# PEET Efficiency Trends Analysis

JANUARY 2021

Product Energy Efficiency Trends -
A project of the Energy Efficient End-use Equipment TCP


Technology Collaboration Programme
by iea

The Technology Collaboration Programme on Energy Efficient End-Use Equipment (4E TCP), has been supporting governments to co-ordinate effective energy efficiency policies since 2008.

Fourteen countries and one region have joined together under the 4E TCP platform to exchange technical and policy information focused on increasing the production and trade in efficient end-use equipment. However, the 4E TCP is more than a forum for sharing information: it pools resources and expertise on a wide a range of projects designed to meet the policy needs of participating governments. Members of 4E find this an efficient use of scarce funds, which results in outcomes that are far more comprehensive and authoritative than can be achieved by individual jurisdictions.

The 4E TCP is established under the auspices of the International Energy Agency (IEA) as a functionally and legally autonomous body.

Current Members of 4E TCP are: Australia, Austria, Canada, China, Denmark, European Commission France, Japan, Korea, Netherlands, New Zealand, Switzerland, Sweden, UK and USA.

Further information on the 4E TCP is available from: www.iea–4e.org

PEET Efficiency Trends Analysis

January 2021

**Acknowledgements**

The 4E TCP thanks Paul Waide, Waide Strategic Efficiency Limited, Anson Wu (Hansheng Ltd) and Jonathan Wood (Tenvic) for their considerable input into this document.

**Disclaimer**

The Technology Collaboration Programme on Energy Efficient End-Use Equipment (4E TCP) has made its best endeavours to ensure the accuracy and reliability of the data used herein, however makes no warranties as to the accuracy of data herein nor accepts any liability for any action taken or decision made based on the contents of this report.

Views, findings and publications of the 4E TCP do not necessarily represent the views or policies of the IEA Secretariat or its individual member countries.

# Contents

# List of Figures



# List of Tables

# Glossary

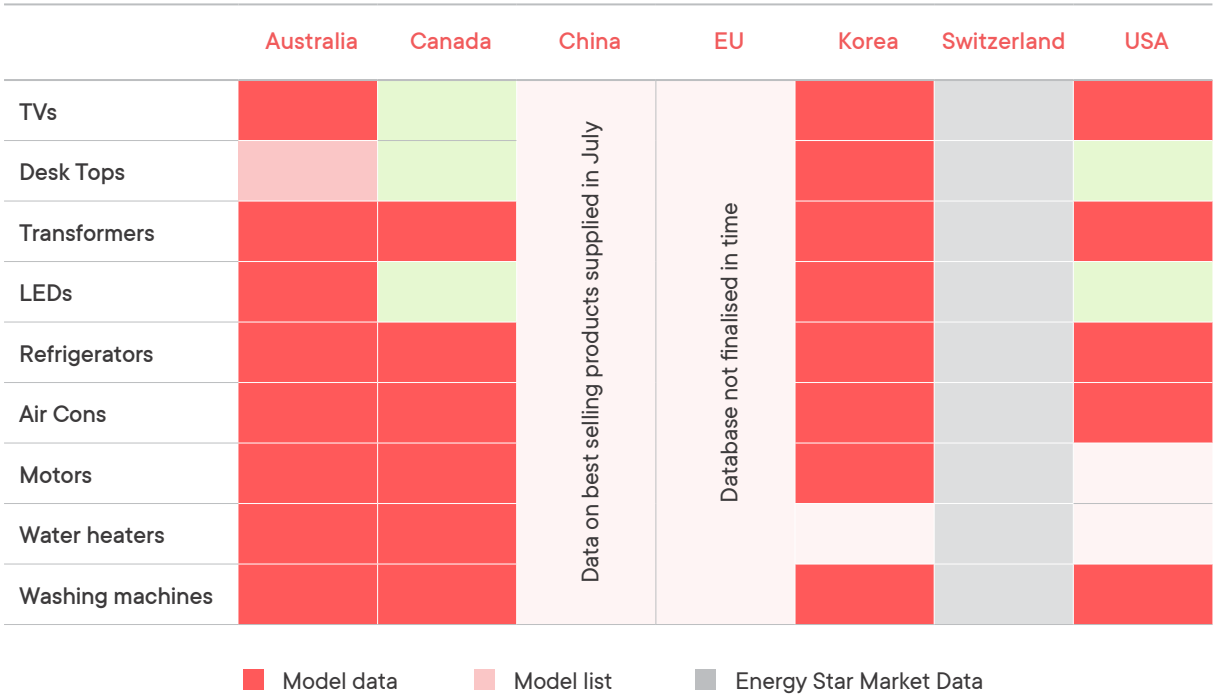
| | |
|---|---|
| **AV** | audio-visual |
| **CSPF** | cooling seasonal performance factor |
| **EER** | energy efficiency ratio |
| **IEA** | International Energy Agency |
| **IEC** | International Electrotechnical Commission ISO International Organization for Standardization |
| **LED** | light emitting diode |
| **MEPS** | minimum energy performance standard |
| **NA** | not available (or applicable) |
| **NEMA** | North American Manufacturers' Association |
| **PEET** | Product Energy Efficiency Trends project |
| **SEER** | seasonal energy efficiency ratio |
| **TEC** | total energy consumption |
| **TR** | Top Runner |
| **UEC** | unit energy consumption |
| **VSD** | variable speed drive |

# 1 Introduction

This report presents the findings of the energy efficiency trends analysis component of the PEET project.

The analysis is focused on determining the normalised energy efficiency of nine product groups (air conditioners, desk top computers, distribution transformers, domestic cold appliances, electric motors, LEDs, televisions, washing machines, electric storage water heaters) to allow comparison of the efficiency of products sold across economies. To support this process data was provided per 4E economy as shown in Figure 1.1. Analysis has only been conducted in the cases where suitable data was available.

**Figure 2.1.1: Data provided per economy by product group and type of data**




The analysis and results are reported for sets of representative reference model groups as described in the following document: *'Product Energy Efficiency Trends project – Methodologies'*.

This document is referred to as the PEET Methodologies Report in this report. It also explains the efficiency metrics which are used to compare product performance and the normalisation methodology used to derive the results reported in this analysis.

The most current (2018/19) energy efficiency results are presented in the next chapter for the nine product groups following application of the normalisation process. Note, normalisation is applied for all product groups except washing machines where the results are reported under the local (national) efficiency metric and are not compared across economies.

# 2 Results: most current energy efficiency levels

This chapter reports the findings on the energy efficiency of products from the most recent data sets supplied to the PEET. The model-, or occasionally, sales-weighted average values are reported for each reference model grouping (per the PEET Methodologies Report). This includes the number of models within each reference model grouping, the average capacity and (normalised) efficiency of those models, and the proportion of the market (usually expressed in terms of the share of the total number of models, but occasionally in actual sales-weighted market shares) that they account for.

## 2.1 Air conditioners

Model data was provided by the following countries: Australia, Canada, Korea, USA. Two metrics are used – an energy efficiency ratio (EER) and a seasonal energy efficiency ratio (SEER). For the EER the ratios are normalised according to that reported in ISO 5051 and are expressed in units of W/W. For the seasonal efficiency it is necessary to choose a specific national metric and normalise the others against that using the approach referenced in the PEET Methodology Report. The seasonal efficiency results reported in Tables 2.1.1 to 2.1.4 below have been normalised against the Korean cooling seasonal performance factor (CSPF), which is a seasonal energy efficiency ratio, expressed in units of W/W, for the cooling mode[1].

For Australia, seasonal efficiency data is not reported by suppliers, nor is there a seasonal efficiency conversion metric readily available, so it is only possible to report and compare the EER data. However, Australia will be adopting a seasonal energy efficiency metric – the Cooling Seasonal Performance Factor (CSPF) in April 2020.

The capacity and efficiency data reported below are the model-weighted average of all products that are in scope and fall within one of the four capacity ranges. The data supplied by Australia includes data on products that are single packaged (e.g. window/wall) types, single-split packaged types and multi-split packaged types – all of which are in scope. For both Canada and the USA the data is only for residential split-packaged units. The “share of models” field indicates the proportion of the complete model data sets that occurred within each of the four capacity ranges, where the range is +/- 5% of the nominal mid-value. This is also why the average capacity can deviate slightly from the nominal mid-value.

As expected, this data shows that the seasonal efficiency (CSPF) is considerably higher than the full load (EER) efficiency for all markets that report seasonal efficiency data. This shows that a high proportion of models now use inverter (variable speed) compressors and thus have relatively efficient part-load performance, which is the performance that is most representative of how air conditioners are actually used. This constitutes a real efficiency gain that is apparent across all markets.

1 There is no specific reason why normalisation was done to the Korean CSPF other than one economy’s metric had to be chosen as the reference – the methodology allows for conversions between many different economy-specific metrics.

