# Household Heating in New Zealand

# ABSTRACT

The aim of this report was to analyse the advantages and disadvantages of the New Zealand government's proposed strategy of subsidising 20% of heat pump (HP) installation costs for 20% of the population that use wood burners and fireplaces as their main source of heating. Through this analysis, the sensibility of the proposed strategy had to be found.

The research required for this report was conducted using statistics primarily from New Zealand government organisations such as the Ministry of Business, Innovation and Employment, StatsNZ, etc.

The benefits of this strategy included:

- Elimination of **972557** to **1021185** tonnes of Carbon Dioxide ($CO_2$), **102374** to **107493** tonnes of Nitrogen Dioxide ($NO_2$) and **35831** to **37623** tonnes of Methane ($CH_4$) from the air per year, resulting in improved overall air quality.

- Giving Kiwis a difference of up to **$196** in their annual energy bill when switching to heat pumps.

The primary setbacks included substantial cost towards the government due to the subsidy and the additional load on the electricity grid requiring a greater dependence on non-renewable resources to meet demand in a short space of time.

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# 1 INTRODUCTION

An adequately heated home is essential towards human health (Gemmel, 2001). Residing in a low temperature area for extended time periods can have detrimental health effects (Harvard Health Publishing, 2014). Subsequently, heat generation is a necessity for every NZ household.

The aim of this report is to investigate the effects of the NZ government's target of replacing 20% of wood and coal dependant heating used by households with heat pumps (HPs) instead. The scope of this report covers the advantages and disadvantages of the NZ governments proposed strategy to meet their target which entails subsidising the cost of HP installation by 20% for households which use wood and coal fuelled heating. A limitation of this report is the data used was obtained through other people's research which varies in terms of the time their studies were carried out. Therefore, the data used does not account for any changes in trends that might have occurred after it was published.

According to Environmental Health Indicators New Zealand (EHINZ), in 2013, **37%** of NZ homes used wood fires for home heating. **4%** of NZ homes used coal fires for heating (EHINZ, 2017). I have assumed woodburners and fireplaces to be included in the same category for the **37%.**

The current household number estimate in NZ is **1,729,300** (StatsNZ, 2017)**.** It can therefore be said **639,841** households in NZ use woodburners or fireplaces. 20% of the woodburner/fireplace household population is **127,968** (**See Appendix A).**

As of 2013, **60,999** NZ households use coal fires (EHINZ, 2017). Due to a relatively small population utilising coal as their heating form (just over 3.5%), I will exclude them from this report. However, their greenhouse gas emissions will be far more substantial than the other heating forms.

# 2.0 DISCUSSION

## 2.1 BENEFITS

### 2.1.1 Reduction in greenhouse gas emissions

To keep a wood burner going for most evenings and weekends during winter, about **10m$^3$** of firewood would be required (Consumer NZ, 2018). Since the average dried pine density is **400-420 kg/m3** (Raidata Pine Breeding Co Ltd, 2003) the firewood mass required will be within the range of **4000kg** to **4200kg** per year**. (See Appendix B).** I have assumed radiata pine to be the firewood of choice as it is the most popular and abundant; covering 90% of NZs forests (FirewoodNZ, n.d.).

**1900g** of carbon dioxide, **200g** of nitrogen dioxide and **70g** of methane is produced from every **1000g** of wood. Nitrogen dioxide is "*300 times more potent as a greenhouse gas than carbon dioxide and lasts 120 years in the atmosphere."* (Crawford, 2008)

Replacing these houses with HPs has the potential to eliminate **972557** to **1021185** tonnes of CO2 from the air along with **102374** to **107493** tonnes of Nitrogen Dioxide and **35831** to **37623** tonnes of methane from the air per year (**See Appendix C and D**).

However, HPs do not completely eliminate the said amounts of gases as HPs are powered by electricity which lead to an electric grid. Some electric grids can be powered by fossil fuels meaning HPs indirectly contribute to a comparatively small amount of greenhouse gases released in the air.

### 2.1.2 Health and air quality improvement

Wood and coal fires are a *"major source of air pollution in most New Zealand urban areas"* (EHINZ, 2017) as they release compounds such as carbon monoxide and nitrogen dioxide. When inhaled frequently, these gases can lead to long term health effects (Centres for Disease Control and Prevention, 2018). Reducing the emissions from wood and coal fires is likely to improve outdoor air quality and the public's health.

