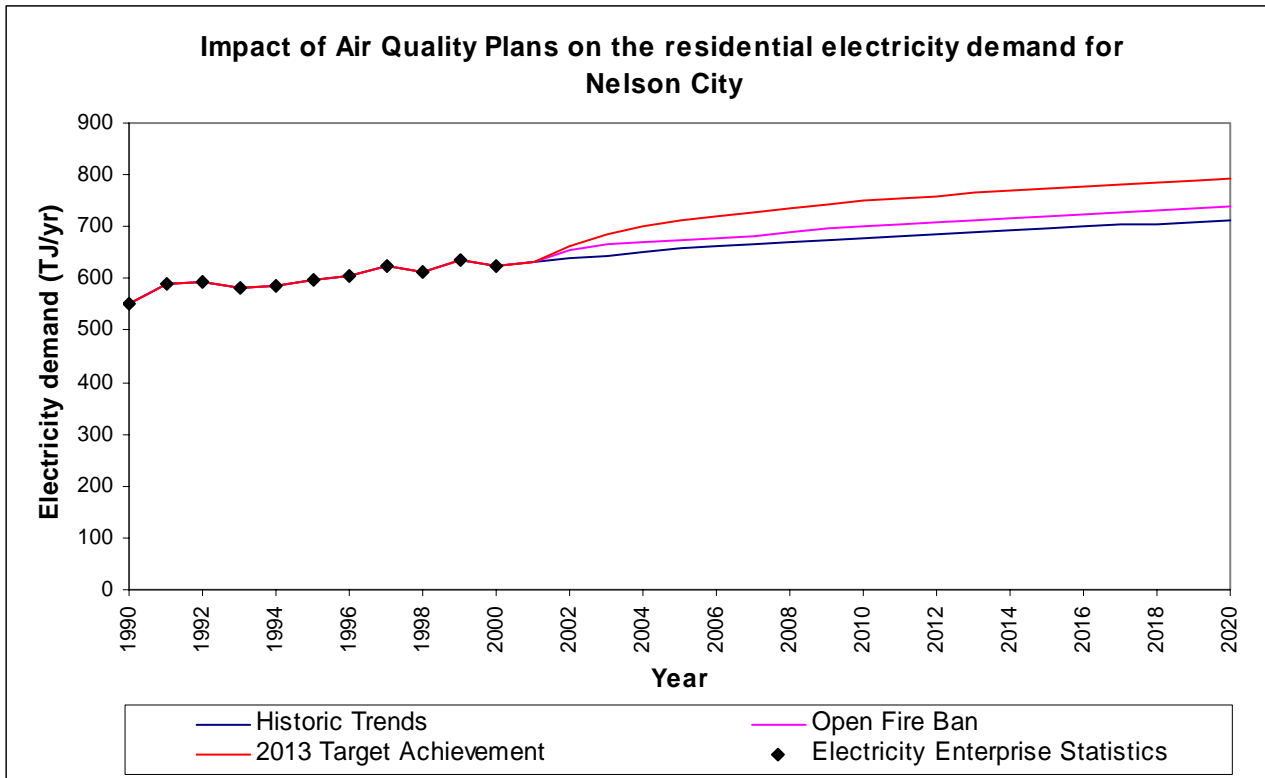


Figure 6: Impact of Air Quality Plans, as expressed by different scenarios, on the electricity demand for Nelson City

