

---

# Pathways for improving the energy-related performance of residential buildings

---

*A report prepared  
for the Department of Sustainability & Environment*

*July 2009*

**Marsden Jacob**  
*A s s o c i a t e s*

<http://www.marsdenjacob.com.au>

**Marsden Jacob Associates**  
Financial & Economic Consultants

ABN 66 663 324 657  
ACN 072 233 204

Internet: <http://www.marsdenjacob.com.au>  
E-mail: [economists@marsdenjacob.com.au](mailto:economists@marsdenjacob.com.au)

Melbourne office:  
Postal address: Level 3, 683 Burke Road, Camberwell  
Victoria 3124 AUSTRALIA  
Telephone: +61 (0) 3 9882 1600  
Facsimile: +61 (0) 3 9882 1300

Brisbane office:  
Level 5, 100 Eagle St, Brisbane  
Queensland, 4000 AUSTRALIA  
Telephone: +61 (0) 7 3229 7701  
Facsimile: +61 (0) 7 3229 7944

Perth office:  
Level 6, 731 Hay Street, Perth  
Western Australia, 6000 AUSTRALIA  
Telephone: +61 (0) 8 9324 1785  
Facsimile: +61 (0) 8 9324 1751

This report may be cited as: *Pathways for improving the energy-related performance of residential buildings*,  
Marsden Jacob Associates 2009

This report has been prepared in accordance with the scope of services described in the contract or agreement between Marsden Jacob Associates Pty Ltd ACN 072 233 204 (MJA) and the Client. Any findings, conclusions or recommendations only apply to the aforementioned circumstances and no greater reliance should be assumed or drawn by the Client. Furthermore, the report has been prepared solely for use by the Client and Marsden Jacob Associates accepts no responsibility for its use by other parties.



Copyright © Marsden Jacob Associates Pty Ltd 2006

# Table of Contents

<b>Summary .....</b>	<b>1</b>
<b>1. Background .....</b>	<b>2</b>
1.1. Context .....	2
1.2. Purpose and scope of this report .....	4
<b>2. Pathways for residential buildings – international experience.....</b>	<b>6</b>
2.1. Pathway characteristics .....	6
2.2. Overview of UK and Californian policy.....	6
2.3. Phasing action over the short, medium and long term .....	7
2.4. Technical feasibility .....	8
2.5. Energy efficiency and the use of renewable energy .....	10
2.6. Cost-effectiveness.....	12
2.7. Action addressing new and existing residential buildings.....	13
2.8. Other policy considerations.....	14
<b>3. Criteria for policy addressing the energy-related performance of residential buildings – learnings from international experience .....</b>	<b>16</b>
3.1. Criteria.....	16
3.2. Interaction between criteria.....	18

# Glossary

Key terms used in this report include —

<i>Energy-related performance of buildings</i>	The performance of residential buildings in terms of their energy efficiency and use of renewable sources of energy.
<i>Energy-related greenhouse gas emissions</i>	Greenhouse gas emissions associated with the consumption of electricity, gas and other forms of energy. In the residential context, emissions may be <i>direct</i> (arising from the combustion of fuels such as gas on-site) or <i>indirect</i> (resulting from the consumption of electricity which is generated off-site).
<i>Existing residential buildings/housing</i>	Residential dwellings such as houses, units and flats that have been built.
<i>New residential buildings/housing</i>	Residential dwellings such as houses, units and flats that are yet to be built.
<i>Off-site renewable energy</i>	Renewable energy that is produced in a location beyond the boundaries of a residential lot/residential development – but which is supplied to the building/development by direct connection.
<i>On-site renewable energy</i>	Renewable energy that is produced inside the boundaries of a residential lot/residential development.
<i>Pathway</i>	A sequence of stages or steps between a starting point represented by the current situation in the residential building sector and a preferred future situation.
<i>Residential buildings</i>	Buildings such as houses, units and flats – excludes commercial and other buildings.
<i>Residential sector energy use</i>	For the purposes of this report, residential sector energy use refers to energy consumed in the home, and excludes transport energy.
<i>Technical feasibility</i>	Relates to whether a proposed measure is practical – including that the necessary technology is available and that (the building) industry possesses the necessary technical expertise to deliver the proposed solution.
<i>Title 24 of the California Code of Regulations</i>	Includes requirements relating to energy efficiency standards for new residential and non-residential buildings, including additions and alterations. Title 24 standards are updated triennially to incorporate new energy efficiency technologies and methods.
<i>UK Code for Sustainable Homes</i>	The Code measures the sustainability of a new home against nine categories of sustainable design, rating the 'whole home' as a complete package. The Code uses a one to six star rating system to communicate the overall sustainability performance of a new home. It sets minimum standards for energy and water use at each level.

## Summary

Actions to reduce greenhouse gas emissions are important in responding to the threat of climate change. All economic sectors have a role to play in achieving emission reductions. In Victoria, energy use in the residential sector is responsible for 17.5% of the state's total net greenhouse gas emissions – the sector's emissions increased by 21% over the 15 years to 2005 and are projected to increase a further 13% in the 15 years to 2020.

Substantial cost-effective opportunities exist to reduce energy-related greenhouse gas emissions in the residential sector.

This report examines the experience of the United Kingdom and California – jurisdictions that have recently established ambitious pathways for energy efficiency and the use of renewable energy in residential buildings. While there are differences between the approaches of the two jurisdictions, there are key learnings that can be drawn from their experiences.

The report draws on these learnings to identify criteria that could assist other jurisdictions that may be contemplating similar policy approaches.

Five criteria are identified for consideration in establishing pathways for improving the energy-related performance of residential buildings:

1. Announcing a timetable for improvement at the outset which specifies requirements over the short, medium and long term.
2. Separate but linked consideration of building energy efficiency and application of renewable energy technologies.
3. Technical feasibility.
4. Cost-effectiveness.
5. Improvements in both new and existing buildings, including those undergoing renovation.