Table 2.1.1: Australia: non-ducted residential air conditioner efficiency data

| Reference model group | No. of models | Share of models | Average kW | CSPF | EER |
|---|---|---|---|---|---|
| Low (2.0 kW) | 75 | 2.9% | 2.07 | | 3.86 |
| Intermediate low (3.5 kW) | 89 | 3.4% | 3.48 | | 3.65 |
| Intermediate high (5 kW) | 110 | 4.2% | 5.08 | | 3.63 |
| High (7 kW) | 150 | 5.8% | 6.92 | | 3.47 |

*Year of data: products available for sale up to May 2019*

Table 2.1.2: Canada: non-ducted residential air conditioner efficiency data

| Reference model group | No. of models | Share of models | Average kW | CSPF | EER |
|---|---|---|---|---|---|
| Low (2.0 kW) | 3 | 0.0% | 2.05 | 8.76 | 3.95 |
| Intermediate low (3.5 kW) | 1535 | 23.6% | 3.51 | 6.88 | 3.36 |
| Intermediate high (5 kW) | 1246 | 19.2% | 5.19 | 6.41 | 3.34 |
| High (7 kW) | 635 | 9.8% | 7.00 | 6.09 | 3.19 |

*Year of data: products available for sale up to May 2019*

Table 2.1.3: Korea: non-ducted residential air conditioner efficiency data

| Reference model group | No. of models | Share of models | Average kW | CSPF | EER |
|---|---|---|---|---|---|
| Low (2.0 kW) | 0 | 0.0% | | | |
| Intermediate low (3.5 kW) | 12 | 2.9% | 3.66 | 5.88 | 3.22 |
| Intermediate high (5 kW) | 8 | 1.9% | 5.32 | 5.62 | 3.26 |
| High (7 kW) | 129 | 31.0% | 7.03 | 5.98 | 3.56 |

*Year of data: products available for sale up to May 2019*

Table 2.1.4: USA: non-ducted residential air conditioner efficiency data

| Reference model group | No. of models | Share of models | Average kW | CSPF | EER |
|---|---|---|---|---|---|
| Low (2.0 kW) | 0 | 0.0% | | | |
| Intermediate low (3.5 kW) | 0 | 0.0% | | | |
| Intermediate high (5 kW) | 255 | 16.2% | 5.21 | 7.48 | 3.49 |
| High (7 kW) | 70 | 4.5% | 7.13 | 7.69 | 3.59 |

*Year of data: products available for sale up to May 2019*

Figure 2.1.1 shows the average EER values per market and capacity group. Figure 2.1.2 shows the average CSPF values per market and capacity group.

**Figure 2.1.1: Average EER for each market in 2019 as a function of the capacity group**

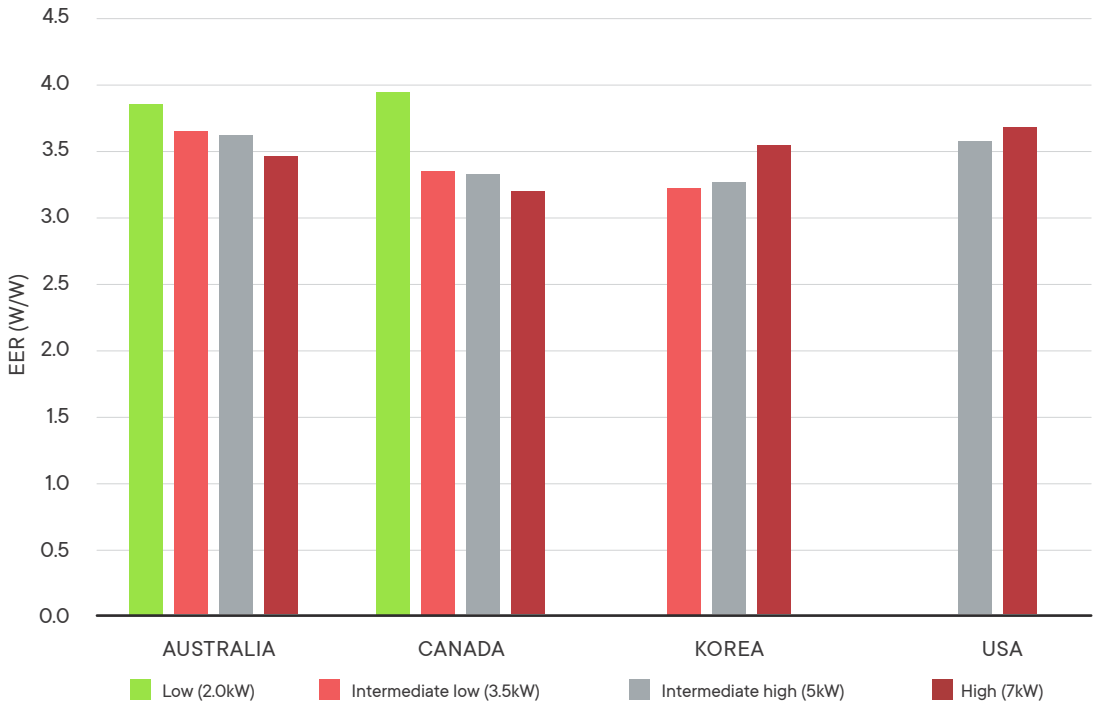
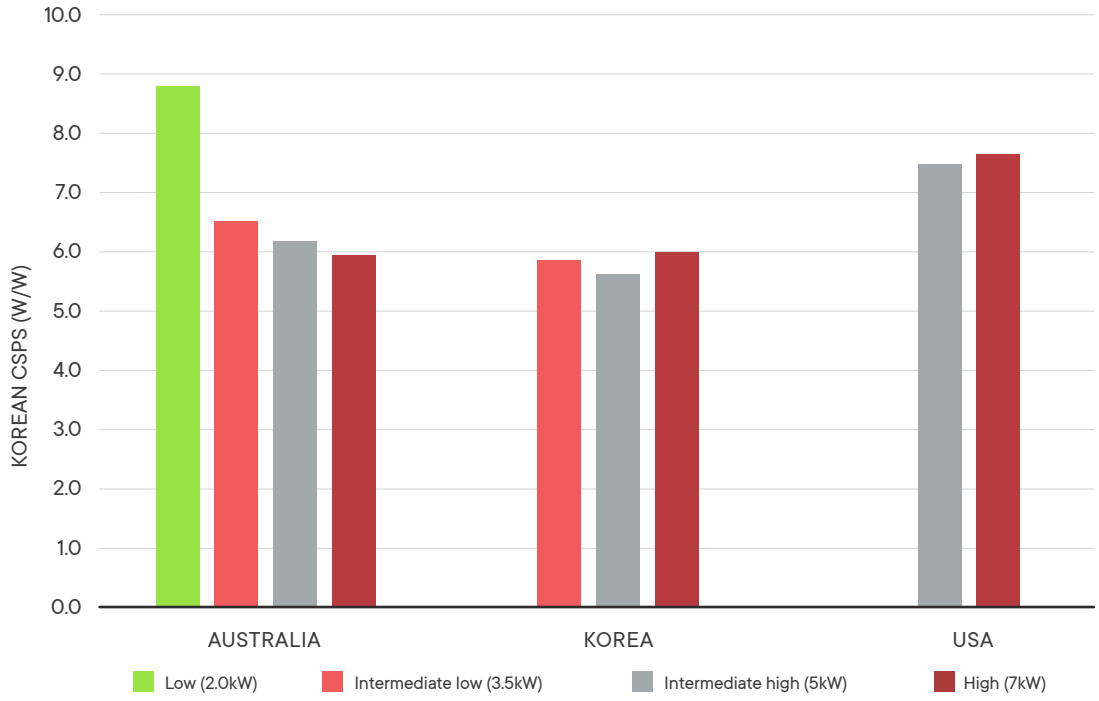



**Figure 2.1.2: Average CSPF for each market in 2019 as a function of the capacity group**



## 2.2 Desktop computers

The scope covers desktop and integrated desktop computers. Model data was provided by the USA, Korea and Australia. The USA database, a full version of the US ENERGY STAR database, included details about which countries/regions each model was available. Canada does not maintain its own ENERGY STAR database as it uses the US version. Canada is detailed separately as the US ENERGY STAR database provides details about which models are sold in Canada. This USA ENERGY STAR data was used to inform analysis of other countries as shown below. The Australian data was not suitable for the analysis as it did not contain any power demand or energy values. The Korean database included energy efficiency data based on the older ENERGY STAR v5.0 test procedure. This data was converted to an estimated ENERGY STAR v7.0 TEC values. The conversion involved identifying the difference in short and long idle power demands in the USA ENERGY STAR database and assigning the average differences between these values to the Korean data. This allowed an estimation of the missing idle (i.e. short idle for desktops and long idle for integrated desktop computers) power demands and calculation of an estimated ENERGY STAR v7.0 TEC value. Furthermore, the Korean TEC values were converted to an estimated TEC value when measured at 115v and 50Hz to allow for enhanced comparison with the results in the USA ENERGY STAR database.

The results shown in the tables below show that the average TEC and share of each model types (i.e. low, medium and high-performance models) is very similar within most countries and regions. This is expected since most data is from the same US ENERGY STAR database. The exception is the Korean data which shows some variation in the distribution of product types and average TEC values.

