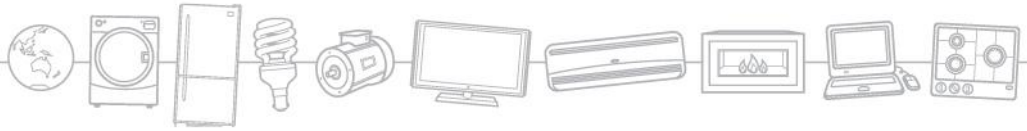
E3
Equipment Energy Efficiency

Impacts of the E3 program:

Projected energy, cost and emission savings

March 2014



A joint initiative of Australian, State and Territory and New Zealand Governments

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Glossary

BAU	Business as Usual
CBA	Cost-benefit analysis
CO_2-e	Carbon dioxide equivalent
COP	Coefficient of Performance
E3	Equipment Energy Efficiency (Program)
EECA	Energy Efficiency and Conservation Authority (New Zealand)
EER	Energy Efficiency Ratio
ELV	Extra low voltage
EPS	External power supply
FY	Financial year (e.g. FY 2013 is the period 1 July 2012 to 30 June 2013)
GEMS	Greenhouse and Energy Minimum Standards
HE	High Efficiency
HH	Household
HVAC	Heating, ventilation and air conditioning
ICT	Information and communications technology
MEPS	Minimum Energy Performance Standards
NEM	National Electricity Market
NFEE	National Framework for Energy Efficiency
NPV	Net Present Value
OBPR	Office of Best Practice Regulation
PV	Present value
RIS	Regulatory Impact Statement
WELS	Water Efficiency Labelling and Standards

Abstract

Drawing on the best available data from impact evaluation studies, regulatory impact statements and product profiles, this report estimates the historical and projected impacts of the Equipment Energy Efficiency (E3 Program) on energy use and greenhouse gas emissions in Australia. It also estimates the value of energy saved, and compares this to the costs imposed by the Program. This is the fifth impacts study completed for the E3 Program, with the previous study being the 2009 publication, *Prevention is Cheaper than Cure*.

For purposes of this analysis, E3 projects have been grouped into four categories:

- Existing energy labelling and minimum energy performance standards (MEPS) programs (i.e. where the regulations are already in place);
- Energy labelling and MEPS projects in train (i.e. where development work has commenced, but the measure has not yet been implemented);
- Demand Response projects in train, where the projected impacts are economic benefits from reductions in electricity system peak demand rather than energy savings; and
- Proposed new projects identified in the E3 2011-14 work plan, but which have yet to commence. This group is the least defined, and is not expected to have any impacts until 2019 at the earliest.

The main findings are:

- The E3 Program will save about 2,021 PJ of end-use energy between 2014 and 2030, of which about 92% is electricity;
- The discounted value of net benefits of the Program is over $57 billion for this period;
- The overall benefit cost ratio of the E3 Program is about 4.6, which means that for every $1 of expenditure on the program (by government and consumers) $4.60 is saved;
- The E3 Program will save about 129 million tonnes of CO_2-e between 2014 and 2020, and 433 million tonnes between 2014 and 2030;
- The effective cost per tonne of CO_2-e avoided is -$118. The emissions savings are at negative cost because the measures are cost-effective in their own right;
- About 79% of energy savings to 2030 come from measures already regulated, 16% from measures in train but not yet implemented, and 5% from new measures for which impacts can be quantified; and
- Demand response measures account for about 47% of the net monetary benefit of measures in train and new.

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Background

This document estimates the impacts (historical and projected) of the Equipment Energy Efficiency (E3) Program on energy use and greenhouse gas emissions in Australia.[1] It also estimates the value of energy saved and compares this with the cost of the Program. This report does not detail the history, structure and scope of the E3 Program, which are described in a number of other documents, including the latest *Achievements* report.[2]

This is the fifth Impacts study. The fourth one was published in January 2009.[3] Although the methodology is largely similar, the projections in the present study cannot be directly compared with previous studies, because:

- The projection period is different: 2000-2030, compared with 2000-2020 in the previous report;
- The projected greenhouse gas-intensity of electricity supply is different; the present report has been adjusted to reflect a more rapid expected decline in intensity;
- Projected electricity prices are different. They start from a different base (2013, compared with 2008) and now exclude the impacts of carbon pricing, which it is assumed will cease from July 2014;
- Several programs have been added and some removed;
- Some programs have been implemented (so the implementation dates are now fixed), while for some programs the expected implementation dates have changed; and
- In some cases the projected impacts have been adjusted due to better information on actual observed impacts (e.g. for refrigerators and air conditioners)[4] or due to the availability of later and more detailed projections. Some of these adjustments have been upward (i.e. greater impacts expected than before) and some downward.

The 'modelling period' is the time span over which the energy impacts of each measure are compared with the 'business as usual' (BAU) case, which is generally the estimated energy use of that product or sector in the absence of the measure.

For measures which commenced before the modelling period (e.g. the energy labelling of refrigerators, which started in 1986), only impacts during the modelling period are estimated. Impacts before 2000 or after 2030 are not taken into account. The great majority of E3 measures have taken effect, or are expected to take effect, between 2000 and 2017, but the impact of earlier programs still dominates due to the natural time profile of changes in the appliance stock. Energy labelling and minimum energy performance standards (MEPS) influence the energy efficiency of all products purchased new after the implementation date. As time passes, these units come to make up more of the installed stock, and after 12 to 15 years account for virtually all of the stock. Thus the costs are incurred mostly upfront for the programs implemented in the next few years while the total benefits will not be fully realised until the end of the modelling period (2030).

Programs Included

Table 1 lists the products and measures that will be covered by the E3 program included in the 2011-14 triennium Work Plan (assuming measures still in the planning stage are approved by E3 ministers and implemented by the target dates. For measures involving both Australia and New Zealand, approval for implementation must be sought

[1] In this report references to the E3 Program as a whole are capitalised, while individual measures are sometimes also called 'programs' in lower case. The E3 Program forms part of the Australian National Framework for Energy Efficiency (NFEE) and the New Zealand National Energy Efficiency and Conservation Strategy. This report only covers the impacts of the E3 Program in Australia, not New Zealand.

[2] http://www.energyrating.gov.au/resources/program-publications/?viewPublicationID=2555

[3] *Prevention is cheaper than cure: Avoiding carbon emissions through energy efficiency* (January 2009) http://www.energyrating.gov.au/resources/program-publications/?viewPublicationID=2204

[4] *Retrospective review of the E3 program: Lessons learnt from two reviews* (March 2011), http://www.energyrating.gov.au/resources/program-publications/?viewPublicationID=2159

from the E3 ministers and the New Zealand cabinet)[5]. Where dates in the past are given, these are actual implementation years. Where more than one date is given for MEPS, the later dates indicate when more stringent MEPS take effect. 'Label enhancements' indicate a re-scaling of the star label, when products previously rated at 5*, say, are re-rated to about 3* to renew the commercial incentive for suppliers to further increase product efficiency.

Re-ratings are sometimes accompanied by minor changes in the energy tests and in label design and content, which are intended to maintain buyer motivation to seek out more energy-efficient purchases and to ensure that label rankings continue to reflect actual product energy use.

[5] Measures on LED lighting are currently being investigated and are not included in the products and measures covered in this report.

Table 1 Products and measures covered by E3 Program Projections[6]

Product or product group	Measures (in place and projected)(a)	Residential	Other (b)
Household refrigerators & freezers	*Energy labelling 1986* *Label enhancements 2000, 2008* *MEPS 1999, 2005, 2017*	✓	
Electric storage water heaters (large)	*MEPS 1999, 2016*	✓	
Electric storage water heaters (small)	*MEPS 2005, 2016*	✓	
Hot water storage tanks	*MEPS 2016*	✓	
Heat pump water heaters	*MEPS & labelling, 2016*	✓	
Solar water heaters	*MEPS & labelling 2016*	✓	
Gas water heaters	*MEPS 2013, MEPS and label enhancement 2018*	✓	
Clothes washers, dishwashers, clothes dryers	*Labelling 1987, 1990* *Label enhancements 2000*	✓	
Household air conditioners	*Energy labelling 1987* *Label enhancements 2000, 2010* *MEPS 2004-2011, 2016*	✓	
Packaged air conditioners	*MEPS 2001, 2010, 2011, 2016*		✓
Air conditioner liquid chillers	*MEPS 2009, 2016*		✓
Close control air conditioners	*MEPS 2009, 2016*		✓
Televisions	*Labelling 2009, Enhancements 2013* *MEPS 2010, 2013*	✓	
Set top boxes	*MEPS 2009*	✓	
External power supplies (EPS)	*MEPS 2009*	✓	✓
Commercial refrigeration products	*MEPS 2006, 2009, 2017*		✓
Fluorescent lamp ballasts	*MEPS 2003, 2017*	✓	✓
Linear fluorescent lamps (tri-phosphor)	*MEPS 2005, 2017*	✓	✓
Incandescent lamps, ELV transformers	*MEPS 2009*	✓	✓
Compact fluorescent lamps	*MEPS 2009*	✓	✓
Electric motors (3 phase)	*MEPS 2001, 2006, 2016*		✓
Power supply transformers	*MEPS 2004, 2016*		✓
Standby energy (range of products)	*MEPS 2016*	✓	✓
Swimming pool pump-units (single phase)	*MEPS & Labelling 2017*	✓	
Personal computers & monitors	*MEPS 2013*	✓	✓
Battery chargers	*MEPS 2018*	✓	
Gas space heaters (d)	*MEPS 2017*	✓	
Additional products - commercial	*From 2019 (c)*		✓
Additional products - industrial	*From 2019 (c)*		✓
Additional products - non-energy (e)	*Not included in this study*	✓	✓
Clothes washers, dishwashers, showers, taps	*Water Efficiency Labelling and Standards 2006 – energy impacts*	✓	✓

(a) Note: Where implementation year is in the future, it is the year currently thought most likely, and assuming that Ministers agree to implementation following full regulation impact assessment. Where programs are also implemented in New Zealand, dates may differ. (b) Programs which mainly target non-residential energy use. Many products are used in all sectors. (c) Earliest practical implementation date. As these programs are still to be fully defined, two rates of implementation are modelled: faster and slower. (d) Does not include potential savings from measures to regulate gas decorative heaters (e) Products with influence on energy use, which are potentially subject to GEMS determinations – e.g. windows, insulation, air conditioning ducts.

[6] Other potential programs are also being investigated, e.g. measures regarding LED lighting

As Table 1 indicates, the impact of some programs is wholly or largely confined to the residential sector, while other programs target industrial and commercial energy use. Some programs have significant impacts across all sectors because the target products may be installed in homes, commercial buildings or factories. Lamps and computer equipment are obvious examples.

The last measure in Table 1 is not strictly speaking part of the E3 Program, but the Water Efficiency Labelling and Standards (WELS) Program administered by the Department of Environment.[7] The energy impacts have been included because they interact closely with E3 measures. Increasing the water use efficiency of clothes washers and dishwashers reduces their energy use beyond the effects of energy labelling alone, because these products either heat some of their water directly or import it from the dwelling's water heater. Shower-head flow rates also impact on hot water demand. These effects are taken into account in projecting the energy impacts of E3 programs targeting clothes washers, dishwashers and water heaters.

The Greenhouse Energy and Minimum Standards (GEMS) Act 2012 gives the Commonwealth minister, in consultation with the other E3 energy ministers, the power to set performance standards for products that do not use energy themselves, but influence the energy performance of other products or energy systems – e.g. air conditioning ducts, building insulation or windows. Measures for these products are currently under investigation in the Department of Industry, but as yet there are no measures of this kind in the E3 work program.

Table 1 omits one of the major programs included in the 2009 impact projections: the phase-out of greenhouse-intensive water heaters in existing dwellings. Although energy ministers (other than Tasmania's) endorsed this program in 2011, policy developments since indicate that it will not be implemented. (In South Australia, significant elements of this program were already in place before 2011, and these are projected to remain).