# 1. Background

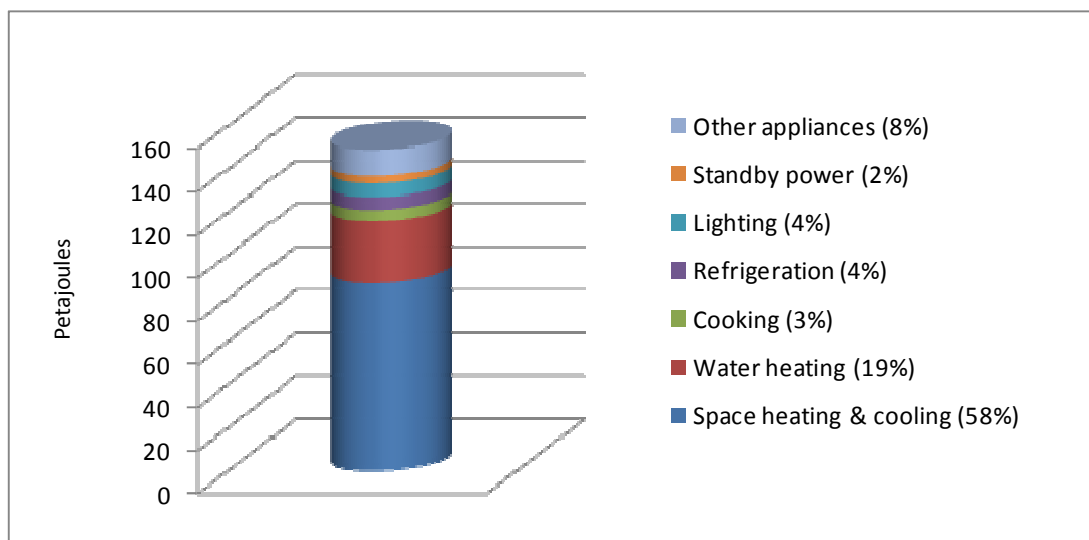
## 1.1. Context

The residential sector is a major source of energy consumption in Victoria and – related to this – greenhouse gas emissions. In 2005, energy consumption in the residential sector was responsible for 17.5% of the state’s total net greenhouse gas emissions<sup>1</sup>.

Figure 1 shows the composition of energy use in Victorian homes in 2005. Space heating and cooling represents the single largest source of energy use (58%), with the other significant contribution coming from water heating (19%). Power used for appliances, including cooking appliances, refrigerators/freezers, lighting and standby power for appliances, accounts for 22% of total consumption.

Greenhouse gas emissions associated with energy use in Victorian homes in 1990 and 2005 – and projected emissions in 2020 – are shown in Figure 2. Emissions increased by 21% between 1990 and 2005 and are projected to increase by another 13% in total by 2020 (relative to 2005). Significantly, while some forms of energy use in homes are actually projected to fall due to efficiency improvements and fuel substitution (e.g. water heating, cooking, refrigeration and lighting), two forms of energy use – space heating and cooling (33% projected increase) and ‘other appliances’ such as electronic goods (69% projected increase) – drive the 13% overall projected growth in emissions.<sup>2</sup>

**Figure 1: Residential energy use – Victoria 2005**

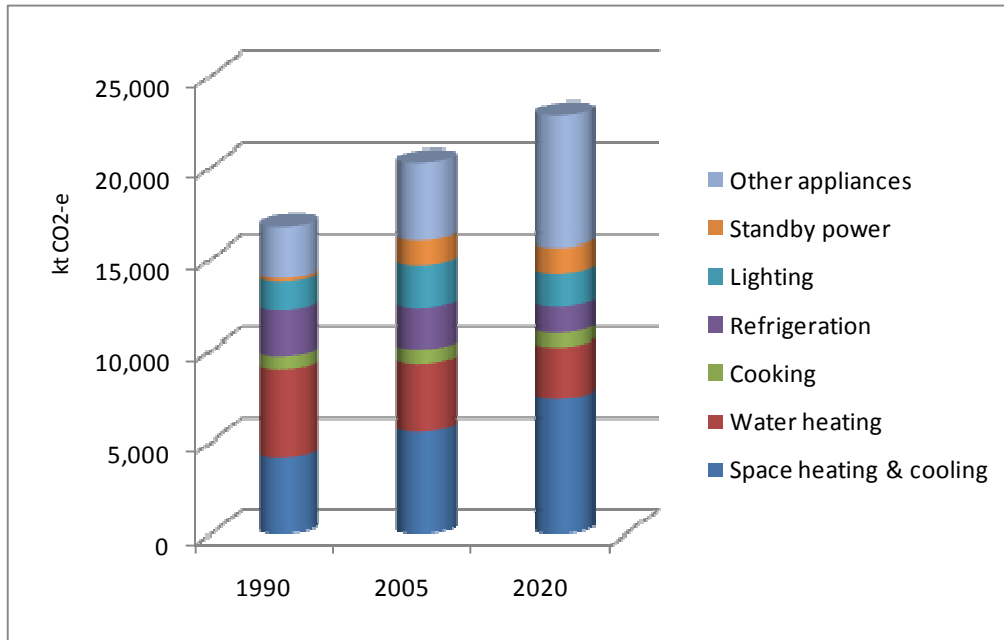


<sup>1</sup> George Wilkenfeld & Associates, 2008 – *Victoria’s Greenhouse Gas Emissions 1990, 1995, 2000 and 2005: End-Use Allocation of Emissions*, p. 119

<sup>2</sup> George Wilkenfeld & Associates, 2008 – *Victoria’s Greenhouse Gas Emissions 1990, 1995, 2000 and 2005: End-Use Allocation of Emissions*, p. 82

Source: *Victoria's Greenhouse Gas Emissions 1990, 1995, 2000 and 2005: End-Use Allocation of Emissions*, George Wilkenfeld & Associates, 2008<sup>3</sup>

**Figure 2: Residential greenhouse gas emissions - Victoria**



Source: *Victoria's Greenhouse Gas Emissions 1990, 1995, 2000 and 2005: End-Use Allocation of Emissions*, George Wilkenfeld & Associates, 2008