**Table 2.2.1: USA: Desktop Computers Registered in US ENERGY STAR database**

| Reference model group | No. of models | Share of models | Average TEC kWh/year |
|---|---|---|---|
| All | 567 | 100.0% | 100.14 |
| Low Performance | 84 | 14.8% | 57.64 |
| Medium Performance | 434 | 76.5% | 93.10 |
| High Performance | 49 | 8.6% | 149.69 |

*Year of data: products available for sale up to May 2019*

**Table 2.2.2: Canada: Desktop Computers Registered in US ENERGY STAR database**

| Reference model group | No. of models | Share of models | Average TEC kWh/year |
|---|---|---|---|
| All | 475 | 100.0% | 100.21 |
| Low Performance | 79 | 16.6% | 56.41 |
| Medium Performance | 354 | 74.5% | 91.83 |
| High Performance | 42 | 8.8% | 152.38 |

*Year of data: products available for sale up to May 2019*

Table 2.2.3: Europe: Desktop Computers Registered in US ENERGY STAR database

| Reference model group | No. of models | Share of models | Average TEC kWh/year |
|---|---|---|---|
| All | 203 | 100.0% | 101.99 |
| Low Performance | 35 | 17.2% | 56.81 |
| Medium Performance | 148 | 72.9% | 87.83 |
| High Performance | 20 | 9.9% | 161.33 |

*Year of data: products available for sale up to May 2019*

Table 2.2.4: Korea: Desktop Computers (Korean Database)

| Reference model group | No. of models | Share of models | Average TEC kWh/year |
|---|---|---|---|
| All | 3014 | 100.0% | 81.08 |
| Low Performance | 43 | 1.4% | 30.72 |
| Medium Performance | 2687 | 89.2% | 96.15 |
| High Performance | 284 | 9.4% | 116.39 |

*Year of data: products available for sale in 2018*

Figure 2.2.1: Average desktop TEC for each market in 2019 as a function of the reference group

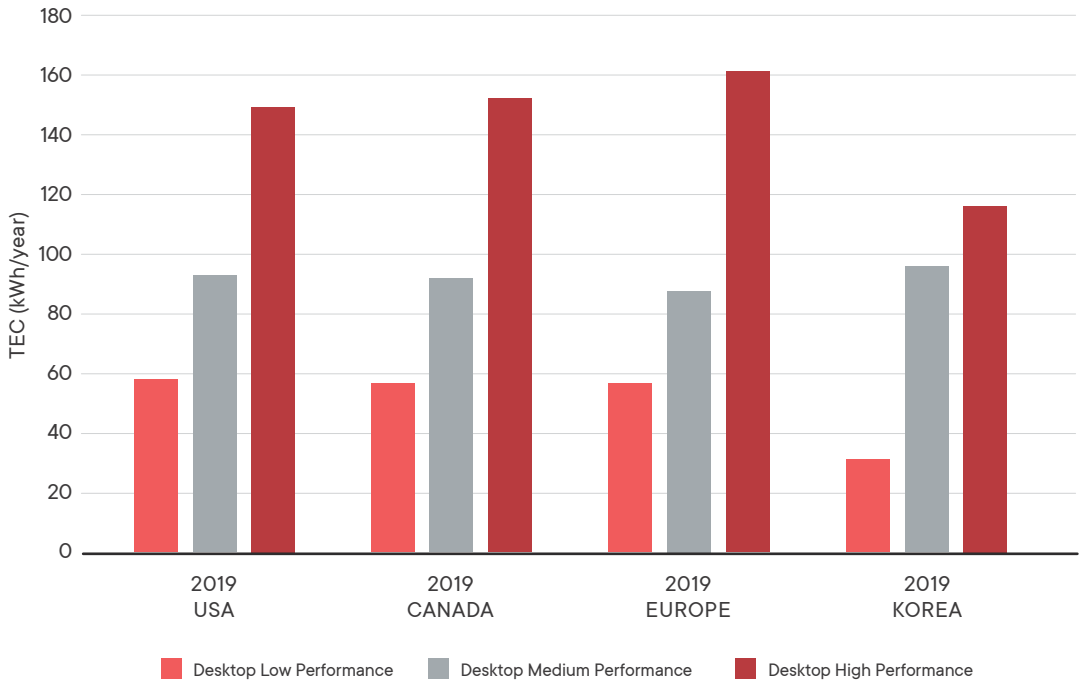


Table 2.2.5: USA: Integrated Desktop Computers Registered in US ENERGY STAR database

| Reference model group | No. of models | Share of models | Average TEC kWh/year |
|---|---|---|---|
| All | 201 | 100.0% | 117.56 |
| Low Performance | 57 | 28.4% | 91.23 |
| Medium Performance | 134 | 66.7% | 105.31 |
| High Performance | 10 | 5.0% | 156.13 |

*Year of data: products available for sale up to May 2019*

Table 2.2.6: Canada: Integrated Desktop Computers Registered in US ENERGY STAR database

| Reference model group | No. of models | Share of models | Average TEC kWh/year |
|---|---|---|---|
| All | 667 | 100.0% | 100.21 |
| Low Performance | 134 | 20.1% | 92.02 |
| Medium Performance | 482 | 72.3% | 103.57 |
| High Performance | 51 | 7.6% | 158.93 |

*Year of data: products available for sale up to May 2019*

Table 2.2.7: Europe: Integrated Desktop Computers Registered in US ENERGY STAR database

| Reference model group | No. of models | Share of models | Average TEC kWh/year |
|---|---|---|---|
| All | 67 | 100.0% | 103.83 |
| Low Performance | 20 | 29.9% | 86.83 |
| Medium Performance | 46 | 68.7% | 102.36 |
| High Performance | 1 | 1.5% | 122.30 |

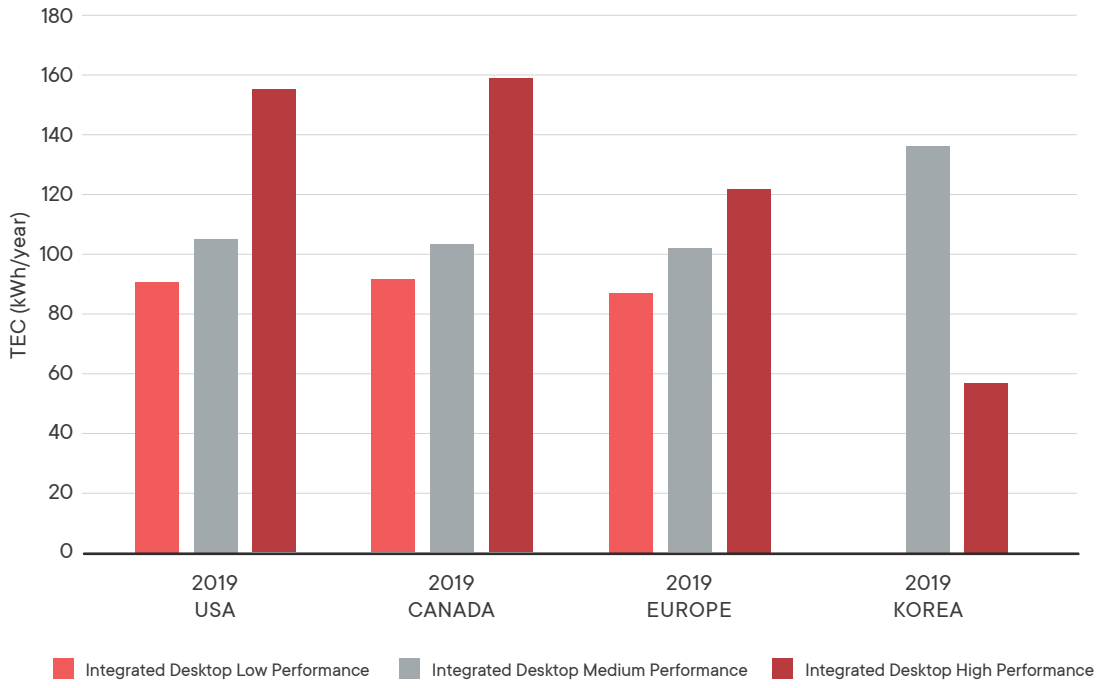
*Year of data: products available for sale up to May 2019*

Table 2.2.8: Korea: Integrated Desktop Computers (Korean Database)

| Reference model group | No. of models | Share of models | Average TEC kWh/year |
|---|---|---|---|
| All | 231 | 100.0% | 97.18 |
| Low Performance | 0 | 0.0% | |
| Medium Performance | 225 | 97.4% | 137.04 |
| High Performance | 6 | 2.6% | 57.31 |

*Year of data: products available for sale in 2018*

Figure 2.2.2: Average integrated desktop TEC for each market in 2019 as a function of the reference group




## 2.3 Distribution transformers

The scope covers liquid-cooled, three-phase, distribution transformers, which are not pole-mounted (i.e. are pad-mounted). Model data was provided by the following countries: Australia, Canada, Korea, USA; however, the Canadian data was not included as it is only for dry-type transformers which are not in scope. The efficiency metric used is the efficiency at 50% of full load thus all the data reported in Tables 2.3.1 to 2.3.4 is fully comparable except that there is an additional, minor, normalisation step to convert the US efficiency values at 60Hz and measured under the IEEE test conditions (Table 2.3.3) to be equivalent to those in the other countries at 50Hz under the IEC test procedure conditions (Table 2.3.4). In general, the lower the losses are at 50% load the more efficient the transformer is.