### *2.1.3 Cheaper heating for Kiwis*

According to the winner of Canstar Blue's most satisfied customers award winner (Canstar Blue New Zealand LImited, 2017), Mitsubishi Electric states on their online calculator **14.3kW** is required to heat the average single level home (Mitsubishi Electric, n.d.) which has:

- **149m$^2$** Area (QV Property, 2011)
- **2.4m** height (Auckland Design Manual, 2018)
- Full insulation

On the Energywise running costs calculator (Energy Efficiency and Conservation Authority, 2017), it shows using an HP with **14kW** capacity **6 months** per year (as heating is not required during the summer months) at an average of **6 hours** a day (3 hours in the morning before work/school and 3 hours in the evening before sleeping) with a 3 star energy rating (note lowest is 0 and highest is 6) is **$698.01** with an annual energy consumption of **2661kWh**. (Energy Efficiency and Conservation Authority, 2017)

According to OVO Energy, an energy company in the UK, it takes **100kWh** of energy towards heating **per square meter per year** in a relatively new house (OVO Energy UK, n.d.). I used UK statistics due to their weather being similar to a New Zealand winter; cold, damp and wet. However, UK has this weather year round which means they require heating year round. I will assume NZ only has cold, damp and wet weather for 6 months of the year. I used the assumption most houses were relatively new due to the housing spike which had occurred in Auckland, Queenstown and Tauranga.

**7450kWh** of energy per year must be put towards heating for the average home in New Zealand (**See Appendix E**). At an average pine price of **$86/m$^3$** since 2016, it would cost **$0.12/kWh** of heat produced (Consumer NZ, 2017). This means it costs **$894 per year** to run a fireplace or woodburner.

## 2.2 DISADVANTAGES

### 2.2.1 Increased demand for electricity

NZ electricity consumption and generation is shown in **Figure 1**. NZs energy consumption would increase by **340.5 GWh** making the total energy consumption **39840.5 GWh per year** (**See Appendix F**). The current electricity grid would be able to sustain it. However, electricity production depends on demand and considers the energy losses through distribution and transmission. Given 85% of NZs electricity is generated from renewable resources, we would have to resort to using more non-renewable resources such as fossil fuels to generate our electricity to meet the increased demand and compensate for the energy losses. This results in more greenhouse gases being released into the air.

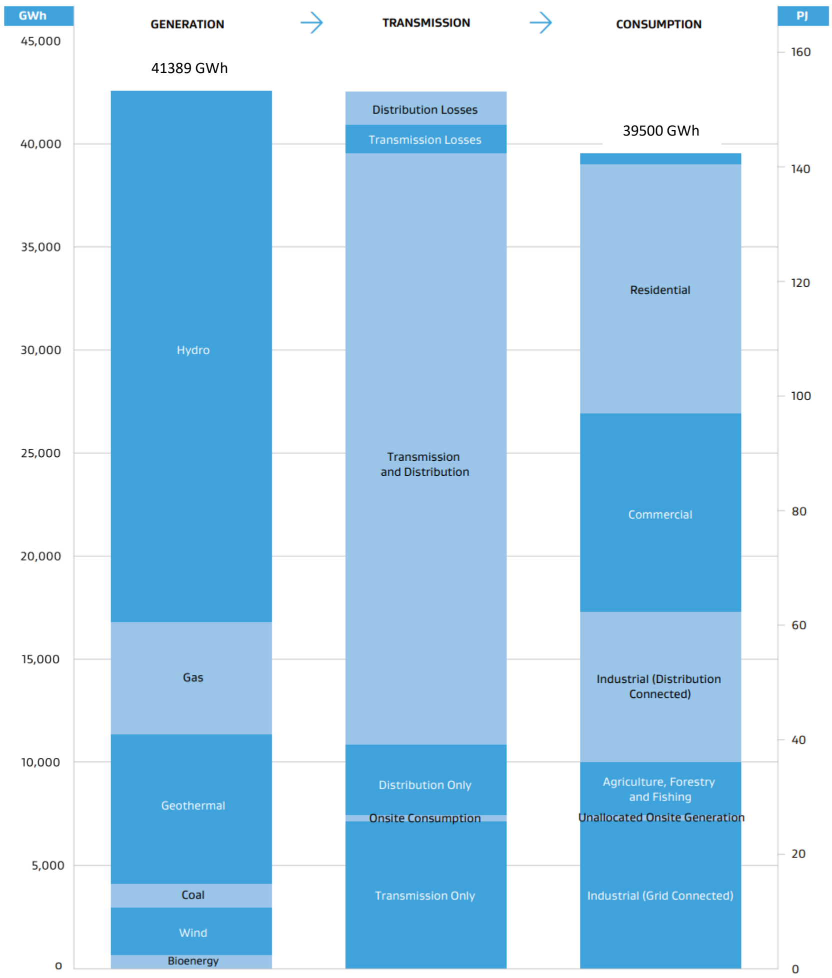


*Figure 1. Electricity Flow Diagram for 2016. Reprinted from "Energy in New Zealand," by Ministry of Business, Innovation and Employment. (2017). Crown Copyright 2017. Adapted with permission under creative commons.*