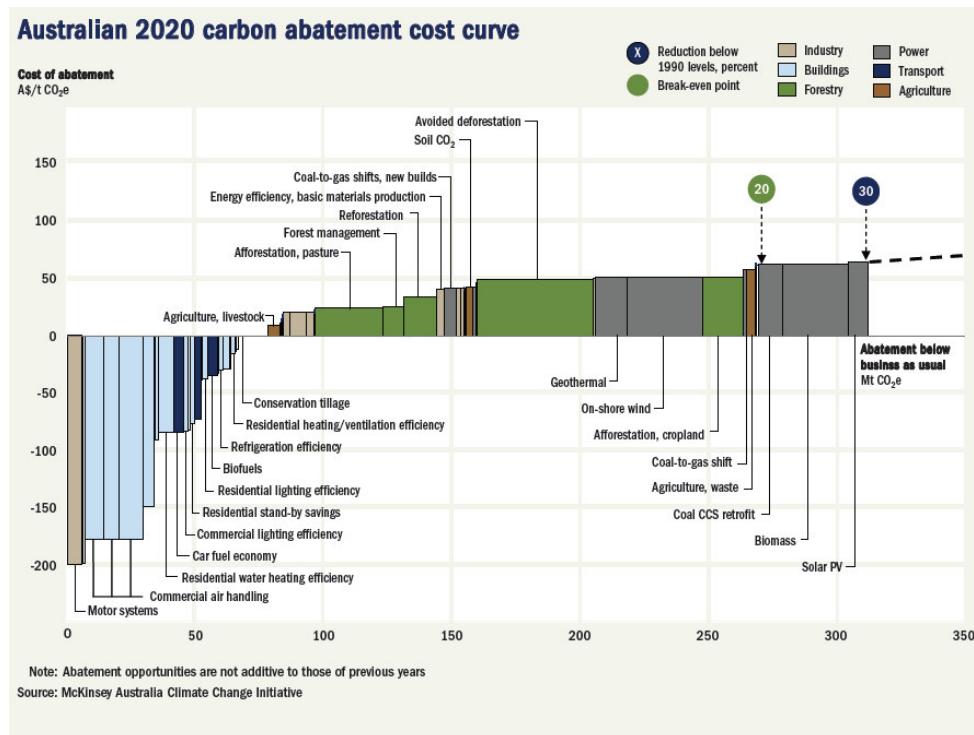
Decreasing the rate of growth of residential sector energy consumption can contribute to efforts to cost-effectively reduce Victoria's greenhouse gas emissions as the state seeks to transition to a low carbon economy. It can also provide financial savings to households.

The report *An Australian Cost Curve for Greenhouse Gas Reduction*<sup>4</sup> indicates that actions to improve energy efficiency in the residential sector can deliver emissions reductions at a negative net cost, i.e. at a net financial benefit to the economy (see Figure 3).

<sup>3</sup> Available at – [http://www.climatechange.vic.gov.au/CA256F310024B628/0/3C8CED14559198CDCA2575C5001B61A4/\\$File/Victorias+Greenhouse+Gas+Emissions+1990+1995+2000+and+2005.pdf](http://www.climatechange.vic.gov.au/CA256F310024B628/0/3C8CED14559198CDCA2575C5001B61A4/$File/Victorias+Greenhouse+Gas+Emissions+1990+1995+2000+and+2005.pdf)

<sup>4</sup> [http://www.gbca.org.au/docs/McKinsey-Australian\\_Cost\\_Curve\\_for\\_GHG\\_Reduction\[1\].pdf](http://www.gbca.org.au/docs/McKinsey-Australian_Cost_Curve_for_GHG_Reduction[1].pdf)

Figure 3: Cost curve for greenhouse gas reduction - Australia



Such findings are consistent with international reports on the potential for emissions reduction associated with residential sector energy use, including by the International Energy Agency<sup>5</sup> and the Intergovernmental Panel on Climate Change (IPCC)<sup>6</sup>.

Australian state and national governments have pursued action to improve the energy-related (and greenhouse gas emission) performance of the residential sector. Regulatory measures – such as energy efficiency standards for residential buildings – have been introduced for new homes. Victoria, for example, introduced five-star thermal performance standards for new homes in 2005. However, new homes represent a small proportion of Victoria’s housing stock. There are approximately 2.1 million existing homes in Victoria. Those built between 1994 and 2004 are estimated to have an energy rating of around two stars, and those built prior to 1994 a rating somewhat less than this.<sup>7</sup>

## 1.2. Purpose and scope of this report

The Department of Sustainability and Environment (DSE) engaged Marsden Jacob Associates (MJA) to examine international jurisdictions that have established pathways for improving energy efficiency and the use of renewable energy in the residential sector.

The aim of the work is to identify ‘what can be learnt from the experience of other jurisdictions about defining pathways from improved energy-related performance in residential buildings’. United Kingdom (UK) and California were selected for this examination, given that they have

<sup>5</sup> [http://www.iea.org/G8/docs/final\\_recommendations\\_heiligendamm.pdf](http://www.iea.org/G8/docs/final_recommendations_heiligendamm.pdf)

<sup>6</sup> <http://www.ipcc.ch/ipccreports/ar4-wg3.htm>

<sup>7</sup> Government of Victoria, 2006, *Energy Efficiency for Victoria: Action Plan*, p. 17

recently established ambitious pathways for energy efficiency and the use of renewable energy in residential buildings.

This report presents the results of this work. The discussion of policy developments in the UK and California is intended only to provide insights into how residential building energy efficiency and the use of renewable energy are being driven in the two jurisdictions. The discussion is not intended – nor should it be interpreted – as a critique of these jurisdictions’ policies.

## 2. Pathways for residential buildings – international experience

### 2.1. Pathway characteristics

Pathways being pursued by the governments of the UK and California to improve the energy-related performance of residential buildings are examined in this section.

While there are differences between the approaches of the two governments, it is possible to identify a set of underlying features or characteristics that the two approaches either have in common, or which are regarded as important by one of the governments.

These characteristics are listed below and subsequently used as the basis for structuring the discussion in this section.

“The ‘Big / Bold’ goal of achieving ZNE for 100% of new residential construction and the supporting interim goals are extremely aggressive. Accordingly, we characterize them in this first *Plan* as ‘reach’ and ‘programmatic’ goals. They are intended to capture the imagination and spark the enthusiasm of all who participate in transforming residential new construction to ultra-high levels of energy efficiency”.