Table 2.3.1: Australia: 3–phase, pad-mounted, liquid distribution transformer data

| Reference model group | No. of models | Share of models | Average capacity (kVA) | Efficiency at 50% load | Losses at 50% load |
|---|---|---|---|---|---|
| Low (400 kVA) | 3 | 2.8% | 400 | 99.33 | 0.67% |
| Intermediate low (1000 kVA) | 11 | 10.2% | 1000 | 99.36 | 0.64% |
| High (1500 kVA) | 10 | 9.3% | 1500 | 99.42 | 0.58% |

*Year of data: products available for sale up to May 2019*

Table 2.3.2: Korea: 3–phase, pad-mounted, liquid distribution transformer data

| Reference model group | No. of models | Share of models | Average capacity (kVA) | Efficiency at 50% load | Losses at 50% load |
|---|---|---|---|---|---|
| Low (400 kVA) | 20 | 4.7% | 398 | 99.15 | 0.85% |
| Intermediate low (1000 kVA) | 36 | 8.4% | 986 | 99.30 | 0.70% |
| High (1500 kVA) | 19 | 4.4% | 1500 | 99.36 | 0.64% |

*Year of data: products available for sale in 2018*

Table 2.3.3: USA: 3–phase, pad-mounted, liquid distribution transformer data – without normalisation to IEC (i.e. values at 60Hz under IEEE test procedure)

| Reference model group | No. of models | Share of models | Average capacity (kVA) | Efficiency at 50% load | Losses at 50% load |
|---|---|---|---|---|---|
| Low (400 kVA) | 10 | 0.1% | 400 | 99.32 | 0.68% |
| Intermediate low (1000 kVA) | 838 | 8.4% | 1000 | 99.43 | 0.57% |
| High (1500 kVA) | 653 | 6.6% | 1500 | 99.48 | 0.52% |

*Year of data: products available for sale up to May 2019*

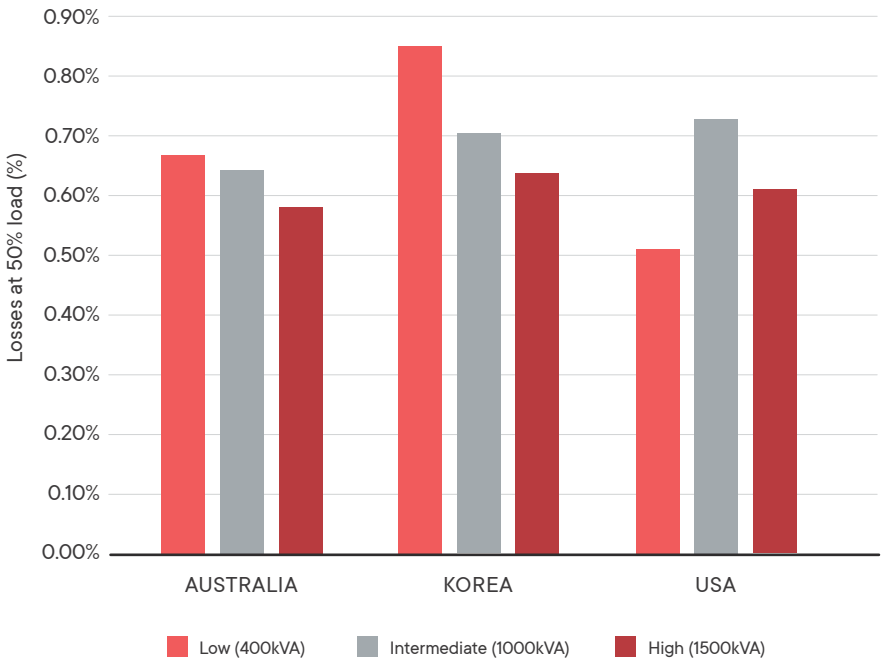
Table 2.3.4: USA: 3–phase, pad-mounted, liquid distribution transformer data –normalised to IEC

| Reference model group | No. of models | Share of models | Average capacity (kVA) | Efficiency at 50% load | Losses at 50% load |
|---|---|---|---|---|---|
| Low (400 kVA) | 10 | 0.1% | 400 | 99.29 | 0.71% |
| Intermediate low (1000 kVA) | 838 | 8.4% | 1000 | 99.41 | 0.59% |
| High (1500 kVA) | 653 | 6.6% | 1500 | 99.47 | 0.53% |

*Year of data: products available for sale up to May 2019*

Figure 2.3.1 shows the same data i.e. as normalised to the IEC test method at 50Hz.

**Figure 2.3.1: Average liquid cooled 3–phase transformer losses at 50% load for each market in 2019 as a function of the capacity group**




## 2.4 Domestic cold appliances

The scope covers domestic refrigerator-freezers. Model data was provided by the following countries: Australia, Canada and Korea.

The normalisation method described in the methodology report accounts for the impact that different test procedures have on thermal loads and thermodynamic efficiency the refrigeration systems. The results reported here are normalised to the old IEC test method which measured energy performance at a constant 25˚C ambient test temperature.

The average normalised energy consumption (kWh/year) is reported for each adjusted volume capacity band (low, intermediate low, intermediate high and high), as set out in the PEET Methodology Report and so is the average normalised energy consumption per unit of normalised adjusted volume.

The results are reported in Tables 2.4.1 to 2.4.3 and Figure 2.4.1 below.

The data reported are model-weighted averages of all products that are in scope and fall within one of the four reference model capacity ranges. It should be noted that there is no mixing of frost-free and direct cool products within a single reference group: in the analysis presented, all the products within the Low reference group are direct cool products and all those within the other three reference groups are frost free products.

The “share of models” field indicates the proportion of the complete model data sets that occurred within each of the four reference model capacity ranges, where the range is +/- 5% of the nominal mid-value. Also shown in these tables are the average local adjusted volume that the models within each reference model grouping have, the average local unit energy consumption, the average local

MEPS threshold (in kWh/year) and the normalised MEPS threshold (also in kWh/year). The term "local" refers to the specific economy in question without applying any normalisation of the data, thus in the case of Korea (which uses a test procedure fully aligned with the old IEC method at 25˚C ambient) the local and normalised results are the same.

The average reference model data has to be interpreted with some caution as some of the groupings only have a very modest number of models within them (depending on the economy). This is especially important to appreciate when viewing Figure 2.4.1. There is a clear relationship between energy consumption and adjusted volume (as expected). Also as expected the normalised UEC/litre adjusted volume exhibits higher values for smaller adjusted volume (especially at the smallest reference model group) for all economies, Figure 2.4.2.

**Table 2.4.1: Australia: refrigerator-freezer efficiency data**

| | | | Adjusted volume | | UEC (Unit Energy Consumption) | | | MEPS | |
|---|---|---|---|---|---|---|---|---|---|
| | No. of models | Share of models | Local Adjusted Volume (litres) | Normalised Adjusted Volume (litres) | Local UEC (kWh/year) | Normalised UEC (kWh/year) | Normalised UEC/litre adjusted volume* | Local MEPS (kWh/year) | Normalised MEPS (kWh/year) |
| Low (150 l) | 5 | 0.3% | 134 | 144 | 262 | 189 | 1.31 | 342 | 246 |
| Intermediate low (450 l) | 165 | 9.2% | 391 | 453 | 368 | 275 | 0.51 | 549 | 411 |
| Intermediate high (750 l) | 117 | 6.6% | 648 | 739 | 432 | 322 | 0.36 | 666 | 496 |
| High (1000 l) | 63 | 3.5% | 850 | 993 | 573 | 424 | 0.36 | 764 | 564 |

*Year of data: products available for sale up to May 2019. *Includes factor of 1.2 adjustment for frost-free compartments*

**Table 2.4.2: Canada: refrigerator-freezer efficiency data**

| | | | Adjusted volume | | UEC (Unit Energy Consumption) | | | MEPS | |
|---|---|---|---|---|---|---|---|---|---|
| | No. of models | Share of models | Local Adjusted Volume (litres) | Normalised Adjusted Volume (litres) | Local UEC (kWh/year) | Normalised UEC (kWh/year) | Normalised UEC/litre adjusted volume* | Local MEPS (kWh/year) | Normalised MEPS (kWh/year) |
| Low (150 l) | 32 | 1.7% | 141 | 150 | 304 | 238 | 1.56 | 335 | 262 |
| Intermediate low (450 l) | 77 | 4.1% | 404 | 442 | 370 | 298 | 0.56 | 405 | 326 |
| Intermediate high (750 l) | 213 | 11.3% | 692 | 753 | 542 | 432 | 0.48 | 584 | 466 |
| High (1000 l) | 183 | 9.7% | 910 | 1007 | 693 | 550 | 0.45 | 738 | 586 |

*Year of data: products available for sale up to May 2019*

Table 2.4.3: Korea: refrigerator-freezer efficiency data

| | | | Adjusted volume | | UEC (Unit Energy Consumption) | | | MEPS | |
|---|---|---|---|---|---|---|---|---|---|
| | No. of models | Share of models | Local Adjusted Volume (litres) | Normalised Adjusted Volume (litres) | Local UEC (kWh/year) | Normalised UEC (kWh/year) | Normalised UEC/litre adjusted volume* | Local MEPS (kWh/year) | Normalised MEPS (kWh/year) |
| Low (150 l) | 8 | 1.8% | 148 | 148 | 177 | 177 | 1.19 | 280 | 280 |
| Intermediate low (450 l) | 10 | 2.2% | 554 | 462 | 213 | 213 | 0.38 | 364 | 364 |
| Intermediate high (750 l) | 12 | 2.6% | 928 | 773 | 296 | 296 | 0.32 | 443 | 443 |
| High (1000 l) | 13 | 2.9% | 1172 | 977 | 407 | 407 | 0.35 | 542 | 542 |

*Year of data: products available for sale up to April 2019. *Includes factor of 1.2 adjustment for frost-free compartments. Note – as Korea tests to 25oC ambient and uses IEC aligned interior compartment temperature values and measurement methods the normalised values are the same as the local values.*

Figure 2.4.1: Average normalised annual energy consumption for refrigerator-freezers for each market in 2019 as a function of the reference model group