Methodology

The implementation of each E3 measure generally follows the same sequence. For products not already subject to MEPS or energy labelling the E3 Committee commissions a 'product profile' which includes a preliminary estimate of current and projected energy consumption and the potential for reducing it through measures such as energy labelling or MEPS. If the E3 Committee then considers that the measure warrants further evaluation, it commissions a Consultation Regulation Impact Statement (RIS), which includes an assessment of whether there are market failures in the supply or consumption of that product or energy service, and a full cost-benefit analysis (CBA) of implementing a range of possible measures. Proposals for new measures for products already regulated under the GEMS Act can sometimes move directly to a RIS.

Once approved by the Office of Best Practice Regulation (OBPR), the RIS is released for public consultation. The proposal may be modified in the light of any comments received, and then a Decision RIS is submitted to energy ministers for their decision. If the measure is implemented there is a suitable lead time before compliance becomes mandatory. There may then be follow-up studies to monitor its effectiveness.

The present report estimates the impact of each measure by drawing on the best available data: impact evaluation studies if available, the RIS or, failing that, the product profile. If none of these are available, a preliminary estimate has been made, based on what is known about the impact of previous measures for the same product.

The essential elements of each impact assessment are:

- The projected sales of the product in question. E3 programs by their nature target new products, so appliances and equipment already in the stock at the time of implementation of a proposed measure will not be affected. Therefore it is sufficient to project the build-up of the stock that is purchased post-implementation, rather than the entire stock.
- The BAU (Business-as-Usual) average annual energy use per unit sold. For products not currently subject to energy labelling and/or MEPS, BAU is the same as the 'no-regulations' case. For products already subject to labelling and/or MEPS, BAU assumes the continuation of those measures at their present level. In either case, BAU generally involves the assumption that product energy efficiency increases (albeit slowly in most 'no-regulation' cases) whether or not the proposed measure is implemented. The BAU energy projection covers both the technical efficiency of products and changes in energy service demand due to factors such as better building insulation, increasing efficiency of hot water use or changing household sizes.

[7] http://www.waterrating.gov.au/about-wels

- The average 'with-measures' energy use per model sold. This models the impact of MEPS, whereby all products sold after a target commencement date must meet specified energy efficiency levels, and energy labelling, which involves changing both consumer and supplier preferences more gradually.[8]

The difference between the BAU energy trend line and the 'with-measures' trend line represents the energy saved, or the 'energy impact' of the measure. For most products, this analysis needs to be carried out separately for different product segments, determined by market structure, product size, capacity and configuration and the structure of the relevant test standards. For example, there are some 13 separate classes of residential refrigerator and freezer, and 12 classes of general-purpose air conditioner covered by MEPS and/or labelling regulations. For climate-sensitive products, the patterns of sales by climate zone are also taken into account.

Once the energy impacts are calculated it is a relatively straightforward matter to calculate the value to consumers of the energy saved, using the electricity tariffs applying to that class of product. For this purpose, projected product sales are usually disaggregated by sector of installation (residential, commercial and industrial) and jurisdiction (State, Territory and New Zealand), because different energy prices apply in each sector and jurisdiction.[9]

The greenhouse impact of the energy saved can be calculated by applying greenhouse gas-intensity factors for electricity and natural gas, which are also usually projected separately for each jurisdiction.

Standardising Assumptions

The data in this report draws on over 50 E3 documents published over the past decade, prepared by 12 to 15 groups of consultants.[10] To maintain consistency of approach, the E3 program produced a *Guide to Preparing RISs* in 2005.[11] The Program also maintains a set of agreed projections of population, household numbers, energy prices and greenhouse gas-intensities, which are updated from time to time.

Even so, there are inevitable differences between studies due to different forecasting time horizons, population and energy price assumptions and OBPR's changing requirements with regard to discount rates. For the present analysis, the calculations in the various studies have been standardised to a common basis by extending the projection period to 2030 in all cases, and adjusting to the latest (post-2011 census) projections of household numbers (which are a better predictor of appliance stocks than population), energy prices (Figure 1 and Figure 2) and greenhouse gas-intensities (Figure 3). All prices are constant 2013 dollars.

The sectoral average electricity prices in Figure 1 take into account the latest projections of the Australian Electricity Market Operator (AEMO) and the Commonwealth government policy to remove carbon pricing from July 2014. This fall accounts for the kinks in Figure 1. Figure 2 shows the corresponding projections for residential natural gas prices. These take into account projections of rising wholesale gas prices in the eastern states.

The price trends illustrated in Figure 1 and Figure 3 and are simplified national averages, unlike the 2009 projections, which were built up from separate jurisdictional sub-models. This means that the same energy price and intensity values are used for all products within the one sector, whereas in reality product ownership and usage levels vary across jurisdictions, so the national average price and intensity levels for each product that would be aggregated from sub-models would be slightly different. The values on Figure 3 are plotted to the same scale, to illustrate the relative greenhouse gas intensities of electricity and natural gas.

[8] It has been observed that product energy efficiency usually begins to increase as soon as suppliers are convinced that mandatory measures are intended, so the energy impacts of measures become evident a year or two before the formal implementation date.
[9] The E3 methodology for Australia uses the marginal retail energy prices (i.e. after initial low-cost tranches) and retail product prices and installation charges faced by consumers to calculate costs and benefits. Some methods use producer costs for both energy and product prices, but this gives very similar cost-benefit ratios.
[10] There were 36 formal E3 RISs published between 2002 and mid-2013, in addition to Product Profiles. Some of these covered the same products at different stages of the program cycle.
[11] http://www.energyrating.gov.au/resources/program-publications/?viewPublicationID=583

Figure 1 Projected average retail electricity prices, Australia (constant 2013 $)

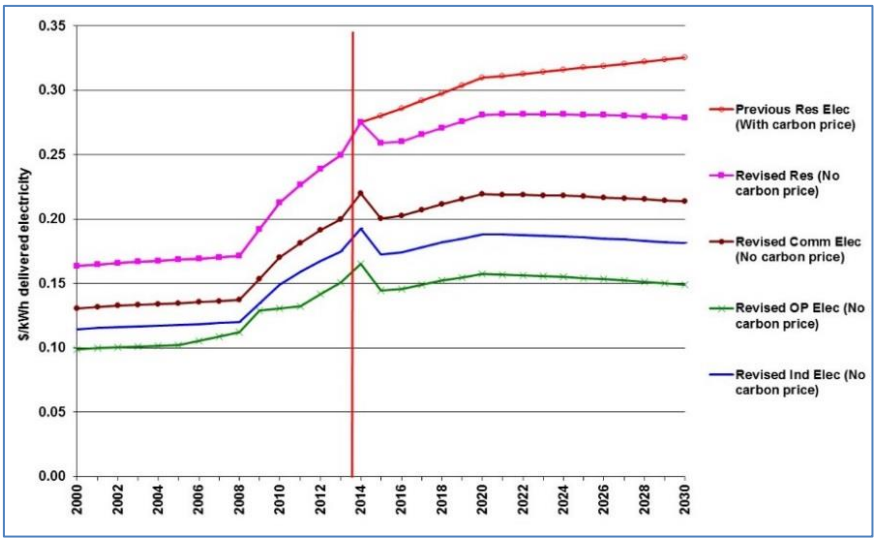


Figure 2 Projected average retail natural gas price, Australia (constant 2013 $)

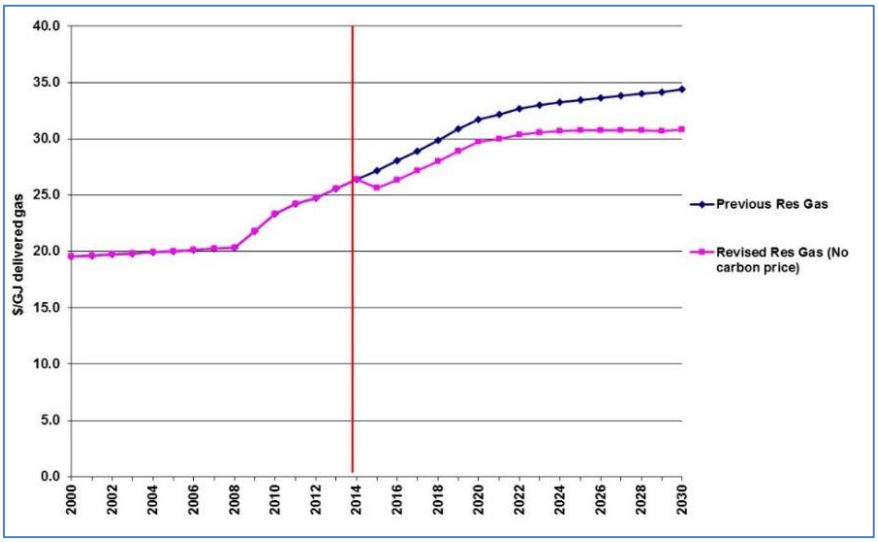
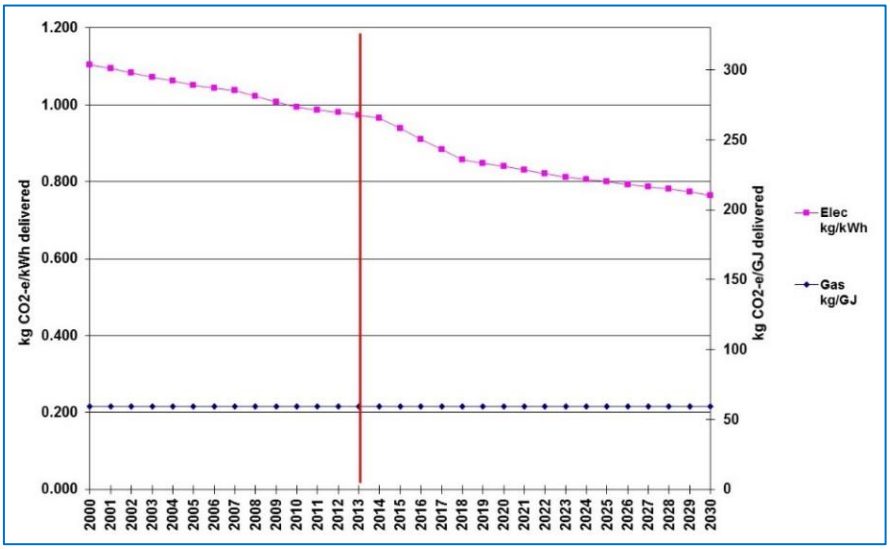


Figure 3 Projected average greenhouse gas-intensity of electricity and gas delivered, Australia



Program Interactions

In combining the impacts of various E3 programs, allowance has been made for 'internal' double-counting – i.e. the interaction of different E3 programs targeting the same product or energy end use. Apart from hot water demand, another source of internal double counting involves measures targeting electronic products and standby energy.[12]

Electronic equipment and appliances containing electronic controls are potentially subject to two or more of the following measures:

1. MEPS for external power supplies (EPS), which took effect in 2009;
2. MEPS for computers and monitors, which took effect in 2013;
3. General standby energy requirements, projected to take effect 2016;
4. Changes to appliance and air conditioner energy tests over the past decade which mean that energy used in standby mode is already counted towards energy ratings and MEPS compliance; and
5. Battery chargers (Product Profile June 2012 – measures projected to take effect 2017).

Laptop computers, for example, are potentially subject to measures 1, 2, 3 and 5. In the projections, an attempt has been made to reduce double counting of impacts by:

- Modelling full impacts for (1)
- Modelling reduced impacts for (2) and (3) – i.e. lower than in the respective RISs
- Reducing projected impacts of (5) by about 50% (the estimated contribution of standby energy to the total energy use of battery chargers).

There are also interactions between commercial lighting and air conditioner programs. A significant share of the heat which must be removed from commercial buildings comes from lighting, so if the power of lighting installations declines due to E3 lighting measure, so does the cooling load and hence the potential energy savings from measures to increase the energy-efficiency of air conditioning. (This works in reverse for heating, where less lighting energy means that more space heating is required, but in commercial buildings the cooling mode tends to dominate, even in colder climates).