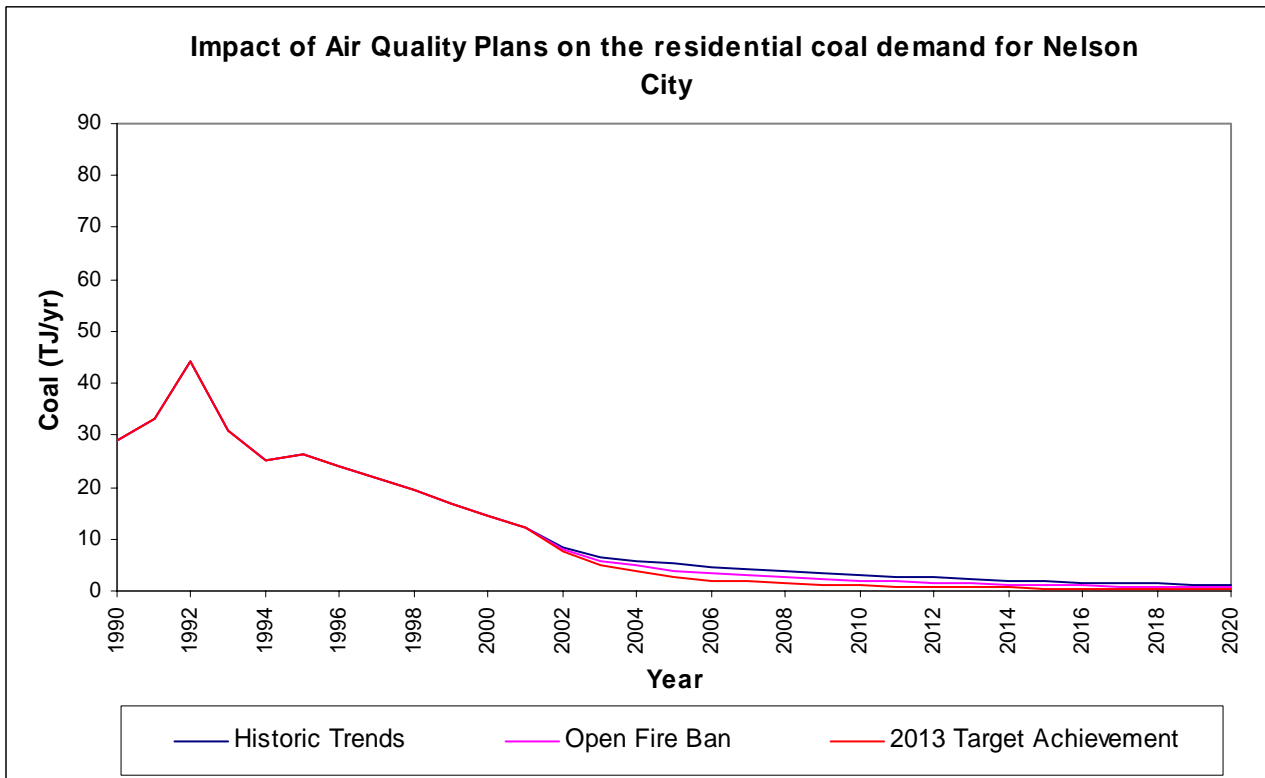


Figure 7: Impact of Air Quality Plans, as expressed by different scenarios, on the coal demand for Nelson City