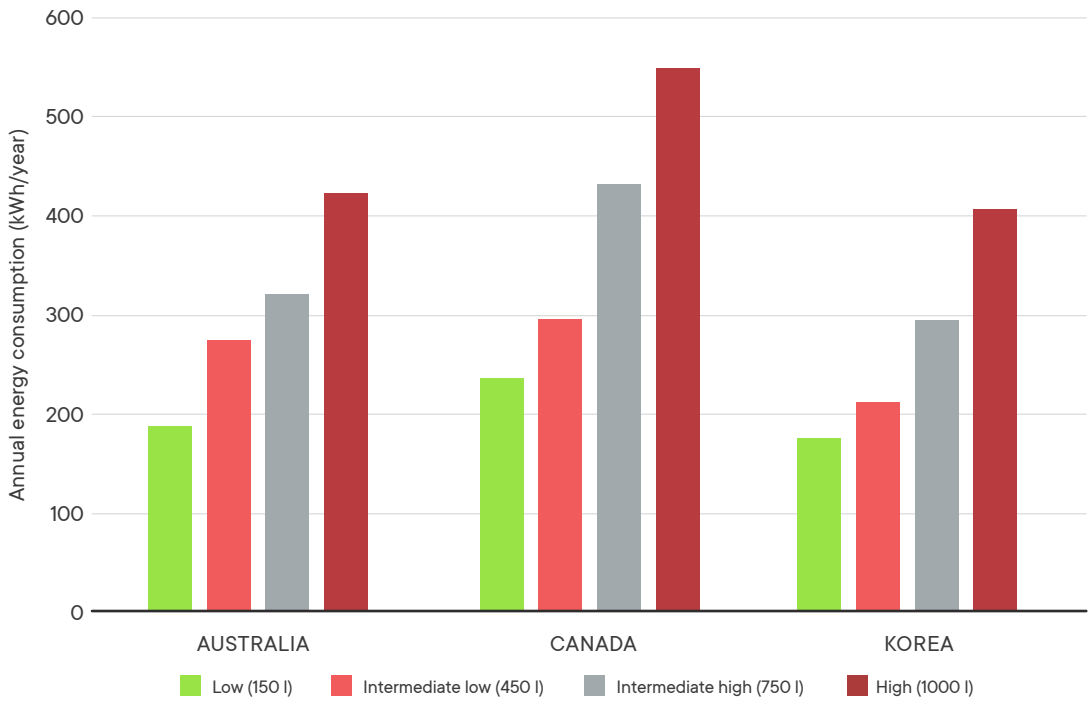
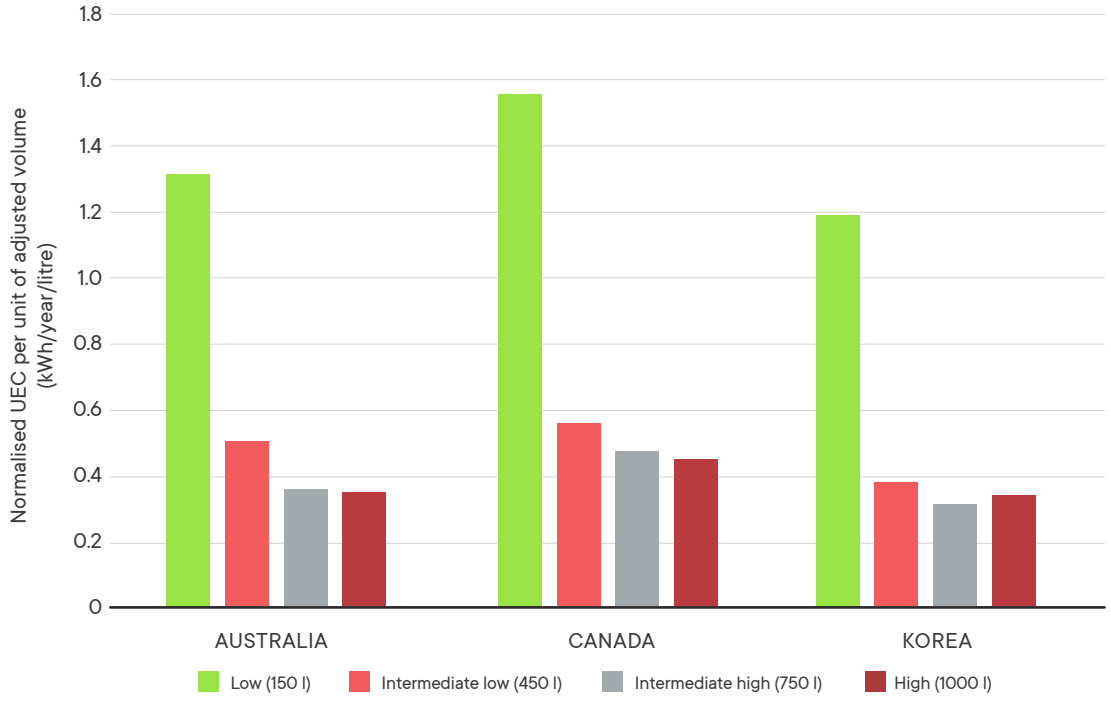


Figure 2.4.2: Average normalised annual energy consumption divided by the average normalised adjusted volume for refrigerator-freezers for each market in 2019 as a function of the reference model group




## 2.5 Electric motors

The scope covers industrial AC induction electric motors of 2, 4, or 6–poles. The efficiency is measured according to the local test conditions but also normalised against the IE3 efficiency class level, or, in the case of 60Hz motors, against the NEMA premium level. As there have been great international efforts to ensure equivalency between the NEMA premium class for 60 Hz motors and the IE3 class for 50Hz motors then these are directly equivalent efficiency performance thresholds and thus the relative efficiency of motors compared to either is a good benchmark of relative efficiency that allows comparison of both 50Hz and 60Hz motors.

Model data was provided by the following countries: Australia, Canada and Korea.

The data is reported for 2–pole models (in Tables 2.5.1 to 2.5.3), 4–pole models (in Tables 2.5.4 to 2.5.6) and 6–pole models (in Tables 2.5.7 to 2.5.9). It includes the average efficiency reported under the local test procedure and also the efficiency relative to IE3 (for 50Hz motors) or NEMA premium (for 60 Hz motors) – noting, that all other things being equal, induction motors operating at a high frequency will have a higher nominal efficiency but will not be more efficient relative to the

IE3/NEMA premium threshold. Note, relative efficiencies of >100% are more efficient than the IE3/NEMA premium threshold and those <100% are less efficient.

The values reported are the average values of the models that fall within +/- 5% of the mid-point capacity (expressed in kW) for each reference model group.

Table 2.5.1: Australia: 2–pole a.c. induction motor efficiency data

| Reference model group | No. of models | Share of models | Average capacity (kW) | Average Efficiency % | Average Efficiency relative to IE3/NEMA Premium |
|---|---|---|---|---|---|
| Low (2.2kW) | 80 | 4.5% | 2.2 | 83.3 | 97.0% |
| Intermediate low (7.5kW) | 93 | 5.2% | 8 | 90.1 | 100.0% |
| Intermediate high (20kW) | 95 | 5.3% | 18.5 | 92.4 | 100.0% |
| High (75kW) | 90 | 5.0% | 75 | 94.9 | 100.2% |

*Year of data: products available for sale up to April 2019*

Table 2.5.2: Canada: 2–pole a.c. induction motor efficiency data

| Reference model group | No. of models | Share of models | Average capacity (kW) | Average Efficiency % | Average Efficiency relative to IE3/NEMA Premium |
|---|---|---|---|---|---|
| Low (2.2kW) | 989 | 7.3% | 2.2 | 87.3 | 102.1% |
| Intermediate low (7.5kW) | 1041 | 7.7% | 7.5 | 90.7 | 101.3% |
| Intermediate high (20kW) | 604 | 4.5% | 18.7 | 91.8 | 100.1% |
| High (75kW) | 441 | 3.3% | 74.9 | 94.5 | 101.0% |

*Year of data: products available for sale (i.e. still registered in the regulatory database) up to April 2019*

Table 2.5.3: Korea: 2–pole a.c. induction motor efficiency data

| Reference model group | No. of models | Share of models | Average capacity (kW) | Average Efficiency % | Average Efficiency relative to IE3/NEMA Premium |
|---|---|---|---|---|---|
| Low (2.2kW) | 278 | 8.4% | 2.2 | 87.1 | 101.9% |
| Intermediate low (7.5kW) | 172 | 5.2% | 7.5 | 90.7 | 101.3% |
| Intermediate high (20kW) | 120 | 3.6% | 18.5 | 92.2 | 100.5% |
| High (75kW) | 96 | 2.9% | 75.0 | 94.6 | 101.0% |

*Year of data: products available for sale up to May 2019*

Table 2.5.4: Australia: 4–pole a.c. induction motor efficiency data

| Reference model group | No. of models | Share of models | Average capacity (kW) | Average Efficiency % | Average Efficiency relative to IE3/NEMA Premium |
|---|---|---|---|---|---|
| Low (2.2kW) | 95 | 5.2% | 2.2 | 86.8 | 100.2% |
| Intermediate low (7.5kW) | 97 | 5.3% | 7.5 | 90.3 | 99.9% |
| Intermediate high (20kW) | 90 | 5.0% | 18.5 | 92.6 | 100.0% |
| High (75kW) | 83 | 4.6% | 75 | 94.9 | 99.9% |

*Year of data: products available for sale up to April 2019*

Table 2.5.5: Canada: 4–pole a.c. induction motor efficiency data

| Reference model group | No. of models | Share of models | Average capacity (kW) | Average Efficiency % | Average Efficiency relative to IE3/NEMA Premium |
|---|---|---|---|---|---|
| Low (2.2kW) | 1195 | 6.6% | 2.2 | 89.6 | 100.2% |
| Intermediate low (7.5kW) | 1249 | 6.9% | 7.5 | 91.9 | 100.2% |
| Intermediate high (20kW) | 785 | 4.3% | 18.7 | 93.6 | 100.0% |
| High (75kW) | 664 | 3.6% | 74.9 | 95.4 | 100.0% |