Apart from 'internal' double-counting between E3 measures there is also the potential for 'external' double-counting when combining the impact of E3 measures with non-E3 programs and policies, including:

1. Building regulations impacting on the thermal performance of new buildings and renovations;
2. Building regulations impacting on the design, energy efficiency or greenhouse-intensity of fixed building systems (e.g. water heating, lighting, air conditioning);
3. Programs impacting on water heater choice, e.g. the availability of Small-scale Technology Certificates (STCs), rebates and cash incentives;
4. Other Commonwealth, State and Territory government programs impacting on appliance choice and in-use efficiency; and
5. Legislated 'White Certificate' programs, e.g. the NSW Energy Saving Scheme (ESS), the Victorian Energy Efficiency Target (VEET) and the SA Residential Energy Efficiency Scheme (REES).

Whenever a product profile or a RIS is prepared, the authors take into account their assessment of the impacts of these external factors. Some external programs are relatively stable and long-lived, while others are more volatile – they turn out not to be introduced as announced at the time, or they are altered or withdrawn sooner than expected. Therefore it is very difficult for E3 measures to account consistently and accurately for external variables.

The overlap with building regulations is subject to a high degree of uncertainty, especially with respect to the savings expected from E3 programs for HVAC products. If the demand for cooling and heating falls over time due to better thermal performance, then the energy saved through rising HVAC equipment efficiency should be less, although occupants may take some of the benefit as greater thermal comfort. RIS authors try to adjust impact projections according to their expectations of improvement in building thermal performance, but different RISs are based on different assumptions about the timing, magnitude and impacts of future changes in building regulations. There may therefore be some overestimates or underestimates in the projected impacts of E3 measures for HVAC products, but the magnitude of these is likely to be within the range of uncertainty of the overall projections.

[12] WELS is also considered an 'internal' E3 program for double-counting purposes since it targets exactly the same product group (clothes washers and dishwashers) and, through its impact on plumbing fittings, is a major influence on hot water demand.

Interactions with State programs are also uncertain. For example, it is difficult to disaggregate the impacts of E3 lighting measures in the residential sector from those of State-based lamp replacement schemes and other market forces, so an assumption of the lighting energy savings attributable to E3 programs has been made.[13] In many respects, E3 is a 'bedrock' program in that most other appliance energy efficiency programs refer to E3 measures or ratings in some way. This could be through restricting eligibility to products above a defined level of efficiency (e.g. star rating) or scaling cash incentives according to the margin by which the efficiency of a product exceeds the E3 MEPS level. In that respect, E3 can exist and function effectively without those programs (and has, for decades) but not vice versa. Therefore the impact of external programs should be seen as marginal to the impact of E3 programs', rather than the other way round.

Relationship to other Forecasts and Projections

The projections in this report relate only to the impacts of E3 measures which target the energy efficiency of a particular product. The impact of each E3 measure is determined in comparison with the BAU baseline for the energy use of that product. The sum of impacts is therefore the aggregated impact of the E3 program as a whole.

However, this approach does not, by itself, yield the following:

- The *total sector energy use* of the sectors where products targeted by E3 measures are installed. Even in the residential sector, where the coverage of total sector energy use by E3 programs is very high, it is still incomplete. Coverage is much lower in the commercial sector and lower still in the industrial, mining and agricultural sectors (and negligible in the transport sector);
- The *total energy end use* of the entire stock of products in question. For RISs it is only necessary to model the energy use of those appliances that will be purchased after the target implementation date, so the stock-wide estimates of product use are often incomplete; and
- A *direct relationship to sectoral energy use projections made by others* (e.g. AEMO, BREE). As many E3 programs have been in place for years or even decades, their impact has already become evident in actual energy use trends, particularly in residential sector electricity use. A large part of the impact of implemented measures (Category A in Table 4) may well be incorporated in national energy and emissions trajectories already, but the impact of measures in train and new measures (Category C and D) is probably not incorporated. Therefore much of the impact is already factored into the BAU projections of other modellers, and subtracting the total E3 impact again would involve an unknown measure of 'modelling double-count' (as distinct from the 'program double count' discussed above).

Nevertheless, the addition of separate E3 impacts, when standardised to a common forecasting horizon and common energy prices, does logically give an accurate picture of the energy that has been saved and is likely to be saved by the E3 Program.

[13] For example, the total reduction in Australian household lighting energy due to all E3, State and Territory programs targeting the sector, as well as market changes, was estimated at 2,409 GWh p.a. in 2013 (S. Beletich, personal communication). The E3 program contribution to this was estimated at 1,061 GWh.

Projected impacts

Program Classification

For purposes of this analysis, E3 projects have been grouped into four categories:

A. Existing energy labelling and MEPS programs (i.e. where the regulations are already in place);
B. Demand Response projects in train. As the projected impacts are economic benefits from reductions in electricity system peak demand rather than energy savings, these are treated separately;[14]
C. Energy labelling and MEPS projects in train (i.e. where development work has commenced, but the measure has not yet been implemented); and
D. Proposed new projects identified in the E3 2011-14 work plan, but which have yet to commence. This group is the least defined, and is not expected to have any impacts unit 2019 at the earliest,

The impacts of measures already legislated and implemented are in effect 'locked in', except to the extent that product supplier and retailer compliance relies on continuing monitoring and check testing activities. If these are relaxed then it is possible that some of the projected gains will be eroded by growing levels of non-compliance.

The categories are further subdivided into the product classes in Table 2.

Table 2 Product classes

Class	Products included
Whitegoods	*Refrigerators, freezers, dishwashers, clothes washers, clothes dryers*
ICT & Electronics	*Televisions, computers, monitors, home entertainment, EPS, chargers, standby*
Lighting	*All types of lamps, ballasts and ELV transformers*
Power distribution equipment	*Distribution transformers*
Industrial equipment	*Motors and drives*
Water heating	*Electric, heat pump, solar water heaters (a)*
Air conditioning – residential	*Residential air conditioners, portable air conditioners*
Air conditioning – non-residential	*Packaged air conditioners, chillers, close control air conditioners*
Commercial refrigeration	*Open display and cabinet refrigerators, icemakers*
Commercial catering equipment	*Cooktops, fryers, ovens, range-hoods (electric)*
Other – residential	*Swimming pool equipment*
Other – non-residential	*All other products (electric)*
Gas products	*Gas space heaters, water heaters, commercial cooking and industrial equipment*

(a) Impact projections for gas water heaters are included with other gas products.

Impacts

Table 3 summarises the estimated impacts of E3 measures up to the end of 2013. This covers measures for which regulations are already in place (Category A), as well as early impacts of measures under way (Category C). Since 2000, the E3 Program has saved over 314 PJ of energy, which would have cost end users about $15.4 billion (in 2013 dollars). It is estimated that the cost of measures was nearly $5.1 billion over the period, for a net benefit of $10.3 billion at a B/C ratio of 3. Emission reductions from energy savings were 86.8 Mt CO_2-e, at an effective cost of -$119/tonne CO_2-e avoided.

The cost of emissions reductions is negative because the value of energy savings exceeds the program costs. This is different from most modes of renewable energy generation, where there is an additional cost compared with BAU

[14] http://www.energyrating.gov.au/products-themes/demand-response/

rather than a saving, and hence a positive cost per tonne CO_2-e avoided. The costs of E3 measures consist almost entirely of the expected increase in the capital cost of products due to their increase in energy-efficiency above BAU, and extra product testing and development costs. Government administration and check testing account for a very small share of total costs (generally less than 1%), and the cost impact of additional measures is negligible, since the E3 administrative infrastructure is already in place.

Table 3 Estimated impacts, costs and benefits, All E3 Programs, 2000-2013

	Energy unit	Energy saved 2013	Energy saved 2000-13	PV of Benefits $M (a)	PV of Costs $M (a)	NPV Net benefit $M (a)	Benefit/ cost ratio	Mt CO_2-e saved 2013	Mt CO_2-e saved 2000-13	$/tonne CO_2-e saved
Electricity	*GWh*	*13,786*	*85,696*							
	PJ	*49.6*	*308.5*	*$15,228*	*$4,936*	*$10,292*	*3.1*	*13.4*	*86.4*	*-$ 119*
Gas	*PJ*	*1.6*	*6.1*	*$147*	*$129*	*$18*	*1.1*	*0.1*	*0.4*	*-$ 49*
Total	*PJ*	*51.3*	*314.4*	*$15,375*	*$5,065*	*$10,310*	*3.0*	*13.5*	*86.8*	*-$ 119*

(a) 2013 $, Undiscounted.

Table 4 projects the impacts of E3 measures over the period 2014-2030. The energy impacts of programs targeting electricity and natural gas use are shown separately, in their customary units (GWh and PJ respectively) and then in a common unit (PJ).[15] Table 4 indicates that:

- The E3 Program is projected to save about 546 PJ of end-use energy between 2014 and 2020, and 2,021 PJ of end-use energy between 2014 and 2030, of which about 92% is electricity;
- The present value of the projected net benefits of E3 measures is about $57.4 billion (over the period 2014-30, at 7% discount rate);
- The overall benefit cost ratio of the program is about 4.6 (4.5 for energy efficiency measures);
- The E3 Program is projected to avoid about 129 million tonnes of CO_2-e between 2014 and 2020, and 433 million tonnes of CO_2-e between 2014 and 2030, of which about 98% is from electricity use;
- For those measures targeting energy efficiency use, and hence also impacting on emissions, the effective cost per tonne avoided is -$118. The emissions savings are at *negative* cost because the measures are cost-effective in their own right;
- About 14% of the emissions savings to 2030 (60.1 Mt CO2-e) come from measures in train (Category C);
- About 4.5% of the emissions savings to 2030 (19.6 Mt CO_2-e) come from new measures (Category D);
- Demand response (Category B) accounts for about 47% of the net benefit of measures in train and new.

Table 5 indicates the effects of more rapid implementation of the new measures for which preliminary estimates have been made. If the rate of implementation were doubled (see Figure 8), the projected energy saved from 2014 to 2030 would be 102 PJ greater (2,123 PJ rather than 2,021 PJ), NPV of net benefits would increase by $1.5 billion, from $57.4 to $58.8 billion, and greenhouse emissions in 2030 would be lower by 2.6 Mt CO_2-e (37.0 rather than 34.4 Mt CO_2-e).

For Category B Demand Response, the costs are related to the provision of demand response interfaces in new air conditioners and other selected products, and the costs of connecting a proportion of those products to the communications systems of energy utilities, demand response aggregators and other third parties. The benefits come from reducing the projected growth in peak demand on the electricity network. It is estimated that the reduction in summer peak demand in the National Electricity Market region alone will be in the range 890 to 2,370 MW, equivalent to 12% to 31% of the total projected growth in summer peak demand from 2013 to 2029 (E3 2014).

Table 6 gives details of the projected impact of each of the E3 programs currently in train. Commercial refrigeration, gas space heaters, gas water heaters, non-residential air conditioning and residential refrigeration offer the largest potential energy savings. Commercial refrigeration, residential refrigeration and standby offer the highest net monetary benefits. The relative contribution of each product is illustrated in Figure 15.

[15] It is estimated that over 95% of gas saved will be natural gas, but household gas appliance efficiency measures also impact consumption of liquefied petroleum gas (LPG) in areas not served by the natural gas grid. As LPG prices exceed natural gas prices, the value of savings will be slightly higher than indicated.

Table 7 details the impact estimates for those new programs that have been quantified to some extent. Only energy savings estimates are available, but these are sufficient to allow calculation of energy cost savings (i.e. benefits) and the associated reduction in emissions. In order to estimate the impacts on product costs, it is assumed that each program will have an ultimate benefit/cost ratio of 3.0, slightly less than the average for MEPS and energy labelling programs in train (3.1). Electric industrial process equipment accounts for the largest share of projected savings, followed by commercial refrigeration and commercial catering. The relative contribution of each product is illustrated in Figure 16.

Figure 4 illustrates the projected reductions in delivered energy use below BAU attributable to all E3 Programs in each year over the period 2000-30. The programs are grouped in the classes in Table 2. Energy savings are projected to reach nearly 174 PJ per annum by 2030. Figure 5 groups the energy reductions by products for which regulations are already in place, projects in train, and new projects. Each of these groups is further broken down by product classes in Figure 6, Figure 7, and Figure 8 respectively. (Note that the Figure 7 and Figure 8 are shown to a larger vertical scale to reveal more detail.) Figure 8 indicates the increase in energy savings possible from doubling the rate of new project implementation (see Table 7).