*California Long Term Energy Efficiency Strategic Plan - 2008*

#### Common characteristics of UK and California pathways

1. The transition beyond current practice involves the phasing in of increasing expectations, moving from the short (~3 years), through the medium (~7 years) to the long term (~10 years and over).
2. Technical feasibility is an important consideration. Technological advances are expected to occur – both as a matter of course and due to the stimulus to innovation provided by policy settings.
3. Achieving substantial improvement in the energy-related performance of residential buildings requires policy to address both energy efficiency and the use of renewable energy.
4. Cost-effectiveness is an important consideration in developing policy regarding the energy-related performance of residential buildings.
5. Policy targeting the energy-related performance of the residential sector addresses both new and existing buildings.

### 2.2. Overview of UK and Californian policy

The UK in its 2007 *Building a Greener Future: policy statement* and California in its 2008 *Long Term Energy Efficiency Strategic Plan* have both set out ambitious policy agendas for the energy-related performance of new residential buildings. At the time of writing, the UK Government is yet to finalise the details of its *Zero Carbon Homes* policy and legislation to give effect to California’s *Net Zero Energy Homes* policy is at the Bill stage in that state’s legislature.

### UK zero carbon homes

As part of its package of measures to reduce the nation's greenhouse gas emissions – which includes participation in the EU Emissions Trading Scheme – the UK Government has committed that “all new homes will be zero carbon by 2016”<sup>8</sup>. Under the policy, all new domestic buildings from 2016 must have zero net emissions from all energy use in the home over the course of a year. The policy covers “all energy use in the home ... (including) energy use for cooking, washing and electronic entertainment appliances as well as space heating, cooling, ventilation, lighting and hot water”<sup>9</sup>. “Carbon emissions from appliance use in the home ... (would be) based on data we have on average energy use by households”<sup>10</sup>. The definition allows for fossil fuels or electricity from the grid to be used, provided they are matched by an equivalent export of low or zero carbon energy, bringing net carbon to zero over the year”<sup>11</sup>.

### California zero net energy homes

The Californian Government has committed that all “new construction will reach ‘zero net energy’ (ZNE) performance (including clean, on-site distributed generation) for all new single and multi-family homes by 2020”<sup>12</sup>.

“A ZNE home employs a combination of energy efficiency design features, efficient appliances, clean distributed generation, and advanced energy management systems to result in no net purchases of energy from the grid”<sup>13</sup>.

“The CPUC (California Public Utilities Commission) has defined ‘Zero Net Energy’ at the level of a single ‘project’ ... in order to enable a wider range of technologies to be considered and deployed, including district heating and cooling systems and/or small-scale renewable energy that serves more than one home or business”<sup>14</sup>.

Homes would still be grid-connected to allow for the export of surplus power to the grid and drawing of electricity from the grid when not enough electricity is being produced. The aim is to have net energy consumption of zero over a typical year; in other words, to have on-site renewable energy sources equal to the amount of energy used in the building over the course of a year.<sup>15</sup>

## 2.3. Phasing action over the short, medium and long term

Both the UK and Californian approaches involve phasing in increasingly stringent requirements over the short, medium and long term.

---

<sup>8</sup> *Building a Greener Future: policy statement*, UK Government, July 2007

<sup>9</sup> *Building a Greener Future: policy statement*, UK Government, July 2007, p. 14

<sup>10</sup> *Building a Greener Future: policy statement*, UK Government, July 2007, p. 14

<sup>11</sup> *Definition of Zero Carbon Homes, Impact Assessment*, UK Department of Communities and Local Government, December 2008, p. 15

<sup>12</sup> *Long Term Energy Efficiency Strategic Plan*, Californian Government, September 2008, p. 11

<sup>13</sup> *Long Term Energy Efficiency Strategic Plan*, Californian Government, September 2008, p. 13

<sup>14</sup> *Long Term Energy Efficiency Strategic Plan*, Californian Government, September 2008, p. 13

<sup>15</sup> *Long Term Energy Efficiency Strategic Plan*, Californian Government, September 2008, p. 13

## UK

The pathway for the UK's Zero Carbon Homes policy involves:

- 2010 – amendments to Part L (Conservation of Fuel and Power) of the UK Code for Sustainable Homes introduced to achieve a 25% improvement (relative to 2006 requirements) in emissions associated with energy use
- 2013 – amendments to Part L – 44% improvement
- 2016 – new homes to be zero carbon (subject to transitional arrangements to be decided).<sup>16</sup> It is anticipated that the zero carbon requirement from 2016 will be phased in. Analyses conducted by/for the UK Government assume that the following percentages of homes built will be zero carbon homes: 2016 – nil; 2017 – 40%; 2018 – 60%; 2019 – 90%; and 100% thereafter.<sup>17</sup>

## California

California's Zero Net Energy Homes policy adopts the following timetable:

- by 2011 – 50% of new homes will surpass 2005 Title 24 standards (*which set energy efficiency and other standards for new Buildings, including additions and alterations, in California*) by 35%, and 10% will surpass 2005 Title 24 standards by 55%
- by 2015 – 90% will surpass 2005 Title 24 standards by 35% and 40% will surpass 2005 Title 24 standards by 55%
- by 2020 – 100% will surpass 2005 Title 24 standards by 35% and 90% will surpass 2005 Title 24 standards by 55%. All new homes to be ZNE.

Californian policy documents relating to this commitment indicate that in the mid-term (2012-2015) and longer term (2016 and onwards) trajectories are to be fine-tuned and revised based on changing energy efficiency state of the art.<sup>18</sup>

## 2.4. Technical feasibility

The UK and Californian policies both explicitly discuss the issue of technical feasibility and/or technology risk.