### 2.2.2 Cost to the government

The HP installation cost per household which complies with NZ building and electrical codes varies between **$750-$1350** (not including the HP unit) (Consumer NZ, n.d.). 20% of this installation cost is between **$150** to **$270.** Getting 20% of the installation cost subsidised would cost the NZ government **$19,195,200** to **$34,551,360** to implement this strategy. (**See Appendix G**)

### 2.2.3 Social Implications

People who have already made the decision to install a HP in their household before the NZ governments policy was put into place would feel they have not been given their necessary compensation by not getting the same subsidy as everyone else. Perhaps the policy could issue a rebate to claim for households who have already switched over from wood burners and fireplaces to HPs. However, this would greatly increase the overall cost incurred by the government.

## 3.0 CONCLUSIONS

The benefits of replacing wood generated heating forms with HPs for 20% of NZ households which use wood burners and fireplaces include:

- Greenhouse gas emission reduction
- Decreased heating costs for households
- Decrease in likelihood of long term health deterioration

However, the substantial cost towards the government due to the subsidy and the increased electricity demands are setbacks along with possible compensation demanded by people who have switched from wood burners and fireplaces to HPs before the policy is put into effect.

Nevertheless, the prospect of improved public health and more affordable heating for many kiwis shows that this is a strategy sensible for mitigating air pollution while providing a wider range of benefits as well.

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# 5.0 APPENDIX

## A: Wood burner/fireplace population

$$Households\ in\ NZ = 1.729{,}300$$

*37% of households use woodburners and fireplaces*

$$Woodburner\ and\ Fireplace\ using\ Population = \frac{1{,}729{,}300}{100} \times 37 = \mathbf{639,841}$$

$$\mathbf{20\%\ of\ Woodburner\ and\ Fireplace\ using\ population} = \frac{639841}{100} \times 20 = \mathbf{127968}$$

## B: Dried Pine Mass used per year per household

$$\text{Firewood volume required per year} = 10\text{m}^3$$

$$\text{Dried Pine Density} = \frac{400\text{kg}}{\text{m}^3}\ to\ \frac{420kg}{m3}$$

$$\text{Dried Pine Mass per year} = \frac{10\cancel{\text{m}^3}}{year} \times \frac{400kg}{\cancel{m^3}}\ \ to\ \frac{10\cancel{\text{m}^3}}{year} \times \frac{420kg}{\cancel{m^3}}$$

$$= \mathbf{4000}\frac{\mathbf{kg}}{\mathbf{year}}\ \boldsymbol{to}\ \mathbf{4200}\frac{\boldsymbol{kg}}{\boldsymbol{year}}$$

## C: Greenhouse gas released per year per household

$$\frac{\text{Mass of dried pine}}{household.\,year} = 4000\frac{\text{kg}}{household.\,\text{year}}\ to\ 4200\frac{kg}{household.\,year}$$

$$\frac{Mass\ of\ Carbon\ Dioxide\ released}{kilogram\ of\ wood} = 1900g = \mathbf{1.9kg}$$

$$\frac{Mass\ of\ Nitrogen\ Dioxide\ released}{kilogram\ of\ wood} = 200g = \mathbf{0.2kg}$$

$$\frac{Mass\ of\ Carbon\ Dioxide\ released}{kilogram\ of\ wood} = 70g = \mathbf{0.07kg}$$

$$\frac{\mathbf{Mass\ of\ GREENHOUSE\ GAS\ released}}{\mathbf{year.household}} = \mathbf{Mass\ of\ Dried\ Pine\ Per\ year} \times \frac{\mathbf{Mass\ of\ Gass\ released}}{\mathbf{kilogram\ of\ wood}}$$

$$\frac{Mass\ of\ Carbon\ Dioxide\ released}{year.\,household} = \frac{4000kg}{year} \times 1.9kg = 7600kg = \mathbf{7.6}\frac{\mathbf{tonnes}}{\mathbf{household}}$$

$$\frac{Mass\ of\ Carbon\ Dioxide\ released}{year.\,household} = \frac{4200kg}{year} \times 1.9kg = 7980kg = \mathbf{7.98}\frac{\mathbf{tonnes}}{\mathbf{household}}$$

$$\frac{Mass\ of\ Nitrogen\ Dioxide\ released}{year.\,household} = \frac{4000kg}{year} \times 0.2\ kg = 800kg = \mathbf{0.8}\frac{\mathbf{tonnes}}{\mathbf{household}}$$

$$\frac{Mass\ of\ Nitrogen\ Dioxide\ released}{year.\,household} = \frac{4200kg}{year} \times 0.2kg = 840kg = \mathbf{0.84}\frac{\mathbf{tonnes}}{\mathbf{household}}$$

$$\frac{Mass\ of\ Methane\ released}{year.\,household} = \frac{4000kg}{year} \times 0.07kg = 280kg = \mathbf{0.28}\frac{\mathbf{tonnes}}{\mathbf{household}}$$

$$\frac{Mass\ of\ Methane\ released}{year.\,household} = \frac{4200kg}{year} \times 0.07kg = 294kg = \mathbf{0.294}\frac{\mathbf{tonnes}}{\mathbf{household}}$$