Figure 9 illustrates annual costs compared with BAU for all energy labelling and MEPS programs (i.e. excluding Category B Demand Response). Figure 10 shows the annual value of energy saved, and Figure 11 the net annual benefit. (All are on the same vertical scale and expressed in constant 2013 dollars; the kink at 2014 in Figure 10 and Figure 11 illustrate the effect of removal of the carbon price, which was in place during 2012/13 and 2013/14). The present value (PV) of these streams of costs and savings, at a 7% discount rate, produce the costs, benefits and net benefits in Table 4 ($14.8 billion, $66.0 billion, and $51.2 billion respectively).

The cumulative build-up of electricity and gas energy savings after 2013 are illustrated in Figure 12, and the build-up of emissions savings is shown in Figure 14. Figure 13 projects that the annual net savings after 2014 will accumulate to over $101 billion by 2030.[16]

The projected annual emission reductions for all E3 programs, in total and classified by measures already regulated, projects in train and new projects, are illustrated in Figure 17 to Figure 21.

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[16] Note that the *undiscounted* accumulation of annual net savings to 2030 is $101 billion. The discounted NPV of the same stream of net savings is $51.2 billion (see Table 4). The NPV of the net savings from Demand Response programs is an additional $6.2 billion.

Table 4 Projected impacts, costs and benefits, All E3 Programs, 2014 – 2030

Category of projects		Energy unit	Energy saved 2020	Energy saved 2030	Energy saved 2014-20	Energy saved 2014-30	PV of benefits $M (a)	PV of costs $M (a)	NPV Net benefit $M (a)	Benefit/ cost ratio	Mt CO_2-e saved 2020	Mt CO2-e saved 2030	Mt CO2-e saved 2014-20	Mt CO_2-e saved 2014-30	$/tonne CO_2-e saved
A. MEPS & labelling - regulations in place	*Electricity*	*GWh*	*23,811*	*32,404*	*136,246*	*424,112*									
		PJ	*85.7*	*116.7*	*490.5*	*1,526.8*	*$54,700*	*$11,400*	*$43,300*	*4.8*	*20.0*	*24.8*	*120.6*	*349.6*	*-$124*
	Gas	*PJ*	*4.1*	*5.3*	*20.9*	*68.5*	*$1,059*	*$72*	*$987*	*NA(c)*	*0.2*	*0.3*	*1.2*	*4.1*	*NA*
	Total	*PJ*	*89.8*	*121.9*	*511.4*	*1,595.3*	*$55,759*	*$11,472*	*$44,287*	*4.9*	*20.2*	*25.1*	*121.9*	*353.7*	*-$125*
B. Demand response – projects in train			*NA (b)*	*NA (b)*	*NA(b)*	*NA(b)*	*$7,238*	*$1,014*	*$6,224*	*7.1*	*NA(b)*	*NA(b)*	*NA(b)*	*NA(b)*	*NA(b)*
C. MEPS & labelling - projects in train	*Electricity*	*GWh*	*2,825*	*8,001*	*6,932*	*69,816*									
		PJ	*10.2*	*28.8*	*25.0*	*251.3*	*$7,056*	*$2,336*	*$4,720*	*3.0*	*2.4*	*6.1*	*5.9*	*55.7*	*-$85*
	Gas	*PJ*	*2.7*	*9.2*	*6.0*	*72.8*	*$959*	*$262*	*$698*	*3.7*	*0.2*	*0.5*	*0.4*	*4.3*	*-$161*
	Total	*PJ*	*12.8*	*38.0*	*31.0*	*324.2*	*$8,016*	*$2,598*	*$5,417*	*3.1*	*2.5*	*6.7*	*6.3*	*60.1*	*-$90*
D. MEPS & labelling - new projects (d)	*Electricity*	*GWh*	*622*	*3,288*	*930*	*23,361*									
		PJ	*2.2*	*11.8*	*3.3*	*84.1*	*$2,118*	*$706*	*$1,412*	*3.0*	*0.5*	*2.5*	*0.8*	*18.5*	*-$76*
	Gas	*PJ*	*0.6*	*2.1*	*0.8*	*17.8*	*$133*	*$44*	*$89*	*3.0*	*0.0*	*0.1*	*0.0*	*1.1*	*-$84*
	Total	*PJ*	*2.8*	*13.9*	*4.2*	*101.9*	*$2,252*	*$751*	*$1,501*	*3.0*	*0.6*	*2.6*	*0.8*	*19.6*	*-$77*
Total E3 Program	*Electricity*	*GWh*	*27,259*	*43,693*	*144,108*	*517,289*									
		PJ	*98.1*	*157.3*	*518.8*	*1,862.2*	*$71,113*	*$15,457*	*$55,656*	*4.6*	*22.9*	*33.4*	*127.3*	*423.9*	*-$131*
	Gas	*PJ*	*7.3*	*16.5*	*27.8*	*159.2*	*$2,152*	*$378*	*$1,774*	*5.7*	*0.4*	*1.0*	*1.6*	*9.5*	*-$188*
	Total	*PJ*	*105.4*	*173.8*	*546.6*	*2,021.4*	*$73,265*	*$15,835*	*$57,430*	*4.6*	*23.3*	*34.4*	*129.0*	*433.3*	*-$133*
MEPS & labelling projects only	*Total*	*PJ*	*105.4*	*173.8*	*546.6*	*2,021.4*	*$66,027*	*$14,821*	*$51,206*	*4.5*	*23.3*	*34.4*	*129.0*	*433.3*	*-$118*

(a) 2013 $, 7% discount rate (b) Impact is on electricity distribution, transmission and generation infrastructure (c) Energy benefit from WELS program; costs not accounted to E3. (d) At scheduled implementation rate. All estimates at upper bound of cost-effectiveness.

Table 5 Projected impacts, costs and benefits, New E3 Programs, 2014 – 2030

Category of projects		Energy unit	Energy saved 2020	Energy saved 2030	Energy saved 2014-20	Energy saved 2014-30	PV of benefits $M (a)	PV of costs $M (a)	NPV net benefit $M (a)	Benefit/ cost ratio	Mt CO_2-e saved 2020	Mt CO_2-e saved 2030	Mt CO2-e saved 2014-20	Mt CO_2-e saved 2014-30	$/tonne CO_2-e saved
NEW PROJECTS – SCHEDULED RATE OF IMPLEMENTATION															
D. MEPS & labelling - new projects	*Electricity*	*PJ*	*2.2*	*11.8*	*3.3*	*84.1*	*$2,118*	*$706*	*$1,412*	*3.0*	*0.5*	*2.5*	*0.8*	*18.5*	*-$76*
	Gas	*PJ*	*0.6*	*2.1*	*0.8*	*17.8*	*$133*	*$44*	*$89*	*3.0*	*0.0*	*0.1*	*0.0*	*1.1*	*-$84*
	Total	*PJ*	*2.8*	*13.9*	*4.2*	*101.9*	*$2,252*	*$751*	*$1,501*	*3.0*	*0.6*	*2.6*	*0.8*	*19.6*	*-$77*
Total E3 Program	*Electricity*	*PJ*	*98.1*	*157.3*	*518.8*	*1,862.2*	*$71,113*	*$15,457*	*$55,656*	*4.6*	*22.9*	*33.4*	*127.3*	*423.9*	*-$131*
	Gas	*PJ*	*7.3*	*16.5*	*27.8*	*159.2*	*$2,152*	*$378*	*$1,774*	*5.7*	*0.4*	*1.0*	*1.6*	*9.5*	*-$188*
	Total	*PJ*	*105.4*	*173.8*	*546.6*	*2,021.4*	*$73,265*	*$15,835*	*$57,430*	*4.6*	*23.3*	*34.4*	*129.0*	*433.3*	*-$133*
MEPS & labelling only		*PJ*	*105.4*	*173.8*	*546.6*	*2,021.4*	*$66,027*	*$14,821*	*$51,206*	*4.5*	*23.3*	*34.4*	*129.0*	*433.3*	*-$118*
Gas share. MEPS & Labelling			*6.9%*	*9.5%*	*5.1%*	*7.9%*	*3.3%*	*2.6%*	*3.5%*		*1.9%*	*2.9%*	*1.3%*	*2.2%*	
NEW PROJECTS – MORE RAPID IMPLEMENTATION (a)															
D. MEPS & labelling - new projects	*Electricity*	*PJ*	*4.5*	*23.7*	*6.7*	*168.2*	*$4,237*	*$1,412*	*$2,825*	*3.0*	*1.0*	*5.0*	*1.6*	*37.0*	*-$76*
	Gas	*PJ*	*1.1*	*4.1*	*1.7*	*35.7*	*$267*	*$89*	*$178*	*3.0*	*0.1*	*0.2*	*0.1*	*2.1*	*-$84*
	Total	*PJ*	*5.6*	*27.8*	*8.4*	*203.9*	*$4,504*	*$1,501*	*$3,003*	*3.0*	*1.1*	*5.3*	*1.7*	*39.1*	*-$77*
Total E3 Program	*Electricity*	*PJ*	*100.4*	*169.1*	*522.1*	*1,946.3*	*$73,231*	*$16,163*	*$57,069*	*4.5*	*23.4*	*35.9*	*128.1*	*442.4*	*-$129*
	Gas	*PJ*	*7.8*	*18.6*	*28.6*	*177.0*	*$2,285*	*$423*	*$1,863*	*5.4*	*0.5*	*1.1*	*1.7*	*10.5*	*-$177*
	Total	*PJ*	*108.2*	*187.7*	*550.7*	*2,123.4*	*$75,517*	*$16,586*	*$58,931*	*4.6*	*23.9*	*37.0*	*129.8*	*452.9*	*-$130*
MEPS & labelling only		*PJ*	*108.2*	*187.7*	*550.7*	*2,123.4*	*$68,279*	*$15,571*	*$52,707*	*4.4*	*23.9*	*37.0*	*129.8*	*452.9*	*-$116*
Gas share. MEPS & Labelling			*7.2%*	*9.9%*	*5.2%*	*8.3%*	*3.3%*	*2.7%*	*3.5%*		*1.9%*	*3.0%*	*1.3%*	*2.3%*	
POTENTIAL INCREASE IN IMPACT FROM MORE RAPID IMPLEMENTATION															
D. MEPS & labelling - new projects	*Electricity*	*PJ*	*2.2*	*11.8*	*3.3*	*84.1*	*$2,118*	*$706*	*$1,412*	*0.0*	*0.5*	*2.5*	*0.8*	*18.5*	*0*
	Gas	*PJ*	*0.6*	*2.1*	*0.8*	*17.8*	*$133*	*$44*	*$89*	*0.0*	*0.0*	*0.1*	*0.0*	*1.1*	*0*
	Total	*PJ*	*2.8*	*13.9*	*4.2*	*101.9*	*$2,252*	*$751*	*$1,501*	*0.0*	*0.6*	*2.6*	*0.8*	*19.6*	*0*
Total E3 Program	*Electricity*	*PJ*	*2.2*	*11.8*	*3.3*	*84.1*	*$2,118*	*$706*	*$1,412*	*-0.1*	*0.5*	*2.5*	*0.8*	*18.5*	*$2*
	Gas	*PJ*	*0.6*	*2.1*	*0.8*	*17.8*	*$133*	*$44*	*$89*	*-0.3*	*0.0*	*0.1*	*0.0*	*1.1*	*$10*
	Total	*PJ*	*2.8*	*13.9*	*4.2*	*101.9*	*$2,252*	*$751*	*$1,501*	*-0.1*	*0.6*	*2.6*	*0.8*	*19.6*	*$2*
MEPS & labelling only		*PJ*	*2.8*	*13.9*	*4.2*	*101.9*	*$2,252*	*$751*	*$1,501*	*-0.1*	*0.6*	*2.6*	*0.8*	*19.6*	*$2*
Gas share. MEPS & Labelling			*-1.1%*	*0.3%*	*0.4%*	*0.1%*	*0.5%*	*0.1%*	*0.2%*	*0.1%*	*0%*	*0.1%*	*0.1%*	*0.0%*	*0.1%*