*Year of data: products available for sale (i.e. still registered in the regulatory database) up to April 2019*

Table 2.5.6: Korea: 4–pole a.c. induction motor efficiency data

| Reference model group | No. of models | Share of models | Average capacity (kW) | Average Efficiency % | Average Efficiency relative to IE3/NEMA Premium |
|---|---|---|---|---|---|
| Low (2.2kW) | 273 | 8.4% | 2.2 | 89.1 | 99.5% |
| Intermediate low (7.5kW) | 196 | 6.0% | 7.5 | 91.3 | 99.5% |
| Intermediate high (20kW) | 114 | 3.5% | 18.5 | 93.7 | 100.1% |
| High (75kW) | 132 | 4.1% | 75.0 | 95.6 | 100.2% |

*Year of data: products available for sale up to May 2019*

Table 2.5.7: Australia: 6–pole a.c. induction motor efficiency data

| Reference model group | No. of models | Share of models | Average capacity (kW) | Average Efficiency % | Average Efficiency relative to IE3/NEMA Premium |
|---|---|---|---|---|---|
| Low (2.2kW) | 63 | 5.3% | 2.2 | 84.4 | 100.2% |
| Intermediate low (7.5kW) | 65 | 5.5% | 8 | 89.4 | 100.4% |
| Intermediate high (20kW) | 65 | 5.5% | 18.5 | 91.8 | 100.2% |
| High (75kW) | 49 | 4.1% | 75 | 94.6 | 100.0% |

*Year of data: products available for sale up to April 2019*

Table 2.5.8: Canada: 6–pole a.c. induction motor efficiency data

| Reference model group | No. of models | Share of models | Average capacity (kW) | Average Efficiency % | Average Efficiency relative to IE3/NEMA Premium |
|---|---|---|---|---|---|
| Low (2.2kW) | 704 | 7.1% | 2 | 90 | 101.3% |
| Intermediate low (7.5kW) | 643 | 6.5% | 7 | 91 | 99.8% |
| Intermediate high (20kW) | 447 | 4.5% | 19 | 93 | 100.0% |
| High (75kW) | 327 | 3.3% | 75 | 95 | 100.0% |

*Year of data: products available for sale (i.e. still registered in the regulatory database) up to April 2019*

Table 2.5.6: Korea: 6–pole a.c. induction motor efficiency data

| Reference model group | No. of models | Share of models | Average capacity (kW) | Average Efficiency % | Average Efficiency relative to IE3/NEMA Premium |
|---|---|---|---|---|---|
| Low (2.2kW) | 59 | 7.3% | 2.2 | 89.0 | 100.5% |
| Intermediate low (7.5kW) | 38 | 4.7% | 7.5 | 91.0 | 99.3% |
| Intermediate high (20kW) | 36 | 4.5% | 18.5 | 92.8 | 99.8% |
| High (75kW) | 33 | 4.1% | 75.0 | 94.9 | 99.8% |

*Year of data: products available for sale up to May 2019*

Figures 2.5.1 to 2.5.3 show the efficiency of the 2–pole, 4–pole and 6–pole motors expressed relative to the IE3/NEMA premium level (depending on whether the motors are 50Hz or 60HZ respectively). This allows a visual comparison of the relative average normalised efficiency of motors available for sale in each of the markets data was supplied for (it is the same data shown in the 5th column of the preceding tables). For the two-pole motor market the average efficiency of the 2019 motors is at or above the IE3/NEMA premium level for all markets and capacity groupings except for the Low capacity grouping in Australia – overall there is a 5% spread in average motor efficiency. For the 4–pole motors the market average efficiency is very close to the IE3/NEMA premium level in all capacity groups and markets, with a 0.7% spread in average efficiency levels across the capacity groups and markets. The average efficiency of the 6–pole motors is also close to the IE3/NEM premium level with an ~1.5% spread across the capacity groups and markets.

**Figure 2.5.1: Average 2–pole motor efficiency relative to the IE3 or NEMA premium level for each market in 2019 as a function of the capacity group**

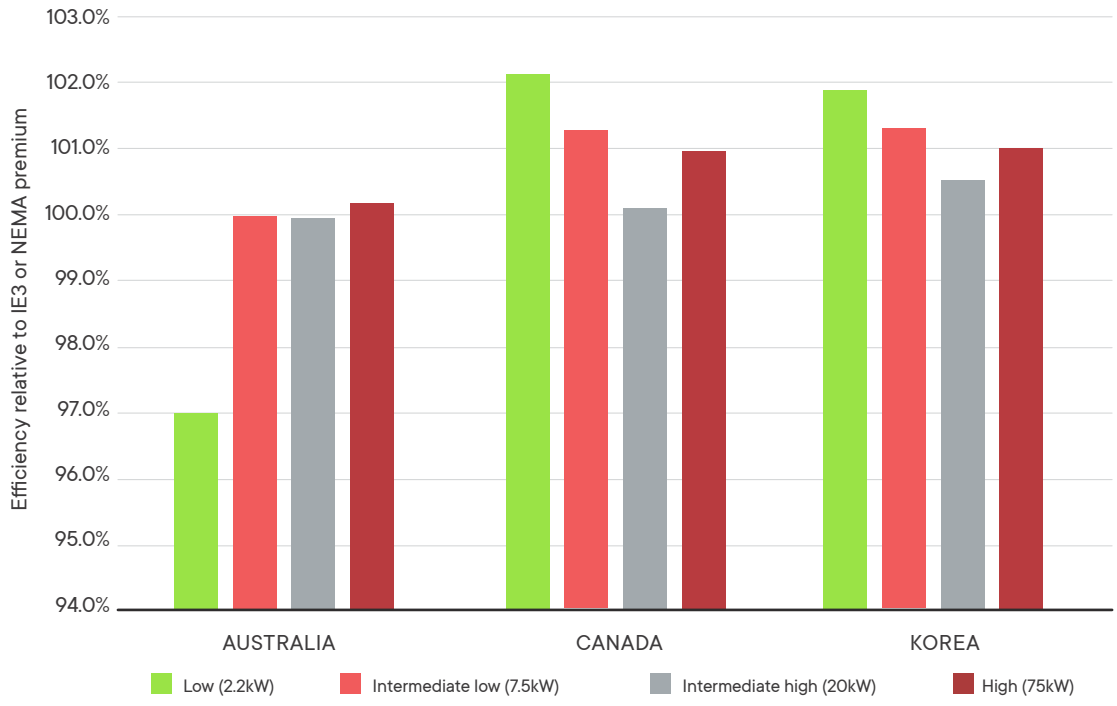


Figure 2.5.2: Average 4-pole motor efficiency relative to the IE3 or NEMA premium level for each market in 2019 as a function of the capacity group

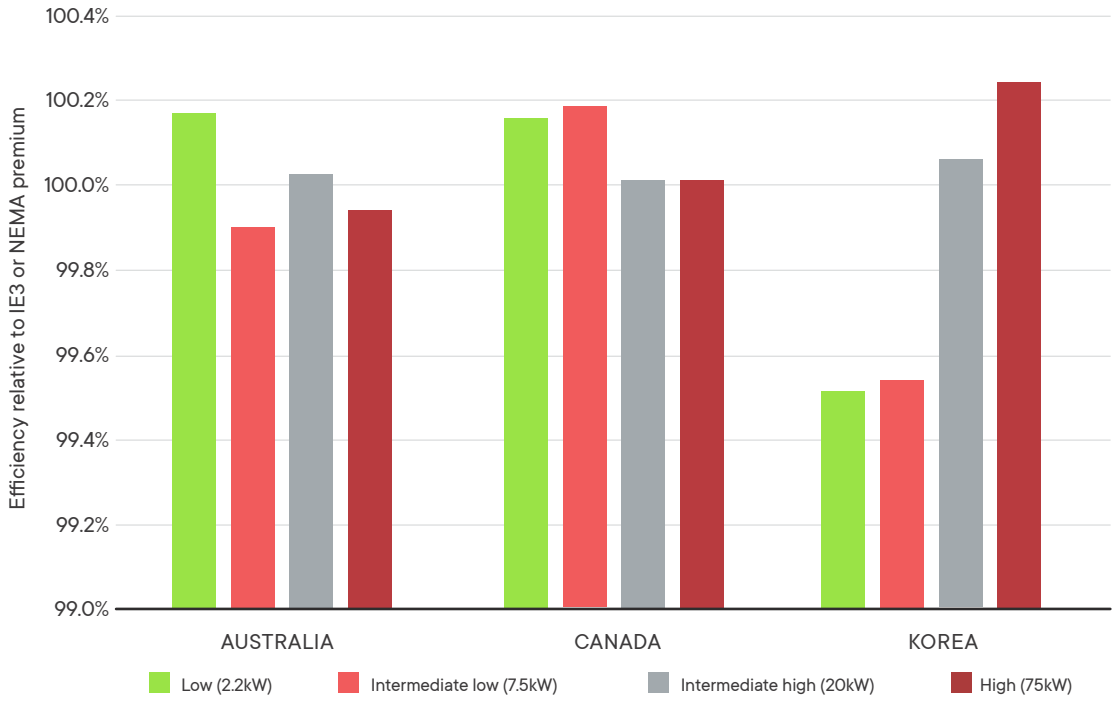
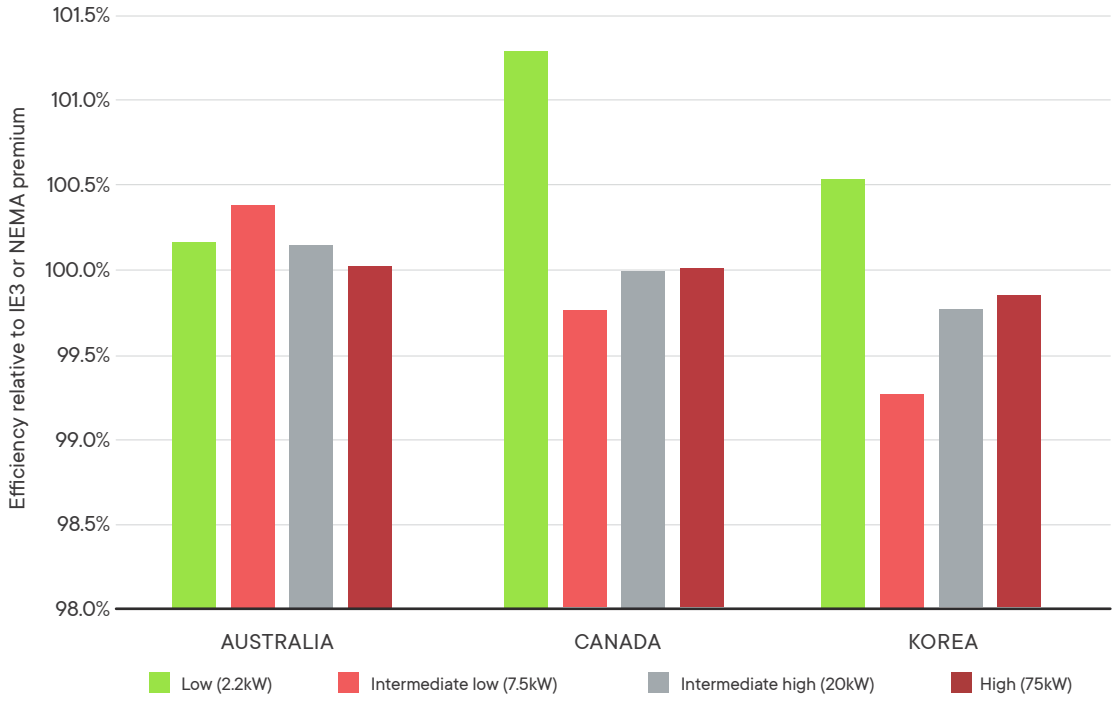