## UK

Reports relating to the UK's Zero Carbon Homes policy state that “the zero carbon policy does not rely on development of brand new technologies, and our analysis has explored the implications of a particular technology (biomass) not being available. So rather than rely on currently unavailable technologies, the policy will encourage the deployment, and perhaps ongoing improvement, of

<sup>16</sup> *Definition of Zero Carbon Homes and Non-Domestic Buildings*, UK Department of Communities and Local Government, December 2008, p. 78

<sup>17</sup> *Definition of Zero Carbon Homes and Non-Domestic Buildings*, UK Department of Communities and Local Government, December 2008, p. 60

<sup>18</sup> *Long Term Energy Efficiency Strategic Plan*, Californian Government, September 2008, p. 17

technologies which are already available but not yet widely adopted in this country”.<sup>19</sup> The report goes on to say that there is a risk that new technologies may not operate as well as predicted. There is also the risk that the policy could inadvertently encourage builders to adopt particular technology solutions which, in the longer term, may prove to be sub-optimal. The policy is designed to accommodate a range of energy technologies at a variety of scales, and should therefore be relatively robust if any particular technology proves to be less effective than assumed in the analysis. The UK Government intends to work with industry and the ‘Zero Carbon Delivery Hub’<sup>20</sup> on monitoring, and will wish to take this general technology risk into account in finalising the carbon compliance level and in its review of the list of “allowable solutions” in 2012.<sup>21</sup>

Recognising these risks, the UK Government has stated that it “will be working with industry and organisations such as English Partnerships to encourage exemplar developments. We will work with the (2016) Taskforce<sup>22</sup> on issues like skills, research and the development and dissemination of good practice”.<sup>23</sup>

### California

California’s *Long Term Energy Efficiency Strategic Plan* notes that “the technical feasibility of ZNE homes is in early stages of demonstration ...”.<sup>24</sup> It also states that “California will need new, cost-effective technologies for home building materials and fabrication techniques, and ‘smarter’ home operating systems, such as visual displays of real-time (or near real-time) energy use ... the energy efficiencies of household equipment and appliances must increase”.<sup>25</sup> In other words, the Californian Government recognises that achieving zero net energy homes will require improvements across all factors influencing household energy use including building fabric, building design and the efficiency of equipment and appliances used by householders.

The *Strategic Plan* also emphasises:

- the role of Research & Development – there will be cooperation between investor-owned utilities (IOU), the California Energy Commission (through its ratepayer-funded Public Interest Energy Research (PIER) program) and other research organisations. “Extensive R&D efforts and partnership programs will push the market further”<sup>26</sup>; and

<sup>19</sup> *Definition of Zero Carbon Homes, Impact Assessment*, UK Department of Communities and Local Government, December 2008, p. 42

<sup>20</sup> The Zero Carbon Delivery Hub is an industry-led body established to identify and address issues to support the building industry and its supply chain with respect to the designs, products, production capability and skills needed to meet the zero carbon standard in 2016.

<sup>21</sup> *Definition of Zero Carbon Homes, Impact Assessment*, UK Department of Communities and Local Government, December 2008, p. 42

<sup>22</sup> The 2016 Taskforce has been established by the UK Government to identify the barriers to implementation of the zero carbon 2016 target, and put in place measures to address them; and to develop a timeline for steps that need to be taken over the next ten years to support the implementation of the zero carbon 2016 target. The Taskforce is jointly chaired by the Minister for Housing and the Executive Chairman of the Home Builders Federation and has senior representatives from a range of stakeholder groups.

<sup>23</sup> *Building a Greener Future: policy statement*, UK Government, July 2007, p. 6

<sup>24</sup> *Long Term Energy Efficiency Strategic Plan*, Californian Government, September 2008, p. 15

<sup>25</sup> *Long Term Energy Efficiency Strategic Plan*, Californian Government, September 2008, p. 16

<sup>26</sup> *Long Term Energy Efficiency Strategic Plan*, Californian Government, September 2008, p. 11

- demonstration projects – California’s “utilities will aggressively promote additional proof of concept pilots, including affordable housing elements in these pilots”.<sup>27</sup>

## 2.5. Energy efficiency and the use of renewable energy

The pursuit of zero carbon homes in the UK and zero net energy homes in California must take account of both energy efficiency and the use of renewable energy.

### UK

The UK is yet to determine its final policy position on what measures will be eligible for meeting the definition of a zero carbon home. Policy documents indicate that measures for achieving zero carbon will be applied as a hierarchy. Specifically, a zero carbon home should:

- a) achieve very high standards of energy efficiency – modelling and consultation to date have looked at both ‘Best Practice Energy Efficiency’ and ‘Advanced Practice Energy Efficiency’
- b) achieve at least a minimum level of carbon reduction through a combination of energy efficiency, on-site energy supply and/or (where relevant) directly connected low carbon or renewable heat from outside the development. This element of the hierarchy is termed ‘carbon compliance’
- c) choose from a range of (mainly off-site) solutions for tackling the remaining emissions. This would involve a combination of predominantly off-site measures from a list of ‘allowable solutions’ to deal with the remaining carbon<sup>28</sup>, “Allowable solutions” are proposed to include:
  - credit for energy-efficient appliances or advanced forms of building control system that reduce the anticipated energy demand from appliances or reduce regulated emissions below the level assumed by a Standard Assessment Procedure
  - credit for carbon savings resulting from export from the development, or from an installation that is connected to the development, of low or zero carbon heat (or cooling) to existing properties that were previously heated (or cooled) by fossil fuels
  - credit for any Planning Obligations paid by the developer towards local low/zero carbon (LZC) energy infrastructure
  - retrofitting works undertaken by the developer to transform the energy efficiency of existing buildings in the vicinity of the development
  - any investment by the developer in LZC infrastructure where the benefits of the investment are passed on to the purchaser of the home
  - where off-site renewable electricity is connected to the development by a direct physical connection, a credit will be given for any carbon savings relative to grid electricity
  - any other measures that government might in future announce as being eligible.<sup>29</sup>

<sup>27</sup> *Long Term Energy Efficiency Strategic Plan*, Californian Government, September 2008, p. 15

<sup>28</sup> *Definition of Zero Carbon Homes and Non-Domestic Buildings*, UK Department of Communities and Local Government, December 2008, p. 10

<sup>29</sup> *Definition of Zero Carbon Homes, Impact Assessment*, UK Department of Communities and Local Government, December 2008, p. 19