(a) See Figure 8

Table 6 Projected impacts, costs and benefits, E3 Programs in Train, 2014 – 2030

Product	Energy saved 2020 PJ	Energy saved 2030 PJ	Energy saved 2014-20 PJ	Energy saved 2014-30 PJ	NPV Benefits $M (a)	NPV Costs $M (a)

Table 7 Projected impacts, costs and benefits, New E3 Programs, 2014 – 2030 (Scheduled implementation rate)

Product	Energy saved 2020 PJ	Energy saved 2030 PJ	Energy saved 2014-20 PJ	Energy saved 2014-30 PJ	NPV Benefits $M (a)	NPV Costs $M (a)	NPV Net benefit $M (a)	Benefit/ cost ratio	kt CO_2-e saved 2020	kt CO_2-e saved 2030	kt CO_2-e saved 2014-20	kt CO_2-e saved 2014-30	$/tonne CO_2-e saved
Comm. ref compressors	*0.3*	*2.2*	*0.5*	*13.6*	*$338*	*$113*	*$225*	*3.0*	*77*	*462*	*115*	*2997*	*-75*
Self-contained food-service	*0.2*	*1.9*	*0.3*	*10.3*	*$249*	*$83*	*$166*	*3.0*	*49*	*413*	*73*	*2257*	*-73*
Comm. ref products	*0.4*	*2.4*	*0.6*	*16.2*	*$406*	*$135*	*$271*	*3.0*	*98*	*500*	*148*	*3565*	*-76*
Process & indust. eqip. - elec	*0.6*	*2.5*	*0.9*	*20.8*	*$534*	*$178*	*$356*	*3.0*	*143*	*531*	*214*	*4590*	*-78*
Process & indust. eqip. - gas	*0.4*	*1.5*	*0.6*	*12.7*	*$83*	*$28*	*$55*	*3.0*	*23*	*87*	*35*	*753*	*-73*
Comm. catering - gas	*0.2*	*0.6*	*0.2*	*5.1*	*$51*	*$17*	*$34*	*3.0*	*10*	*35*	*14*	*306*	*-110*
Comm. catering - elec	*0.4*	*1.6*	*0.6*	*13.4*	*$343*	*$114*	*$229*	*3.0*	*92*	*342*	*138*	*2954*	*-78*
Comm. electronics & lighting	*0.3*	*1.3*	*0.4*	*9.8*	*$249*	*$83*	*$166*	*3.0*	*64*	*268*	*96*	*2153*	*-77*
Total	*2.8*	*13.9*	*4.2*	*101.9*	*$2,252*	*$751*	*$1,501*	*3.0*	*555*	*2638*	*833*	*19574*	*-77*

(a) 2013 $, 7% discount rate.

Figure 4 Projected delivered energy savings 2000–2030, by main product groups

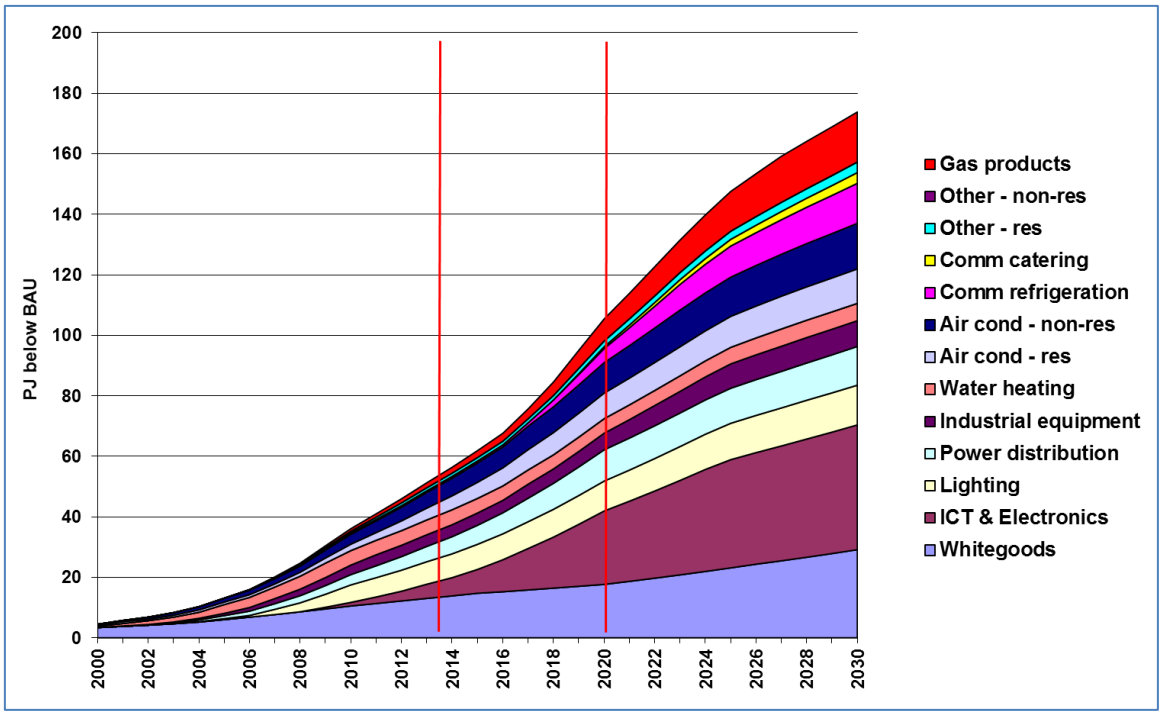


Figure 5 Projected delivered energy savings 2000–2030, by project category

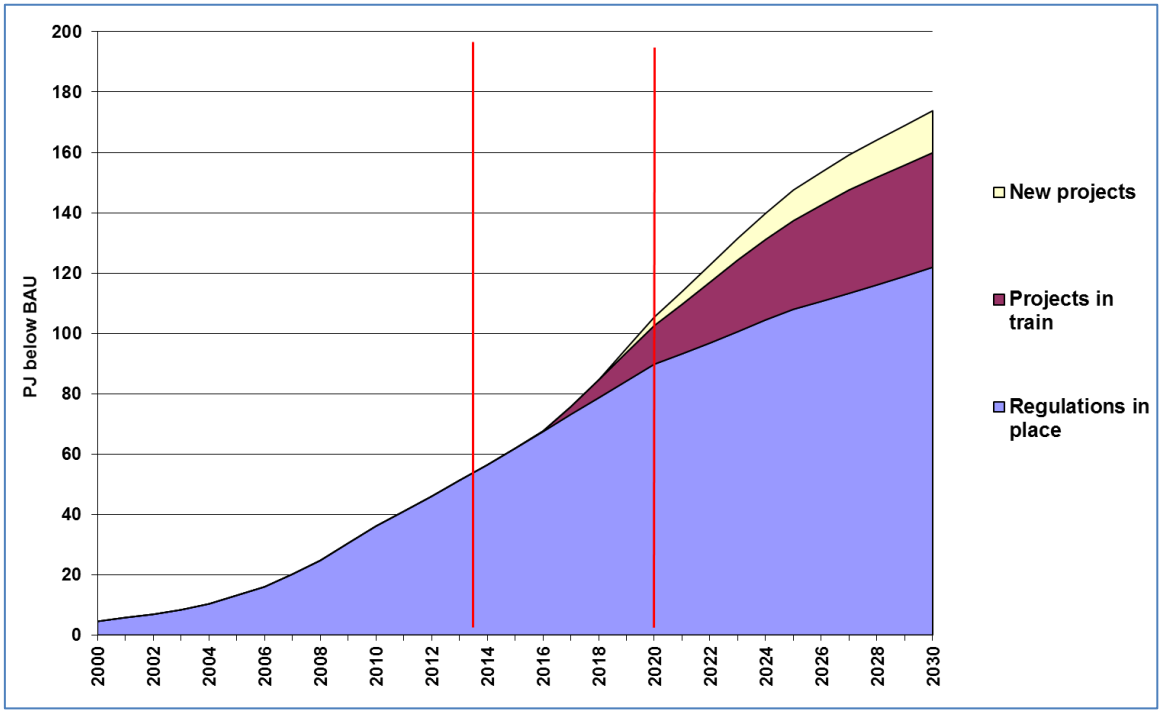


Figure 6 Projected delivered energy savings 2000–2030 for projects implemented, by main product group