## D: Greenhouse gas released by 20% of NZ households using wood burners and fireplaces.

$$\textbf{Greenhouse gases released by 20\% of NZ Woodburner and Fireplace using population} =$$

$$\frac{\textbf{Tonnes of Greenhouse Gas released}}{\boldsymbol{household.year}} \times \textbf{20\% of NZ Woodburner and Fireplace using population}$$

$$\textbf{Carbon Dioxide released by 20\% of NZ Woodburner and Fireplace using population} =$$

$$\frac{\text{7.6tonnes to 7.98tonnes}}{household.year} \times 127968 \text{ households} = \frac{\textbf{972, 556 tonnes}}{\boldsymbol{year}} \textbf{ to } \frac{\textbf{1, 021, 185 tonnes}}{\boldsymbol{year}}$$

$$\textbf{Nitrogen Dioxide released by 20\% of NZ Woodburner and Fireplace using population} =$$

$$\frac{\text{0.8tonnes to 0.84tonnes}}{household.year} \times 127968 \text{ households} = \frac{\textbf{(102, 374 tonnes)}}{\boldsymbol{year}} \textbf{ to } \frac{\textbf{107, 493 tonnes}}{\boldsymbol{year}}$$

$$\textbf{Methane released by 20\% of NZ Woodburner and Fireplace using population} =$$

$$\frac{\text{0.28tonnes to 0.294tonnes}}{household.year} \times 127968 \text{ households} = \frac{\textbf{35, 831 tonnes}}{\boldsymbol{year}} \textbf{ to } \frac{\textbf{37623 tonnes}}{\boldsymbol{year}}$$

## E: Heating energy required per year per household

$$\textbf{Average house size} = \mathbf{149m^2}$$

$$\frac{\mathbf{100}\boldsymbol{kWh}}{\boldsymbol{year.m^2}} \boldsymbol{of\ heating\ required}$$

$$\frac{100kWh}{m^2} \times 149m^2 = \textbf{14, 900 kWh of energy required for average household}$$

$$\underline{Divide\ this\ figure\ by\ 2\ as\ NZ\ only\ requires\ heating\ for\ half\ a\ year}$$

$$\frac{\left(\frac{14{,}900kWh}{year}\right)}{2} = \frac{\mathbf{7450}\boldsymbol{kWh}}{\boldsymbol{year}}$$

## F: Increase in energy consumption per year

$$\boldsymbol{Energy\ consumption\ of\ each\ HP} = \mathbf{2661}\boldsymbol{kWh}$$ (Energy Efficiency and Conservation Authority, 2017)

$$\boldsymbol{Converted\ Households} = \mathbf{127,968}$$

$$\boldsymbol{Overall\ increase\ in\ energy\ consumption}\ = 2611kWh\ \times 127{,}968 =\ \mathbf{340.5}\ \boldsymbol{GWh}$$

$$\boldsymbol{Total\ energy\ cosumption} = 39{,}500GWh + 340.5\ GWh =\ \mathbf{39,840.5}\ \boldsymbol{GWh}$$

$$Total\ energy\ cosumption\ (39840.5) < Energy\ Produced\ (41389\ GWh)$$

$$\boldsymbol{Therefore, electricity\ grid\ can\ sustain\ additonal\ load}$$

## G: Subsidy Cost

$$\frac{\textbf{Installation}}{\boldsymbol{household}} = \$\mathbf{750\ to\ }\$\mathbf{1350}$$

$$\mathbf{20\%\ of}\,\frac{\textbf{installation}}{\boldsymbol{household}} = 0.2(\$750)\ to\ 0.2(\$1350) =\ \$\mathbf{150\ to\ }\$\mathbf{279}$$

$$\textbf{Total cost incurred by government} = \mathbf{127968\ households}\ \times\ \mathbf{20\%\ of}\,\frac{\textbf{installation}}{\boldsymbol{household}}$$

$$\text{Total cost incurred by government} = 127968\text{ households }\ \times \$150\text{ to }\$270 = = \$\mathbf{19,195,200\ to\ }\$\mathbf{34,551,360}$$