Figure 2.5.3: Average 6-pole motor efficiency relative to the IE3 or NEMA premium level for each market in 2019 as a function of the capacity group



## 2.6 LEDs

The scope covers omni-directional household LED lamps with the driver incorporated into the lamp. Model data was provided by the following countries: Australia, Canada, Korea and the USA. In the case of Canada and the USA the data is that reported in the Energy Star database, which means it will tend to be biased towards the higher efficiency end of the market. For Korea the data is that registered in the regulatory database. The Australian data is different in that it is sales-weighted and based on a survey of sold lamps in the Australian market. By contrast, the other data are lists if models sold on the national market in question.

The efficiency metric used in efficacy, expressed in lumens per watt.

The data is reported in Tables 2.6.1 to 2.6.4 and shown graphically in Figure 2.6.1. The product capacity groups are expressed in terms of the luminous flux (lumens), which is equivalent to the light output of a traditional incandescent lamps (expressed in Watts). Both this and the efficacy data reported below are the model-weighted average of all products that are in scope and fall within one of the four luminous flux ranges, with the exception of the Australian data, which is sales-weighted.

The average efficacy of these LED lamps is between 81 and 106 lumens/watt which is very favourable when compared to the (much lower) efficiency of incandescent lamp technology, and even fluorescent lamps.

**Table 2.6.1: Australia: residential omni-directional LED lamp data**

| | No. of models | Market share | Average Lumens | Average Efficacy (lm/W) |
|---|---|---|---|---|
| Low (40W equivalent) | 1 | 3.9% | 500 | 83 |
| Intermediate low (60W equivalent) | 12 | 31.7% | 805 | 90 |
| Intermediate high (75W equivalent) | 1 | 3.5% | 1000 | 91 |
| High (100W equivalent) | 2 | 11.2% | 1400 | 106 |

*Year of data: products available for sale up to May 2019*

**Table 2.6.2: Canada: residential omni-directional LED lamp data**

| | No. of models | Share of models | Average Lumens | Average Efficacy (lm/W) |
|---|---|---|---|---|
| Low (40W equivalent) | 183 | 7.7% | 485 | 81 |
| Intermediate low (60W equivalent) | 1148 | 48.2% | 802 | 88 |
| Intermediate high (75W equivalent) | 257 | 10.8% | 1100 | 95 |
| High (100W equivalent) | 407 | 17.1% | 1595 | 102 |

*Year of data: products registered for sale up to May 2019*

Table 2.6.3: Korea: residential omni-directional LED lamp data

| | No. of models | Share of models | Average Lumens | Average Efficacy (lm/W) |
|---|---|---|---|---|
| Low (40W equivalent) | 31 | 0.7% | 504 | 90.6 |
| Intermediate low (60W equivalent) | 176 | 3.9% | 796 | 87.9 |
| Intermediate high (75W equivalent) | 243 | 5.4% | 997 | 91.5 |
| High (100W equivalent) | 228 | 5.1% | 1491 | 97.7 |

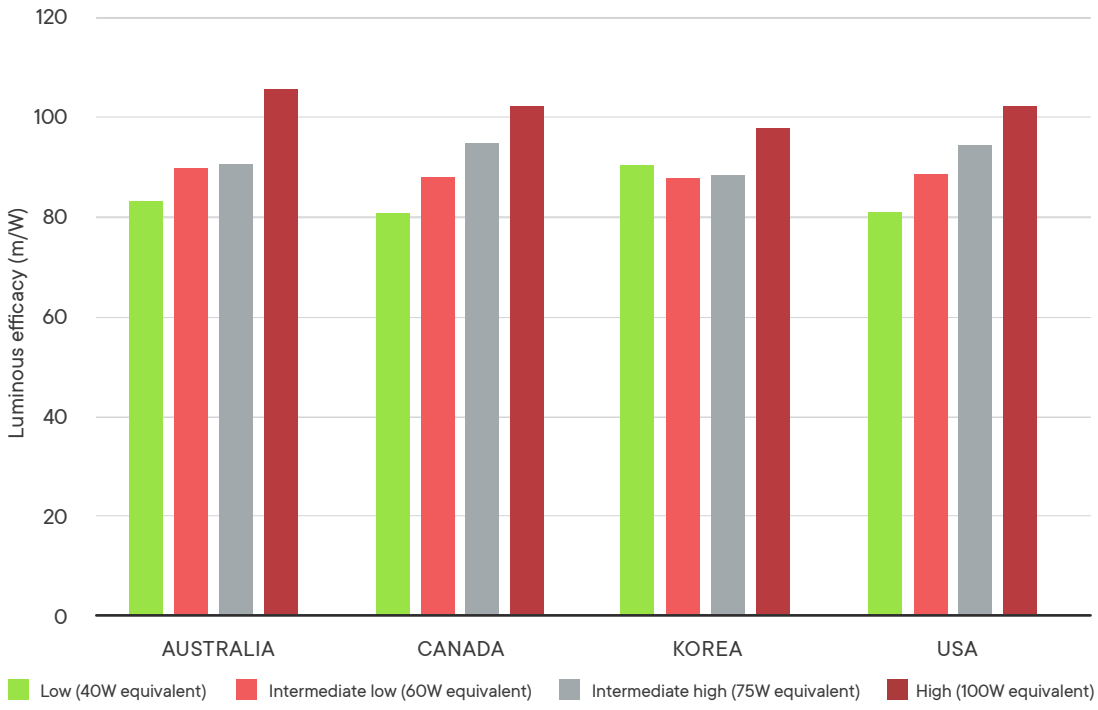
*Year of data: products available for sale up to May 2019*

Table 2.6.4: USA: residential omni-directional LED lamp data

| | No. of models | Share of models | Average Lumens | Average Efficacy (lm/W) |
|---|---|---|---|---|
| Low (40W equivalent) | 229 | 7.2% | 484 | 81 |
| Intermediate low (60W equivalent) | 1434 | 45.1% | 802 | 89 |
| Intermediate high (75W equivalent) | 390 | 12.3% | 1100 | 95 |
| High (100W equivalent) | 565 | 17.8% | 15941 | 102 |

*Year of data: products available for sale up to May 2019*

Figure 2.6.1: Average omni-directional household LED lamp with integrated driver efficacy for each market in 2019 as a function of the lumen package group



## 2.7 Televisions

The reference models capture approximately 60% of all TV models and provide a good representation of the general market. The larger models (55" and 65") account for around 40% of the market.

The efficiency is similar across all regions. Australia and Europe show very similar efficiency levels, while USA and Canada are the most efficient. In part, this is likely to be a result of the data sources used. The US and Canadian data for all years except 2018 USA is sourced from ENERGY STAR which should only contain the more efficient products on the market (and hence is probably not representative of the entire market). This means the long-term trends are similar between these countries. However, Table 2.7.5 is a snapshot of 2018 only, and uses the more market-representative USA PEET data. The efficiency is therefore closer to the regions outside North America, but is still more efficient on average (1.0W/dm2 vs 1.2W/dm2)

The relationship between screen size and efficiency shows 42" screens have the lowest efficiency while 32" and 65" have the highest. In general, efficiency is expected to increase as the physical size of the pixels increase. However, the introduction of 4k (3160 x 2180) resolution in 55" and 65" TVs means the pixel size has decreased, which will lower efficiency, while 32" TVs remain full HD (1920x1080). 42" TVs are now a mix of 4k and FHD.