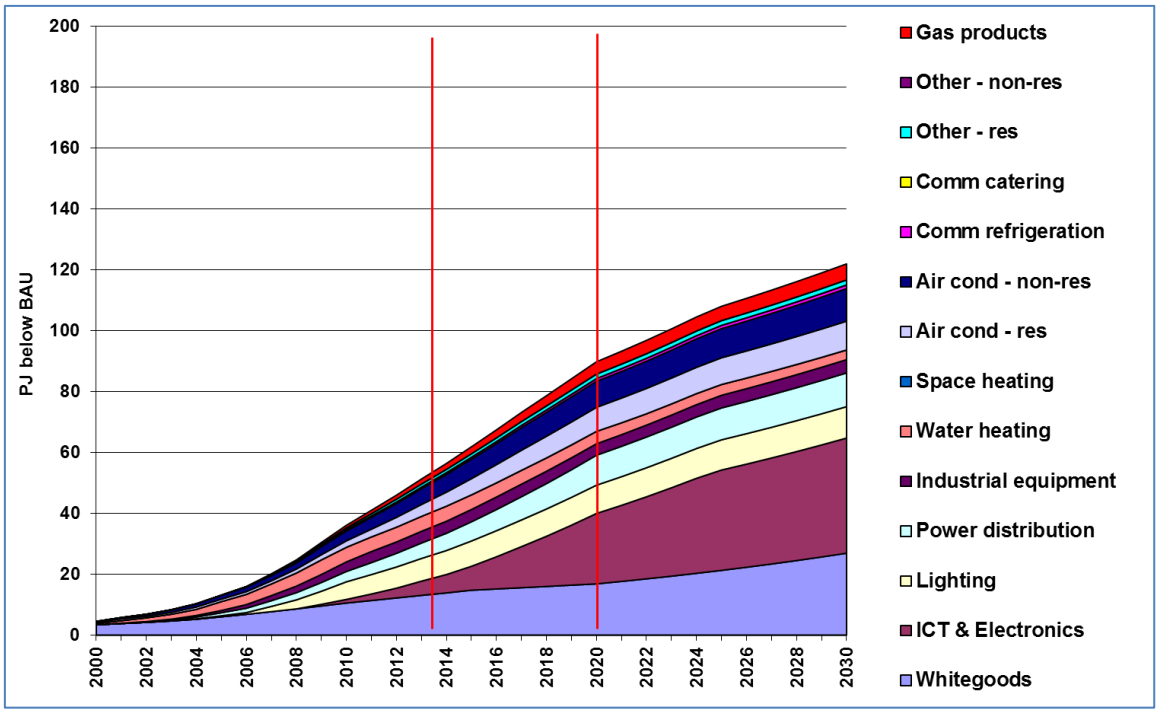


Figure 7 Projected energy savings to 2030, projects in train

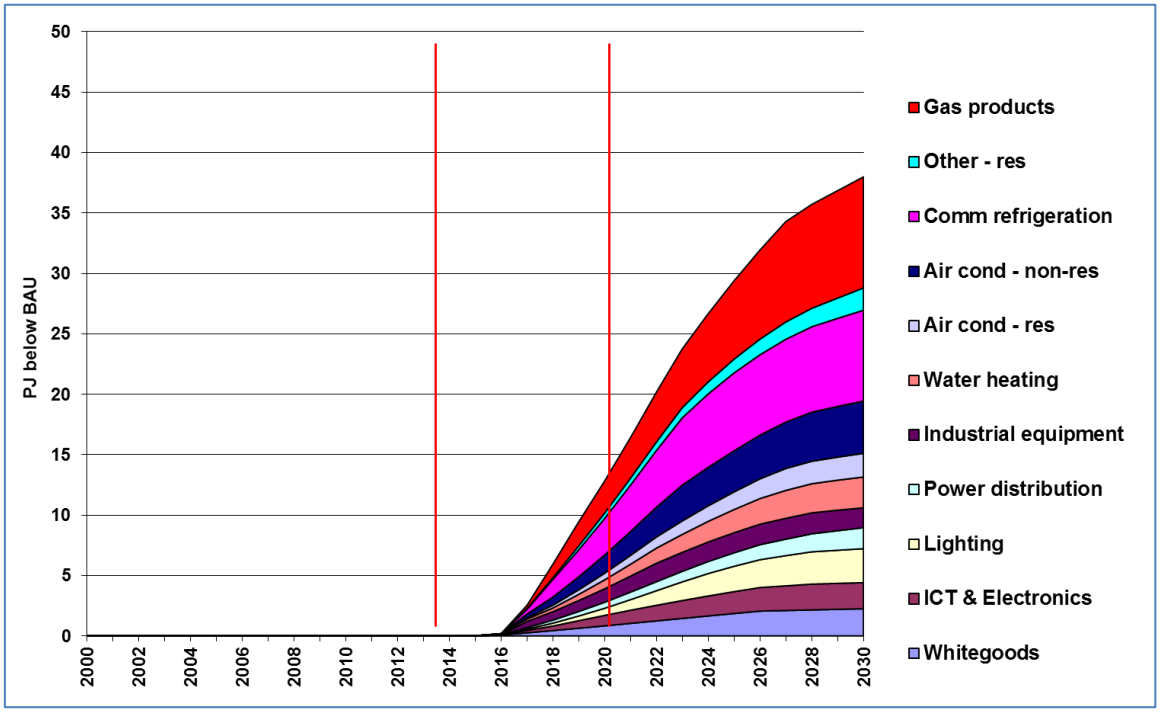


Figure 8 Projected energy savings to 2030, new projects

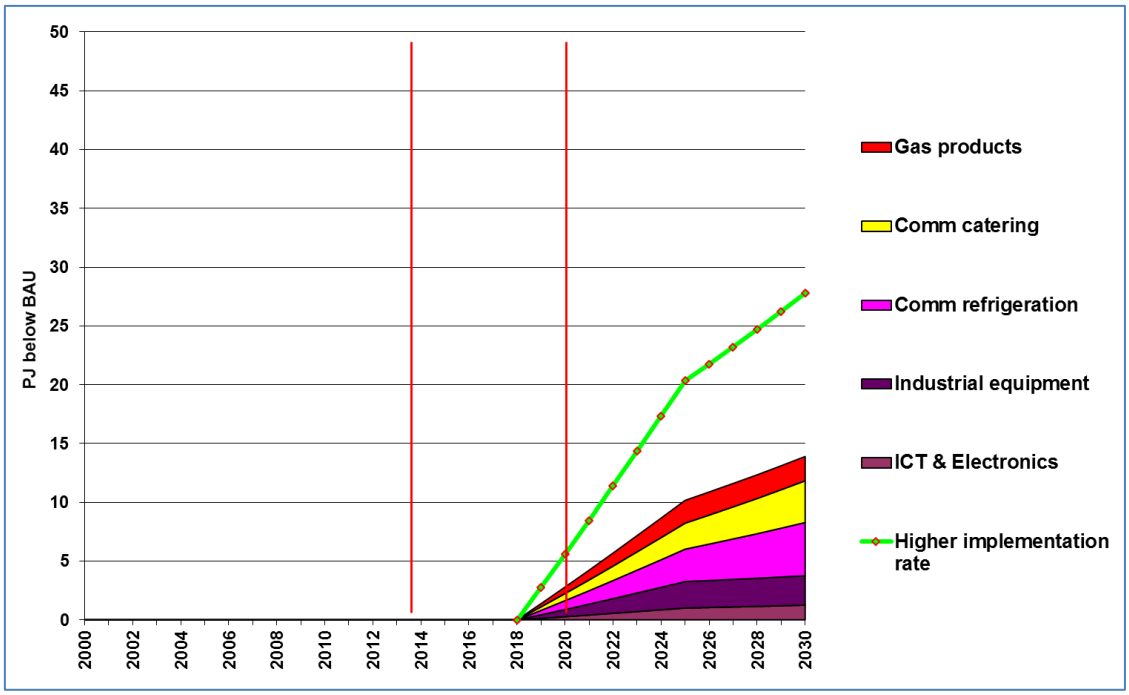
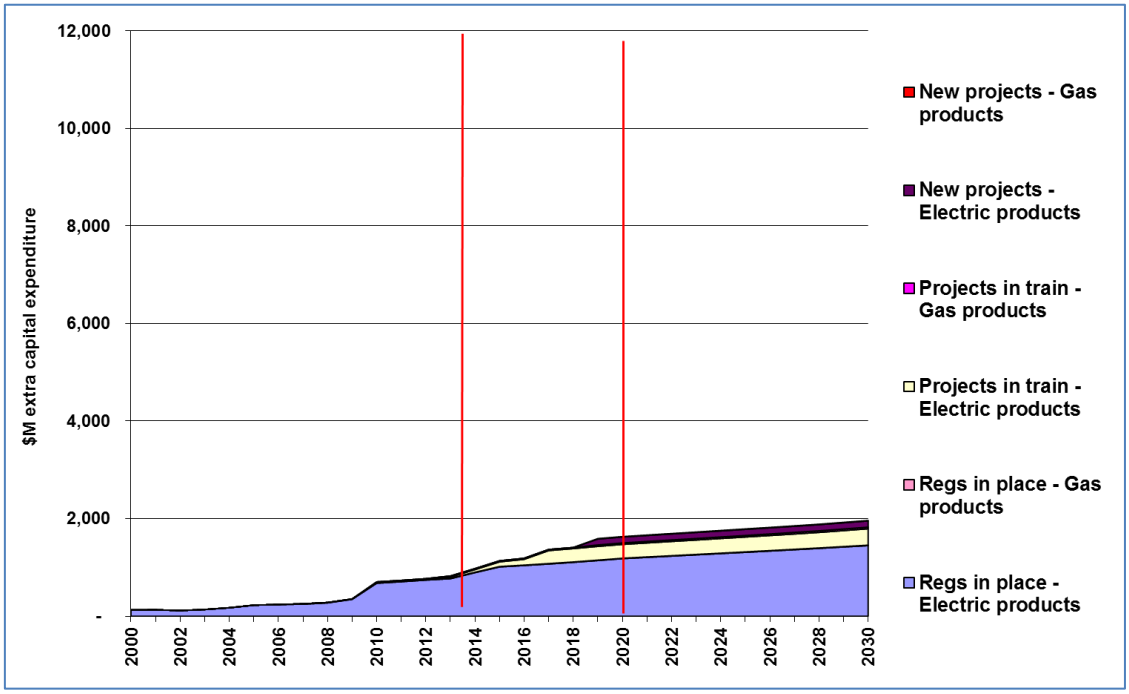
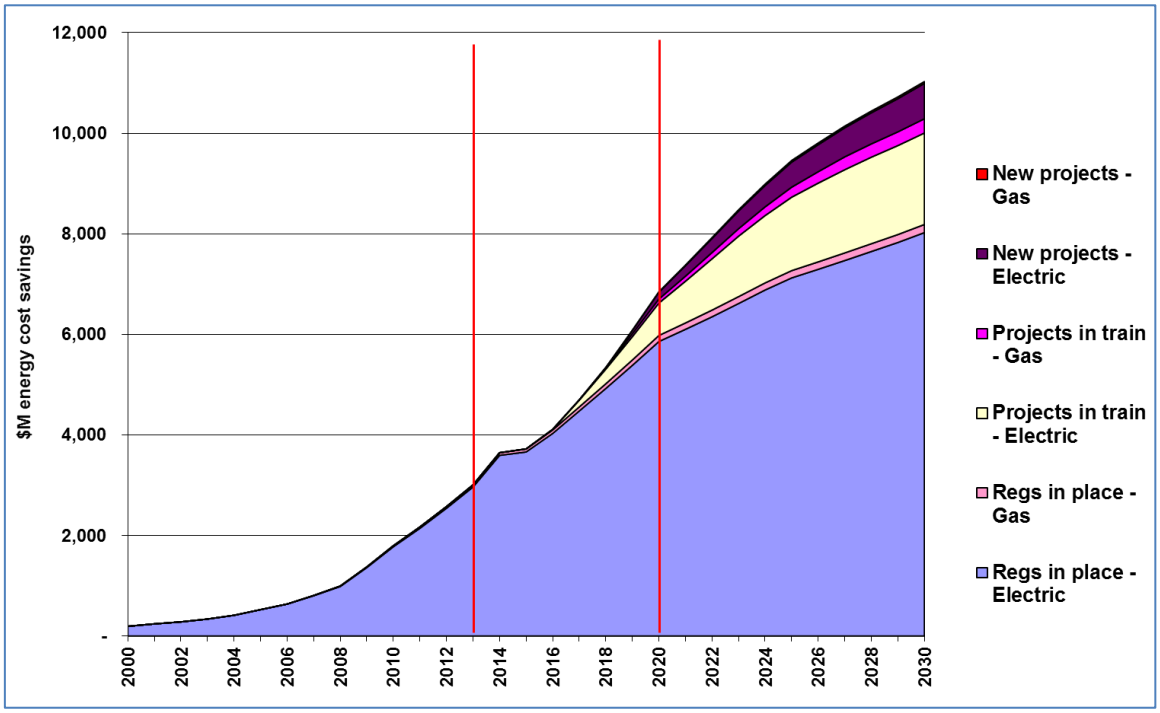


Figure 9 Projected annual cost increases 2000–2030 due to all E3 programs



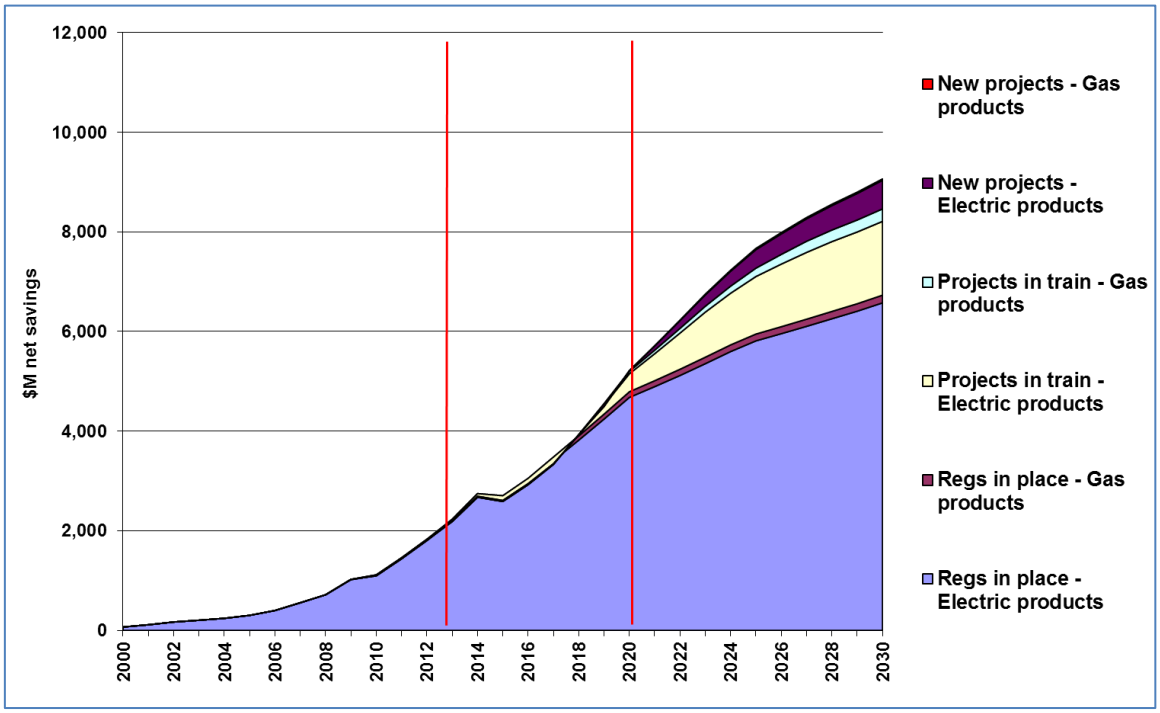
All values 2013 $

Figure 10 Projected annual energy cost savings 2000–2030 due to all E3 programs



All values 2013 $

Figure 11 Projected net annual cost savings, 2000–2030 due to all E3 programs



All values 2013 $

Figure 12 Cumulative energy savings 2014–2030, all E3 MEPS and labelling programs