The level at which to set the carbon compliance level for 2016 and the proportionate contribution of each element remains under consideration and is the subject of consultation. A consultation document issued in December 2008 sets out the following options for comment by stakeholders:

- 44% energy/carbon reduction (relative to 2006 requirements) through energy efficiency plus ‘carbon compliance’ (equivalent to Level 4 in the Code for Sustainable Homes), with residual emissions to be addressed through “allowable solutions”
- 70% reduction through energy efficiency plus “carbon compliance” with residual emissions to be addressed through ‘allowable solutions’
- 100% energy/carbon reduction through energy efficiency plus “carbon compliance” (equivalent to Level 5 in the Code for Sustainable Homes)
- 100% energy/carbon reduction through energy efficiency plus “carbon compliance” plus emissions from cooking and appliances, which currently do not fall within Building Regulations (equivalent to Level 6 in the Code for Sustainable Homes). Hence, this implies a reduction of around 150% to 170% compared with today’s Building Regulations.<sup>30</sup>

The option 44% is the level of carbon reduction that has been announced for 2013<sup>31</sup> and sets the minimum level of emission reductions to be achieved through a combination of energy efficiency and renewable energy (carbon compliance) in new homes from 2016.

The UK Government notes that carbon reductions from 25% to 44% are possible through demanding energy efficiency standards alone.<sup>32</sup> It has indicated that such energy efficiency standards are likely to be part of the 2016 Building Regulations, in particular for new homes.

*“Energy efficiency measures should be the most cost effective and should be pursued first.”*<sup>33</sup> The UK Government put this claim into action within Part L (Conservation of Fuel and Power) of the UK Code for Sustainable Housing, which places *“limits on design flexibility to discourage excessive and inappropriate trade-offs – e.g. buildings with poor insulation standards offset by renewable energy systems with uncertain service lives”*.<sup>34</sup>

## California

As described in Section 2.2, California’s approach to zero net energy homes will involve an amalgam of energy efficiency design features, efficient appliances, clean distributed generation, and advanced energy management systems. California’s *Long Term Energy Efficiency Strategic Plan* states that the Government’s vision is that “residential energy use will be transformed to ultra-high levels of energy efficiency resulting in Zero Net Energy new buildings by 2020. All

<sup>30</sup> *Definition of Zero Carbon Homes and Non-Domestic Buildings*, UK Department of Communities and Local Government, December 2008, p. 38

<sup>31</sup> 2013 amendments to Part L (Conservation of Fuel and Power) of the UK Code for Sustainable Homes

<sup>32</sup> *Definition of Zero Carbon Homes and Non-Domestic Buildings*, UK Department of Communities and Local Government, December 2008, p. 34

<sup>33</sup> *Definition of Zero Carbon Homes and Non-Domestic Buildings*, UK Department of Communities and Local Government, December 2008, p. 34

<sup>34</sup> *Part L of the Building Regulations, Approved Documents L1A Conservation of Fuel and Power in New Dwellings (Coming into effect 6 April 2006)*, Office of the Deputy Prime Minister, 2006, p15 [available at [http://www.planningportal.gov.uk/uploads/br/BR\\_PDF\\_AD\\_L1A\\_2006.pdf](http://www.planningportal.gov.uk/uploads/br/BR_PDF_AD_L1A_2006.pdf)]

cost-effective potential for energy efficiency, demand response and clean energy production will be routinely realized for all dwellings on a fully integrated, site-specific basis”.<sup>35</sup>

## 2.6. Cost-effectiveness

The UK and Californian governments both regard cost-effectiveness as an important consideration in the pursuit of policies regarding the energy-related performance of residential buildings.

### UK

The UK Government has conducted extensive analysis to assess the net benefits/costs of its Zero Carbon Homes policy and the comparative net benefits/costs of alternative approaches. The Government notes that “it is important that the costs of zero carbon do not undermine the economic viability of housing development”<sup>36</sup>, and has made clear its commitment to take into account new evidence about costs and practicalities and the development of technologies in determining the definition of zero carbon for the purposes of Building Regulations. The “assessment of the full costs and benefits of achieving zero carbon homes will therefore be kept under review at each phase of the timetable to zero carbon in 2016, as the detailed process for delivery through the Building Regulations progresses”.<sup>37</sup>

The UK Government’s view – issued for comment by stakeholders – is that:

- it would not be appropriate to set carbon compliance at the most demanding levels (i.e. eliminating regulated emissions plus emissions associated with appliances)
- a 100% reduction in regulated emissions appears to be at the top end of what is realistic, but is substantially reliant on biomass technologies and involves a significant cost premium of £12,400 to £17,000 per home
- a 70% reduction “is interesting” – cost premiums are significantly lower than for a 100% reduction and there are fewer technology issues
- a 44% reduction is technically robust with a capital cost premium of £7,500 to £9,500 per home. But this does not achieve any further on-site carbon reductions beyond the level foreseen in the 2013 amendments to Part L (Conservation of Fuel and Power) of the UK Code for Sustainable Housing.<sup>38</sup>

The importance of cost-effectiveness as an issue to the UK Government is also reflected in its consideration of a cap on the cost of “allowable solutions” (see Section 2.5). In order to provide the necessary level of predictability, the UK Government favours putting in place a maximum level of costs that it expects developers to spend on “allowable solutions”. This would most likely be expressed in terms of expenditure per tonne of CO<sub>2</sub>.<sup>39</sup> Options floated by the UK Government for stakeholder comment include: use of a Shadow Price of Carbon (£25.50 in 2007, rising at 2%

<sup>35</sup> *Long Term Energy Efficiency Strategic Plan*, Californian Government, September 2008, p. 9

<sup>36</sup> *Definition of Zero Carbon Homes, Impact Assessment*, UK Department of Communities and Local Government, December 2008, p. 42

<sup>37</sup> *Building a Greener Future: policy statement*, UK Government, July 2007, p. 22

<sup>38</sup> *Definition of Zero Carbon Homes and Non-Domestic Buildings*, UK Department of Communities and Local Government, December 2008, p. 41-42

<sup>39</sup> *Definition of Zero Carbon Homes and Non-Domestic Buildings*, UK Department of Communities and Local Government, December 2008, p. 52

p.a. in real terms); the price of CO<sub>2</sub> implied by future prices of Renewables Obligation Certificates (~£100/t CO<sub>2</sub>); and the price of CO<sub>2</sub> implied by incentives for emerging renewable technologies (~£200/t CO<sub>2</sub>).<sup>40</sup> This and other issues relating to progress with zero carbon homes will be reviewed in 2012.