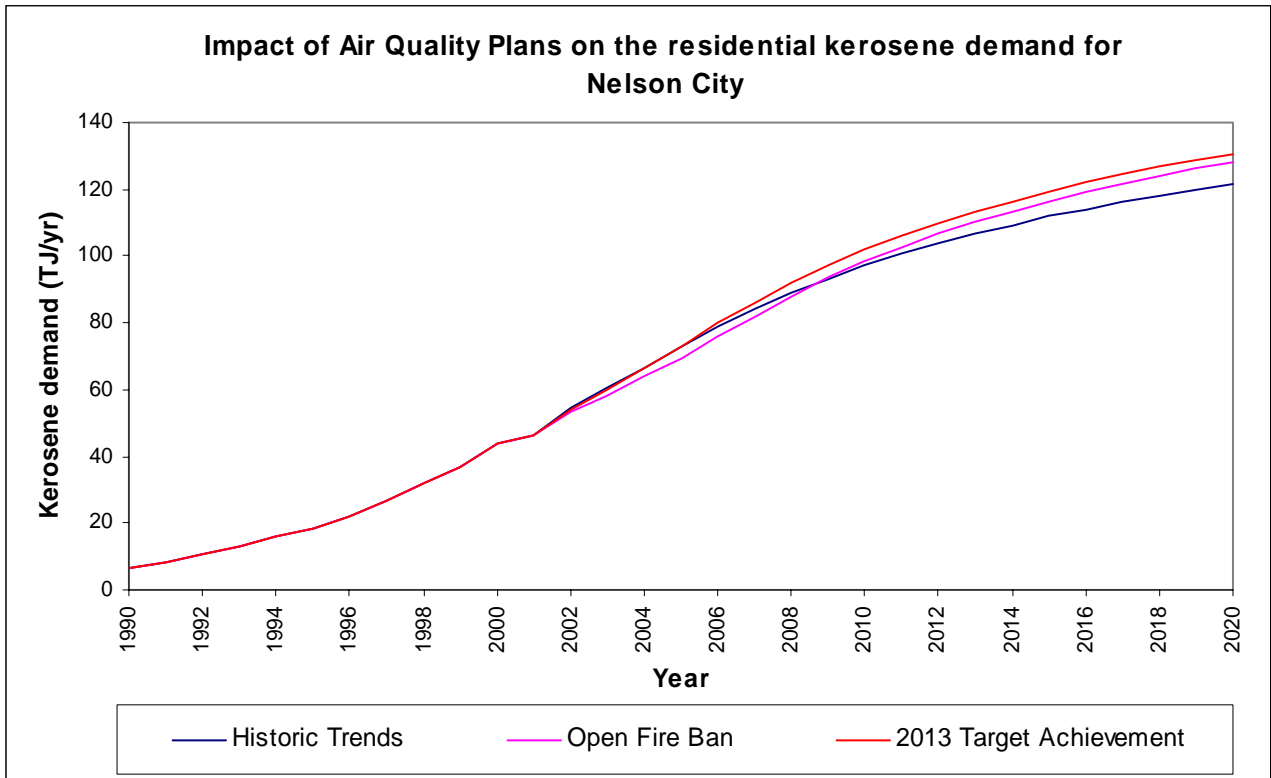


Figure 8: Impact of Air Quality Plans, as expressed by different scenarios, on the kerosene demand for Nelson City