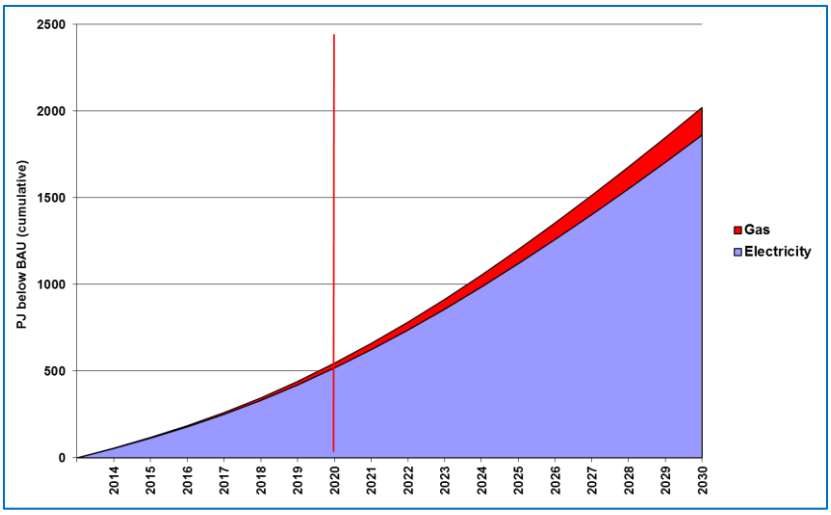


Figure 13 Cumulative net benefits 2014-2030, all E3 MEPS and labelling programs

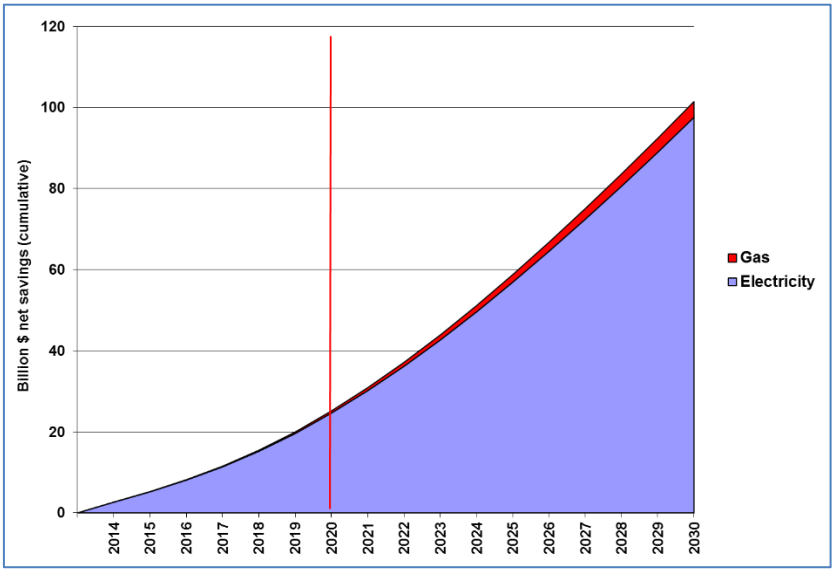


Figure 14 Cumulative emission savings 2014–2030, all E3 MEPS and labelling programs