## California

As stated in its vision for residential buildings, the Californian Government's aim is to realise all cost-effective potential for energy efficiency, demand response and clean energy production. The significance of cost-effectiveness as a consideration is highlighted by the fact that the State's *Long Term Energy Efficiency Strategic Plan* includes action to pursue "innovative financing solutions, such as loans that remain with the property through the owner-occupant turnover and energy efficiency mortgages", noting that this "will be essential in allowing builders and owners to leverage the cost-savings inherent in ZNE buildings into investment costs".<sup>41</sup>

## 2.7. Action addressing new and existing residential buildings

### UK

While its Zero Carbon Homes policy focuses on new residential buildings, the UK Government has a suite of measures targeting the energy performance of existing homes. These include:

- *Carbon Emission Reduction Target (CERT)* – this scheme requires electricity and gas suppliers in Great Britain to achieve targets for the promotion and delivery of energy efficiency into their customers' homes. Suppliers can choose from a range of measures including provision of insulation, microgeneration and behavioural measures in order to deliver their obligation.<sup>42</sup> The Government announced recently that it will increase the target under CERT by 20% to a revised level of 185 million lifetime tonnes of carbon.<sup>43</sup>
- *Energy Performance Certificates* – a requirement for all homes on the market, including new buildings and the sale and rent of existing buildings, to have an energy rating.<sup>44</sup>
- *Community Energy Saving Programme* – a £350 million programme that will target around 100 fuel-poor areas on a street-by-street basis, offering free and discounted central heating and energy efficiency measures.<sup>45</sup>
- *Reduced VAT (Value Added Tax)* – for professional installation of a range of energy-saving materials and microgeneration technologies within residential properties.<sup>46</sup>
- *Information/education* – working with the public sector, business and voluntary organisations to ensure consumers are given the right advice and support to understand the impact they have

<sup>40</sup> *Definition of Zero Carbon Homes and Non-Domestic Buildings*, UK Department of Communities and Local Government, December 2008, p. 54-55

<sup>41</sup> *Long Term Energy Efficiency Strategic Plan*, Californian Government, September 2008, p. 16

<sup>42</sup> *Meeting the Energy Challenge – A White Paper on Energy*, UK Government, May 2007, p. 58-61

<sup>43</sup> <http://nds.coi.gov.uk/Content/Detail.aspx?NewsAreaId=2&ReleaseID=404208&Subject>

<sup>44</sup> *Meeting the Energy Challenge – A White Paper on Energy*, UK Government, May 2007, p. 66

<sup>45</sup> <http://www.number10.gov.uk/wp-content/uploads/energy-saving-programme110908.pdf>

<sup>46</sup> *Meeting the Energy Challenge – A White Paper on Energy*, UK Government, May 2007, p. 66

on the environment and to allow them to make better, more environmentally friendly lifestyle choices.<sup>47</sup>

## California

California's *Long Term Energy Efficiency Strategic Plan* includes an objective to "reach all existing homes and maximize their energy efficiency potential through delivery of a comprehensive package of cost-effective, whole-house energy efficiency retrofit measures – including building shell upgrades, high-efficiency HVAC units, and emerging deep energy reduction initiatives – with comprehensive audits, installation services and attractive financing."<sup>48</sup> The pathway for achieving this objective involves:

- 25% of existing homes having a 70% decrease in purchased energy from 2008 levels
- 75% of existing homes having a 30% decrease in purchased energy from 2008 levels
- 100% of existing multi-family homes having a 40% decrease in purchased energy from 2008 levels.

The *Strategic Plan* suggests that these goals will not be pursued using the same policy levers applying to new homes, but rather will be pursued through:

- action by local government, which can adopt residential energy conservation ordinances for energy ratings and possible improvements at the time of sale
- supporting programs from investor-owned utilities (IOUs) including audits, appliance rebates and education
- workable financing mechanisms such as on-bill financing that allow energy bill savings from improvements occurring in the individual units to offset the up-front capital costs typically paid by building owners and homeowners' associations
- increasing awareness of, and information on, energy efficiency to create market demand for efficient homes
- demonstration programs. The California Energy Commission (CEC) will adopt its Home Energy Rating System (HERS) standards for existing homes by the end of 2008. In cooperation with the CEC, IOUs will begin voluntary pilot programs to implement the HERS system and to encourage local governments to adopt residential energy conservation ordinances for energy ratings at the time of sale
- research and development into new/advanced cost-effective innovations to reduce energy use in existing homes.<sup>49</sup>

## 2.8. Other policy considerations

Policy-related documents produced by the UK and Californian governments indicate that other important considerations include:

<sup>47</sup> *Meeting the Energy Challenge – A White Paper on Energy*, UK Government, May 2007, p. 62

<sup>48</sup> *Long Term Energy Efficiency Strategic Plan*, Californian Government, September 2008, p. 18

<sup>49</sup> *Long Term Energy Efficiency Strategic Plan*, Californian Government, September 2008, p. 18

- **Compliance and enforcement.** The Californian Government notes, for example, that “strengthening building codes without improving local on-the-ground compliance leads to illusory progress”.<sup>50</sup> The UK Government believes there is a need to improve compliance with Building Regulations as well as raising standards. It recognises that “there is a risk that builders will not comply with the regulations and that they will not be effectively enforced by the relevant regulators ... the risk will be reduced by giving industry and regulators sufficient time to become accustomed to the regulations and by ensuring that there is straightforward guidance on how to comply”.<sup>51</sup>
- **Skills and training.** There is a need for a sufficient number of workers in the building industry with the skills needed to build dwellings in accordance with policy requirements. The UK Government states that pursuing the zero carbon target “will require the development of new skills across the sectors involved”.<sup>52</sup> California’s *Long Term Energy Efficiency Strategic Plan* states that “in order to accommodate the dramatic increase in energy efficiency activities envisioned by this Plan and required by AB 32, California must develop a trained workforce, including people qualified in energy-efficiency engineering, construction, maintenance, program design and implementation, and financial analysis. Meeting the goals established in the Plan will require at least two categories of personnel development: completely new types of jobs that do not exist today (e.g., corporate emissions manager) and supplemental training for existing positions (e.g., training engineers to enhance energy efficiency)”.<sup>53</sup>