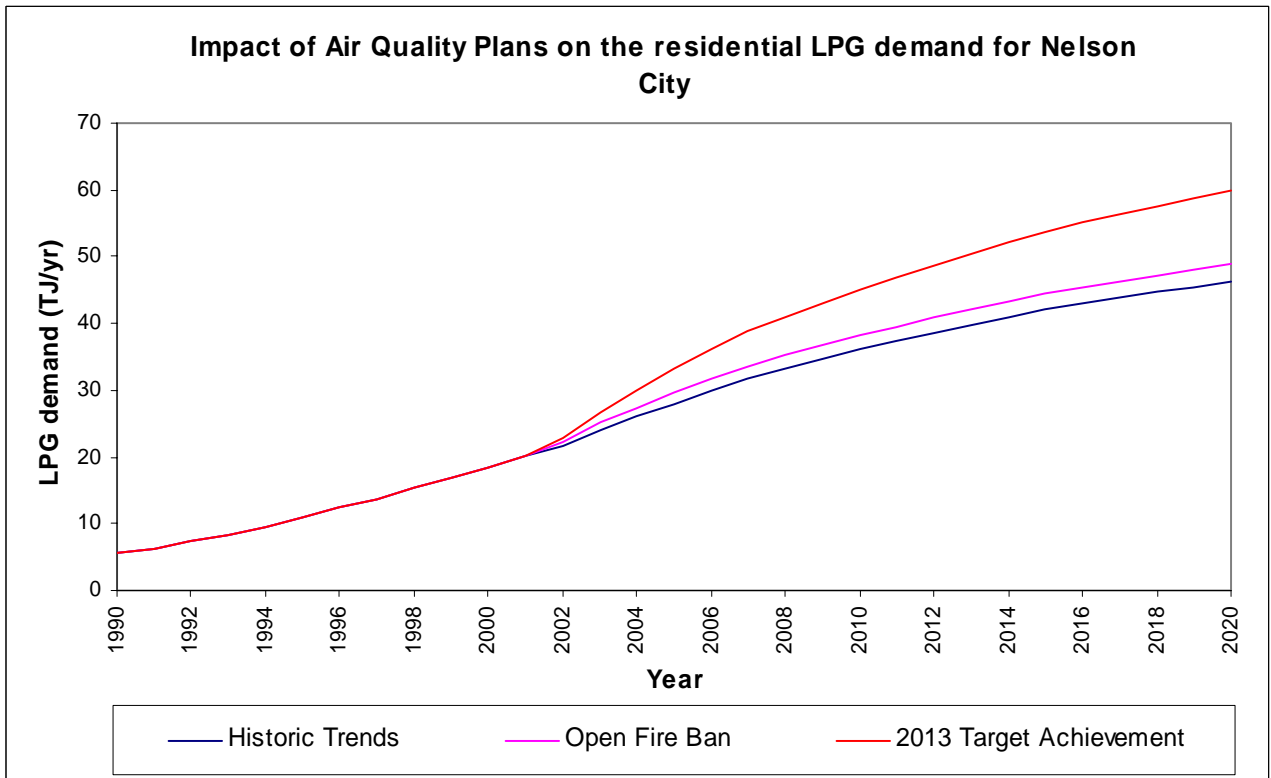


Figure 9: Impact of Air Quality Plans, as expressed by different scenarios, on the LPG demand for Nelson City

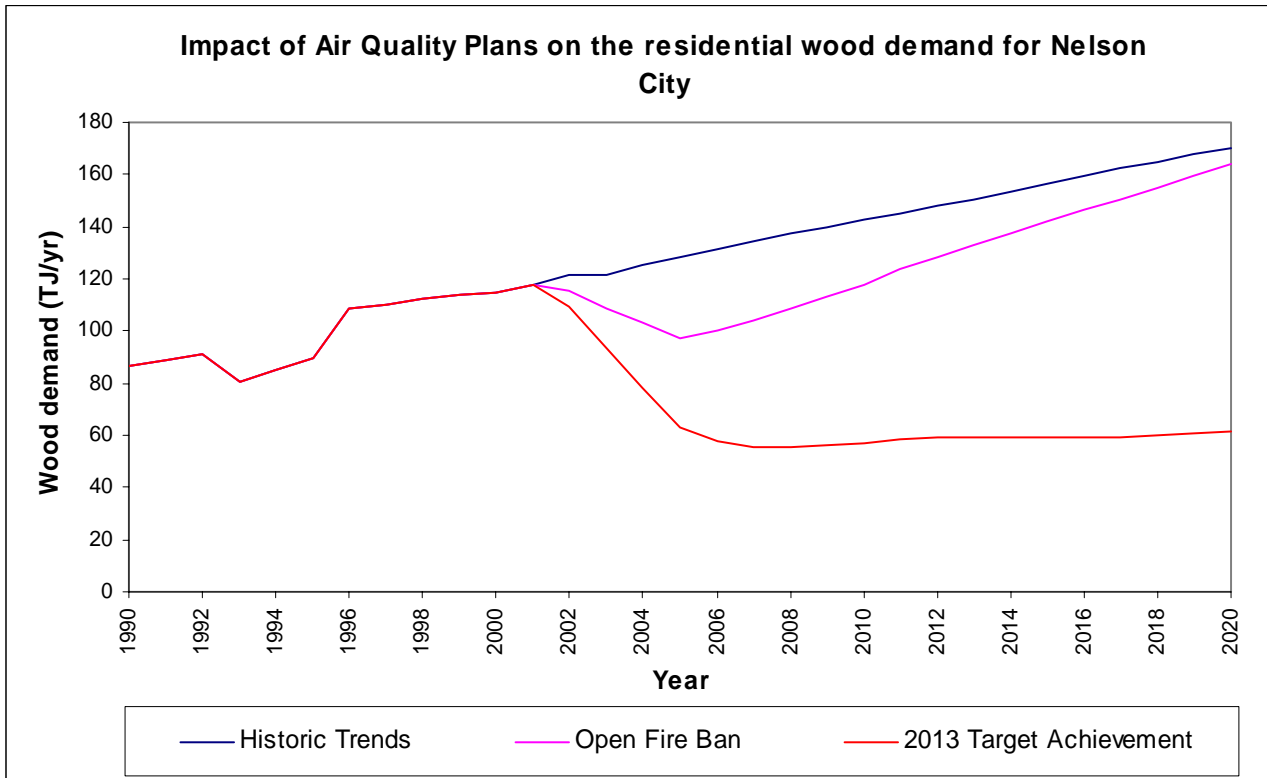


Figure 10: Impact of Air Quality Plans, as expressed by different scenarios, on the wood demand for Nelson City