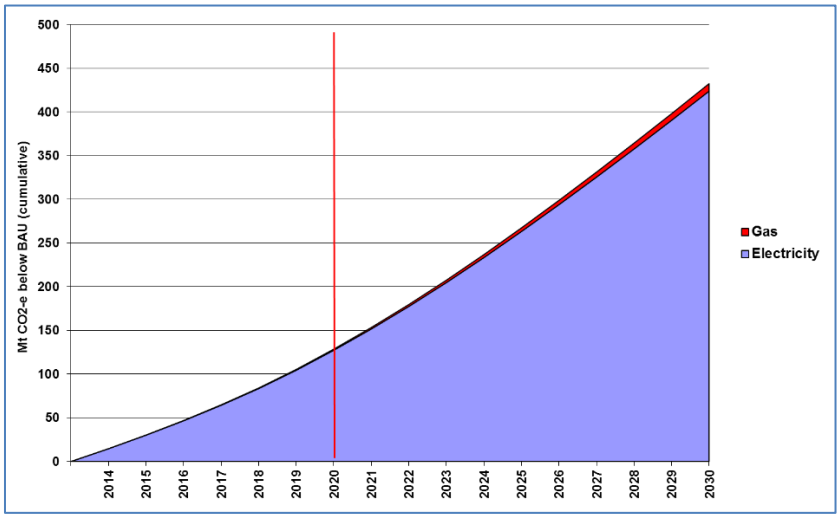


Figure 15 Detailed energy savings by product, 2013–2030, E3 programs in train

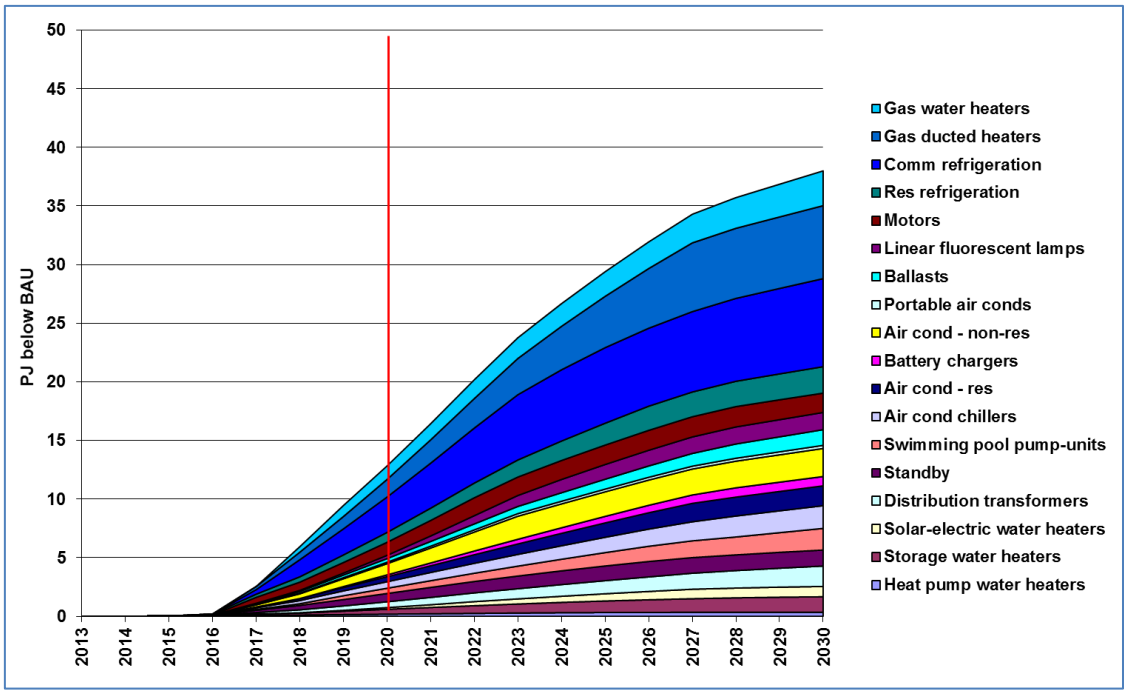


Figure 16 Detailed energy savings by product, 2013–2030, new E3 programs

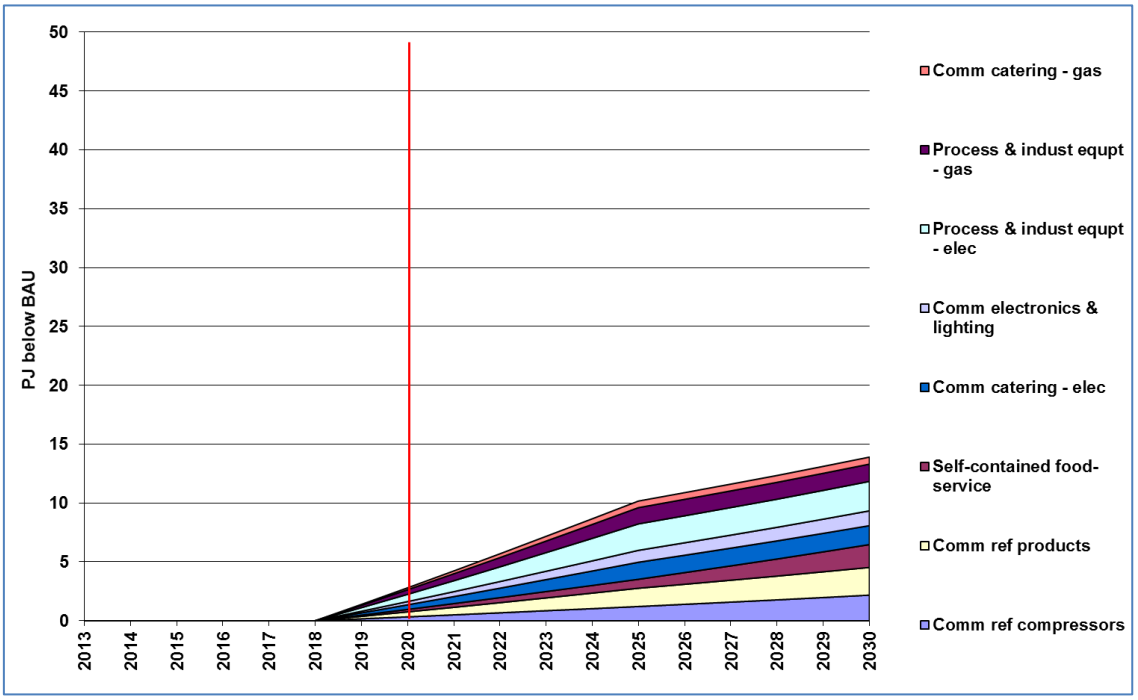


Figure 17 Projected emission savings, by main product group, 2000–2030

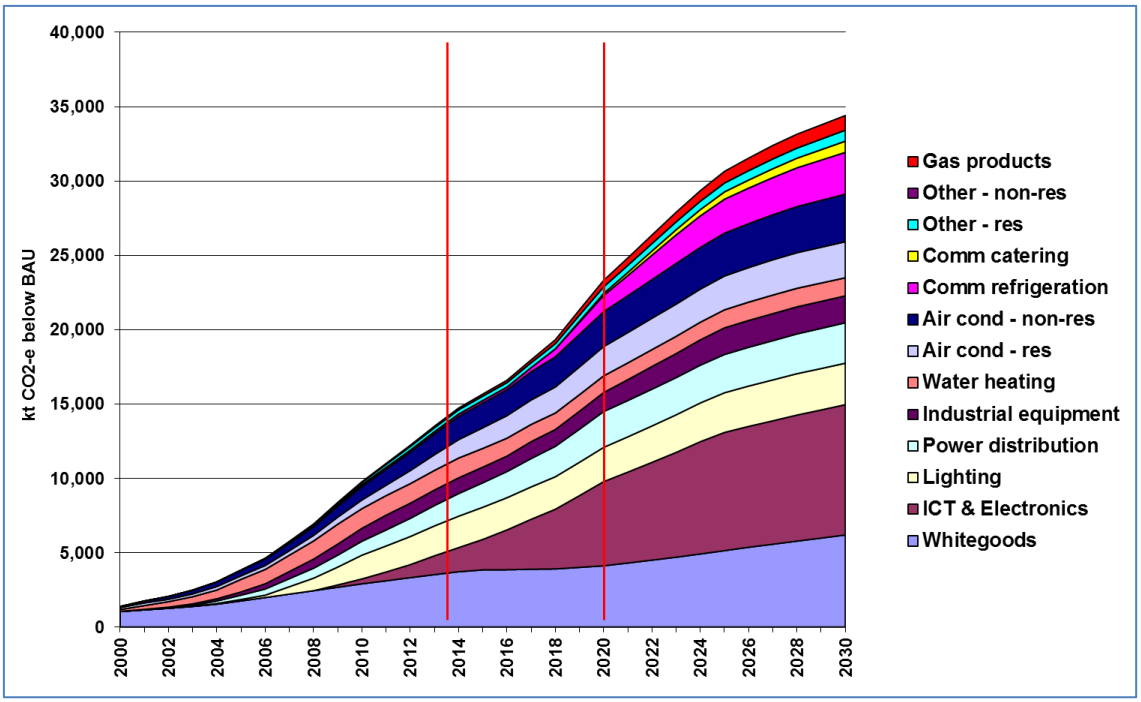


Figure 18 Projected emission savings 2000–2030, by project category

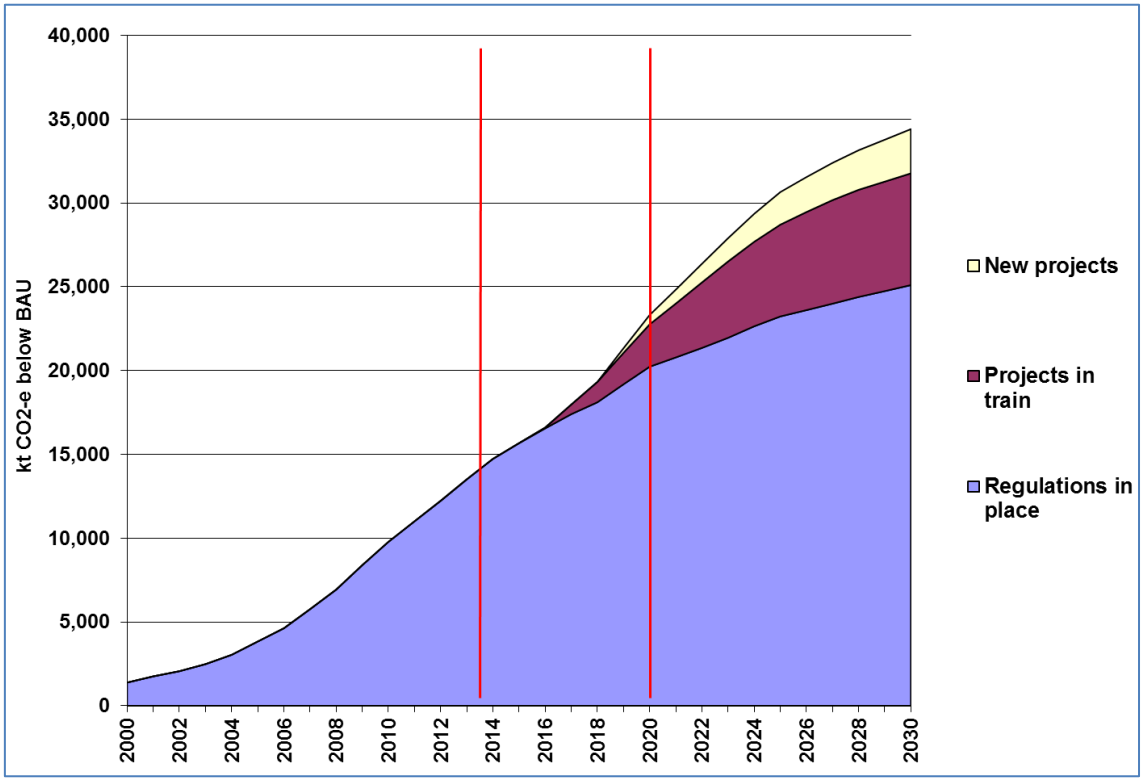


Figure 19 Projected emission savings 2000–2030, projects implemented

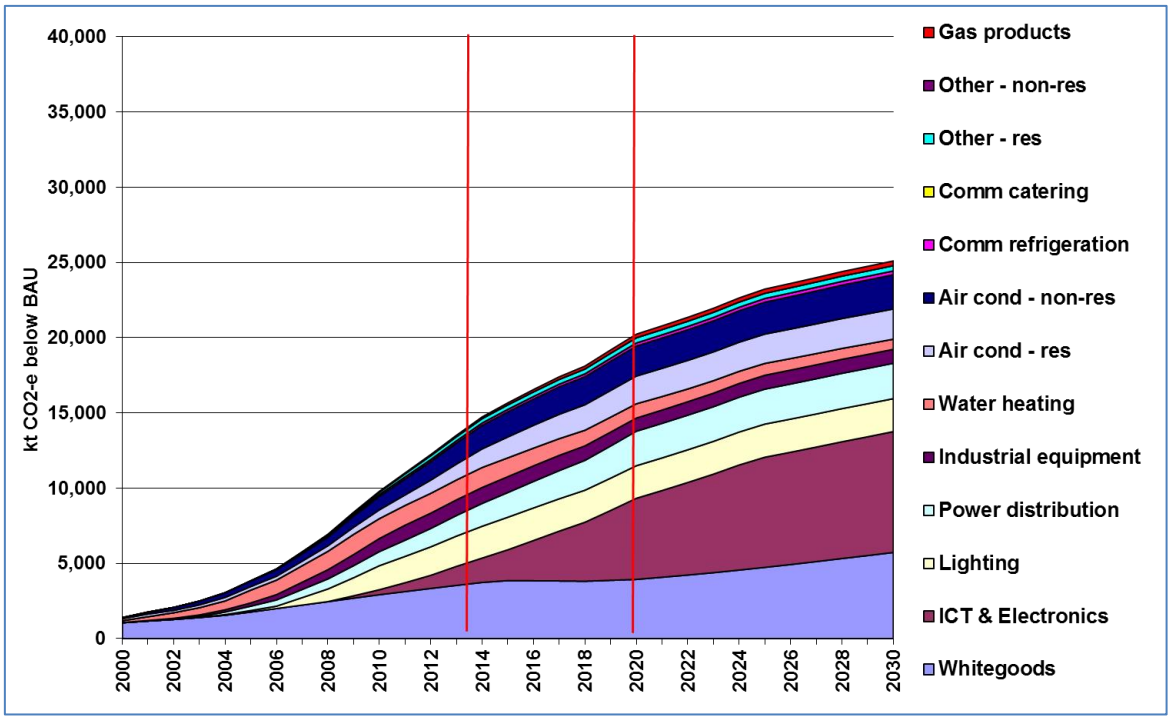


Figure 20 Projected emission savings 2000–2030, projects in train

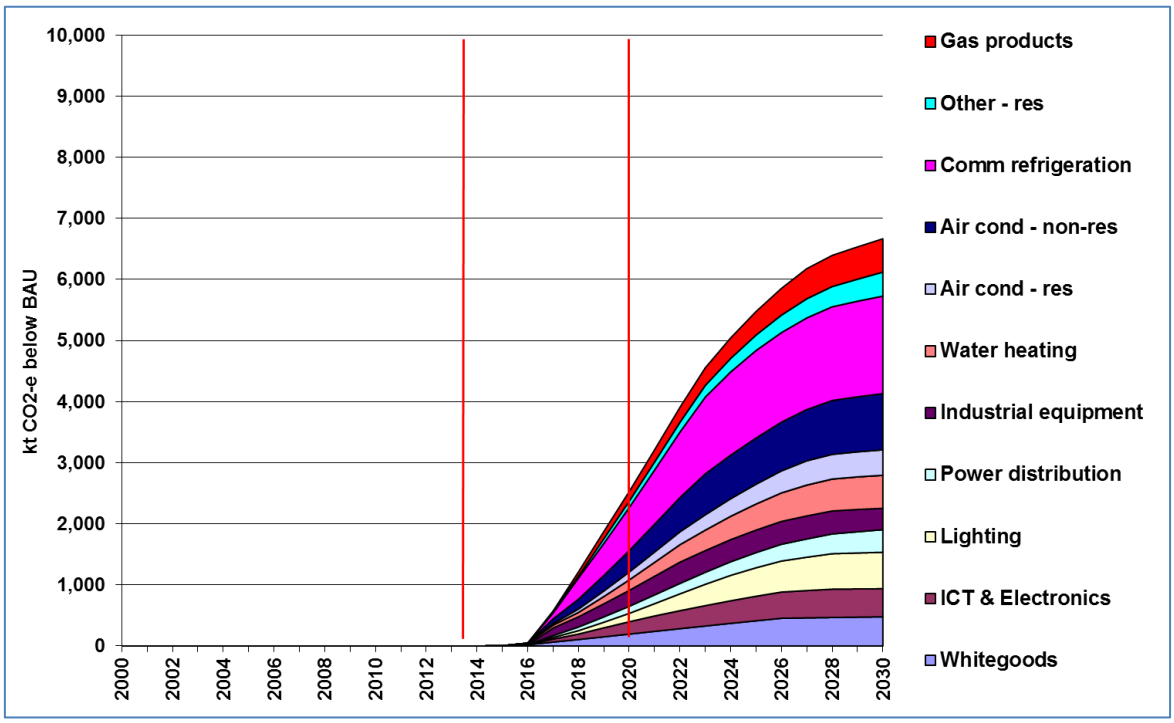
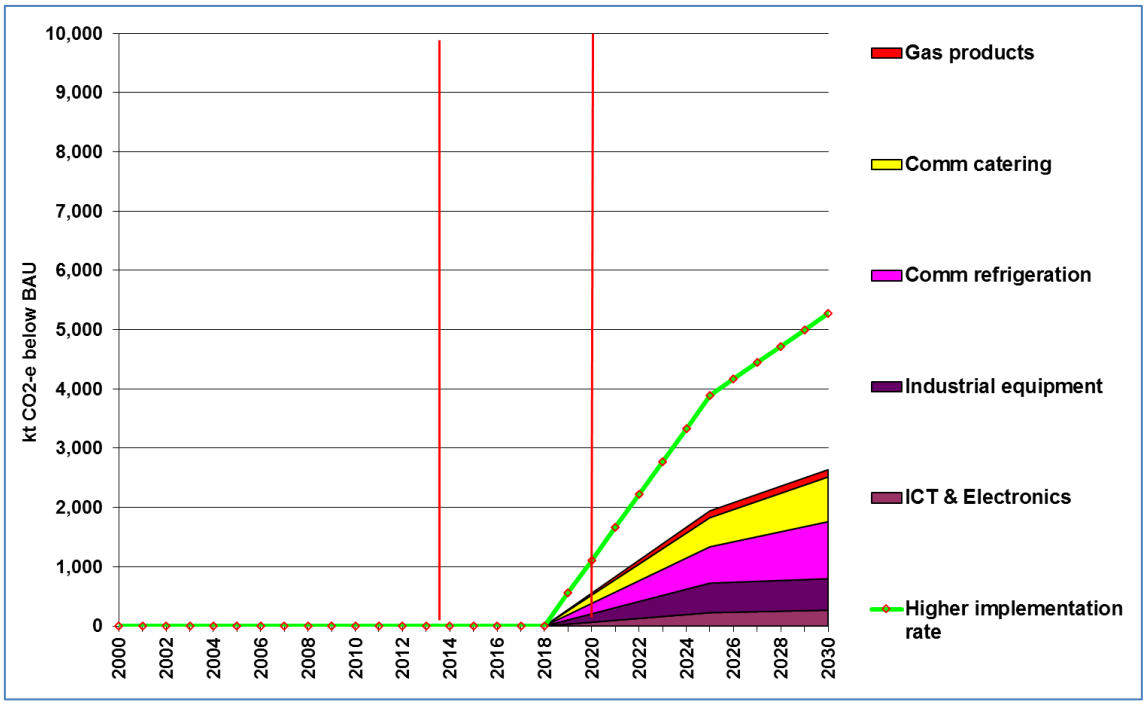


Figure 21 Projected emission savings 2000–2030, new projects (scheduled implementation rate)



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