---

<sup>50</sup> *Long Term Energy Efficiency Strategic Plan*, Californian Government, September 2008, p. 19

<sup>51</sup> *Definition of Zero Carbon Homes, Impact Assessment*, UK Department of Communities and Local Government, December 2008, p. 42

<sup>52</sup> *Building a Greener Future: policy statement*, UK Government, July 2007, p. 20

<sup>53</sup> *Long Term Energy Efficiency Strategic Plan*, Californian Government, September 2008, p. 74

### 3. Criteria for policy addressing the energy-related performance of residential buildings – learnings from international experience

Section 2 of this report described the characteristics of the UK's Zero Carbon Homes and California's Zero Net Energy Homes policies – both of which, despite differences in approaches, are examples of innovative, cutting edge policy to drive a quantum improvement in the energy-related performance of residential buildings.

Drawing on learnings from the approaches taken by these two jurisdictions, it is possible to identify broad criteria that could assist other jurisdictions that may be contemplating similar policy approaches. Five criteria are identified. These are presented below, with their rationales.

#### 3.1. Criteria

**In establishing pathways for improving the energy-related performance of residential buildings, it is important to consider:**

##### 1. **Announcing a timetable for improvement at the outset which specifies requirements over the short, medium and long term**

Such an approach has a number of potential benefits:

- Establishing and announcing a pathway over the short (up to ~3 years), medium (up to ~7 years) and long term (~10 years+) is expected to provide a level of certainty for the building industry and consumers (and other interested parties) as to the aims and direction of government policy. In contrast, announcing only short-term requirements and leaving medium- to long-term directions unstated has the potential to create uncertainty and lessen the potential for maximising longer term gains.
- Phasing in increased levels of stringency over such a timetable will provide lead time for the building industry to adjust to new requirements.
- The approach explicitly acknowledges the potential for, and helps facilitate, technological advances over time, including advances occurring naturally and those occurring due to the stimulus for innovation provided by the pathway.

The approach taken by the UK and Californian governments suggests that it may be appropriate to review medium- to long-term elements of the pathway over time. This will ensure that new information or unforeseen developments (e.g. in the scale and pace of technological change) can be assimilated into pathway requirements.

##### 2. **Separate but linked consideration of building energy efficiency and the application of renewable energy technologies**

If ambitious net zero energy/carbon pathways are contemplated, it will be necessary to consider not only high levels of energy efficiency, but also the use of renewable energy in buildings subject to the pathway. This is the case because energy efficiency improvements alone cannot deliver zero net energy or zero carbon homes, as some energy will always be consumed to operate household appliances and equipment.

Energy efficiency and renewable energy are linked issues. The appropriate balance between the extent of energy efficiency improvements and the use of renewable energy – on-site and/or off-site – will likely vary according to factors such as geographic location and the type of residential development. Recognising this, requirements might best be couched in outcome-oriented terms that allow for flexibility to be pursued in an integrated manner and for the implementation of site-specific solutions. The potential risk of inappropriate trade-offs, e.g. inadequate energy-efficiency offset by renewable energy systems, needs to be addressed when establishing the pathway.

### **3. Technical feasibility**

Technical feasibility relates to whether a solution is practical – including whether the necessary technology is available and whether the building industry possesses the necessary technical expertise to deliver the proposed solution.

In establishing pathways for improving the energy-related performance of residential buildings, it is important to recognise that technology is not static. Over time, developments in technology will likely enable the pursuit of increasingly stringent requirements – both from the point of view that new and evolving technologies will “make more things possible”; and because the costs of technology generally decline over time due to economies of scale, “learning-by-doing” and innovation. This latter point is relevant to the consideration of cost-effectiveness (see criterion 4).

### **4. Cost-effectiveness**

Cost-effectiveness can be considered from both a household and a societal perspective. Both are important considerations for pathways seeking to improve the energy-related performance of residential buildings. Cost-effectiveness for households is important in gaining support for policy. Cost-effectiveness from the perspective of society as a whole is also important, reflecting the fact that energy efficiency and renewable energy measures are key elements of national efforts to reduce greenhouse gas emissions. Policies and measures to drive improved energy efficiency and the deployment of renewable energy need to be assessed in light of the cost-effectiveness of alternative abatement options across the economy; to do so, a societal rather than private perspective of costs and benefits needs to be considered.

The range of benefits and costs to be accounted for in defining cost-effectiveness requires careful consideration by government.

### **5. Improvements in both new and existing buildings – including those undergoing renovation**

Such an approach is required because:

- the predominance of existing buildings in the total housing stock means that it is not possible to achieve substantial and swift improvement in the energy-related performance of the residential sector by focusing exclusively on new buildings
- equity (i.e. “fairness”) across the residential sector requires that effort is directed to improving the performance of all residential buildings, not just new buildings.

Nonetheless, it is important to recognise that the level of improvement sought with respect to existing buildings will likely vary from that for new buildings, given the different challenges associated with retrofitting older building stock.

### 3.2. Interaction between criteria

Since the five criteria interact, they are best considered together rather than applied independently. By way of illustration:

- Setting a timetable for improving the energy-related performance of residential buildings that establishes increasingly stringent requirements over the short, medium and long term (*criterion 1*) needs to consider the technical feasibility (*criterion 3*) and cost-effectiveness (*criterion 4*) of opportunities to achieve such improvements.
- Requirements relating to the extent of energy efficiency improvement and the use of renewable energy that is sought (*criterion 2*) need to be determined in recognition of cost-effectiveness (*criterion 4*) in different circumstances.