**Table 2.7.1: Australia: Television efficiency data**

| Reference model group | No. of models | Share of models | Average power W | Average W/dm² |
|---|---|---|---|---|
| 32" | 66 | 10.3% | 30.6 | 1.12 |
| 42" | 53 | 8.3% | 63.9 | 1.28 |
| 55" | 140 | 21.9% | 98.9 | 1.20 |
| 65" | 130 | 20.4% | 128.1 | 1.12 |

*Year of data: products available for sale in 2018*

**Table 2.7.2: Canada: Television efficiency data**

| Reference model group | No. of models | Share of models | Average power W | Average W/dm² |
|---|---|---|---|---|
| 32" | 13 | 13.5% | 24.5 | 0.89 |
| 42" | 12 | 12.5% | 46.9 | 0.94 |
| 55" | 14 | 14.6% | 70.7 | 0.86 |
| 65" | 18 | 18.8% | 83.9 | 0.73 |

*Year of data: products available for sale in 2018*

Table 2.7.3: Europe: Television efficiency data

| Reference model group | No. of models | Share of models | Average power W | Average W/dm² |
|---|---|---|---|---|
| 32” | 59 | 8.0% | 34.7 | 1.26 |
| 42” | 102 | 13.8% | 64.0 | 1.28 |
| 55” | 167 | 22.6% | 104.6 | 1.27 |
| 65” | 143 | 19.4% | 136.2 | 1.19 |

*Year of data: products available for sale in 2018*

Table 2.7.4: Korea: Television efficiency data

| Reference model group | No. of models | Share of models | Average power W | Average W/dm² |
|---|---|---|---|---|
| 32” | 153 | 15.6% | 26.63 | 0.97 |
| 42” | 138 | 14.0% | 50.68 | 1.01 |
| 55” | 217 | 22.1% | 95.31 | 1.15 |
| 65” | 224 | 22.8% | 128.58 | 1.10 |

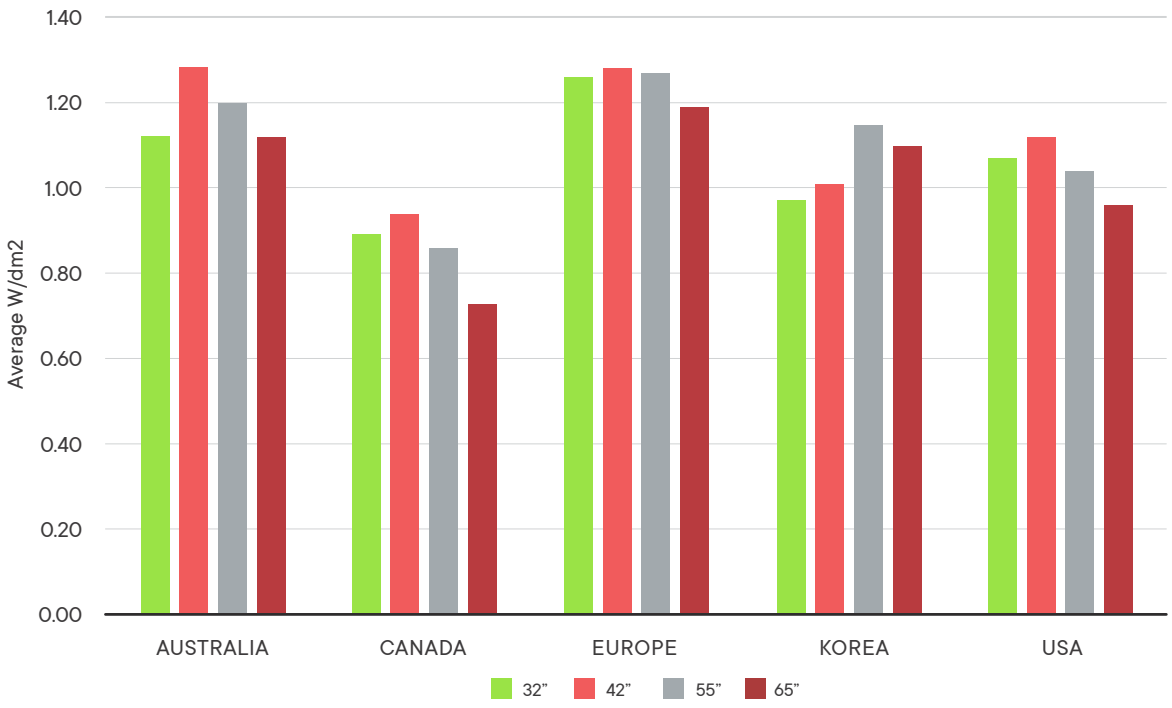
*Year of data: products available for sale in 2018*

Table 2.7.5: USA: Television efficiency data

| Reference model group | No. of models | Share of models | Average power W | Average W/dm² |
|---|---|---|---|---|
| 32” | 246 | 10.1% | 29.89 | 1.07 |
| 42” | 291 | 11.9% | 56.55 | 1.12 |
| 55” | 464 | 19.0% | 86.26 | 1.04 |
| 65” | 403 | 16.5% | 110.80 | 0.96 |

*Year of data: products available for sale in 2018*

Figure 2.7.1: Average television efficiency for each market in 2018 as a function of the screen size group




## 2.8 Washing machines

Products in scope are residential washing machines (clothes-washers). Model data on washing machine energy efficiency was provided by Australia, Canada and Korea. As it is not technically viable to attempt to normalise washing machine energy performance across the (incompatible) performance metrics used in 4E economies, the analysis presented here is expressed in terms of the economy- specific metrics which are currently in use.

For Australia, the efficiency is expressed in terms of the average star rating index (SRI) and the corresponding average energy label star rating – both expressed for the most recent (new) energy labelling rating system.

Table 2.8.1: Australia: washing machine data

| Reference model group | No. of models | Average capacity (kg) | Average new SRI | Average new star rating | Average annual energy consumption CEC (kWh/year) | Average hot water use (litres/wash) |
|---|---|---|---|---|---|---|
| All products in scope | 684 | 8.14 | 3.42 | 3.29 | 416.24 | 81.2 |

*Year of data: products available for sale up to May 2019*

For Canada, the efficiency is expressed in terms of the average Integrated modified energy factor (where a higher value indicates a more efficient machine). Also shown is by how much the average product exceeds the efficiency limits set in the current MEPS.

Table 2.8.2: Canada: washing machine data

| Reference model group | No. of models | Average capacity (litres) | Average Integrated modified energy factor L/kWh/cycle | Annual energy consumption kWh | MEPS limit for Integrated modified energy factor L/kWh/cycle | MEPS satisfaction factor |
|---|---|---|---|---|---|---|
| All products in scope | 287 | 108.2 | 62.4 | 129.7 | 47.5 | 129.9% |

*Year of data: products available for sale up to May 2019*

For Korea, the efficiency is expressed in terms of the average R value, which expresses a weighted energy consumption efficiency index in units of Wh/kg. Also shown is the average efficiency rating on the Korean energy labelling scheme (ranked from 1 to 5).

Table 2.8.3: Korea: washing machine data

| Reference model group | No. of models | Standard washing capacity (kg) | Water consumption | Annual power consumption (kWh) | R (Consumption efficiency rating index) (Wh/Kg) | [Efficiency Rating] |
|---|---|---|---|---|---|---|
| All products in scope | 283 | 15.3 | 106.0 | 115.6 | 56.9 | 2.38 |

*Year of data: products available for sale up to May 2019*

## 2.9 Water heaters (electric storage)

Products in scope are residential electric storage water heaters, including conventional electric storage water heaters and heat pump storage water heaters, but not those powered by fuels other than electricity or with hybrid energy sources. Model data on water heaters was provided by Australia and Canada. The Australian and Canadian data is only for electric (resistance) storage water heaters. Normalisation is per the approach that described in the methodology report. Values are expressed in terms of total unit energy consumption in units of kWh/year.

Table 2.9.1: Australia: residential electric water heater data

| | No. of models | Share of models | Average capacity litres) | Local average standing losses (W) | Normalised average standing losses (W) | Average TUEC (kWh/year) |
|---|---|---|---|---|---|---|
| Low (60 litres) | 51 | 7.0% | 50 | 59.5 | 40.6 | 4774 |
| Intermediate low (115 litres) | 84 | 11.6% | 125 | 77.0 | 52.5 | 4923 |
| Intermediate high (185 litres) | 7 | 1.0% | 200 | 98.8 | 67.3 | 5063 |
| High (310 litres) | 128 | 17.6% | 315 | 119.7 | 81.6 | 5197 |

*Year of data: products available for sale up to May 2019*

Table 2.9.2: Canada: residential electric water heater data

| | No. of models | Share of models | Average capacity (litres) | Local average standing losses (W) | Normalised average standing losses (W) | Average TUEC (kWh/year) |
|---|---|---|---|---|---|---|
| Low (60 litres) | 23 | 4.3% | 66 | 49.09 | 41 | 4795 |
| Intermediate low (115 litres) | 59 | 11.2% | 108 | 55.09 | 46 | 4863 |
| Intermediate high (185 litres) | 165 | 31.2% | 179 | 64.25 | 54 | 4945 |
| High (310 litres) | 17 | 3.2% | 306 | 81.24 | 68 | 5079 |

*Year of data: products available for sale up to May 2019*

Figure 2.9.1: Average water heater TUEC for each market in 2019 as a function of the capacity group