

ENERGY EFFICIENCY AND HEAT PUMPS: HOW POLICY WILL DRIVE THE MARKET

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Abstract: In the last five years there has been a sharp rise in the focus given to energy efficiency in energy ministries across the 27 member countries of the International Energy Agency and this is leading to substantial changes in policy environments with important implications for the HVAC and refrigeration industry. Major new policy initiatives have been launched and are set to be strengthened in all large economies as governments apply themselves to the challenge of realising the substantial cost-effective energy savings that have been identified. This paper reviews why this change in emphasis has come about, what it already means for the heat pump industry and what changes might be expected in the future.

Key Words: *energy efficiency policy, heat pumps, climate change*

1 INTRODUCTION: ENERGY'S TRIPLE DILEMMA

Over the last few years government policy makers have been severely taxed by rising pressures in the areas of energy security, climate change and energy costs which have combined to push energy to the top of the political agenda. The call by the President of the European Commission, José Manuel Barroso, for a “new industrial revolution” in energy is but one of many high profile examples of senior policy makers putting energy at the heart of their discourse. Energy concerns both in terms of the need to reduce dependence on foreign energy imports and growing worries about climate change featured strongly in US-mid-term congressional elections in 2006 and bore fruit with the passage of the Energy Independence and Security bill at the end of 2007. Among the G8 countries the UK made energy and climate change the focus of their 2005 presidency which led to the G8 summit initiative Aiming at a Clean, Clever and Competitive Energy Future, Russia put energy security as the focus of their 2006 presidency and both Germany and Japan are setting sustainable energy at the centre of their G8 presidencies in 2007 and 2008 respectively.

So why is there all this heightened concern about energy? According to the latest World Energy Outlook forecasts from the IEA global energy demand is set to rise by 1.6% per annum to 2030 if current policy settings are continued. Meeting this demand will require investment in new and replacement energy supply infrastructure valued at 22 trillion US\$, or roughly US\$960 billion per year. In addition to continuing economic growth in the OECD economies this rapid growth in demand for energy is driven by the spectacular economic development of emerging economies such as China and India. In recent years growth in demand for energy outstripped the capacity of available supply resulting in a sharp rise in fossil fuel prices from 2005 onwards. Energy economists are no longer talking of long-term costs of oil in the region of US\$30 a barrel that still seemed plausible in 2004 and the simmering debate about the moment at which the peak of oil production will be passed has been reignited.

Of considerable concern to OECD economies is the simultaneous decline of their own fossil energy supplies. Most OECD governments are becoming increasingly dependent on energy

imports at a time when international supplies have become less secure. Established OECD economies such as the European Union are becoming substantially more reliant on imported oil and gas. This increasing energy dependence coincides with higher international competition for fossil energy resources as economic growth continues around the world and demand from non-OECD regions intensifies. Furthermore, recent history is peppered with examples of the unreliability of supplies of energy from third countries where the largest fossil energy reserves reside.

Yet ironically, ensuring access to reliable fossil energy supplies may be a lesser problem than what could happen from the continued unmodified exploitation of those reserves. The latest projections regarding anthropogenic climate change are sobering. The World Energy Outlook projects that energy-related emissions will increase from 26 billion tonnes of CO₂ in 2004 to over 40 billion tonnes in 2030 if new measures are not put in place. Based on an analysis of similar projections the European Commission has asserted that “there is a more than 50% chance that global temperatures will rise during this century by more than 5°C”. When considering that this is almost as great as the difference between the current global average surface temperature and that of the last ice age it is easier to see why the Stern report, released by the UK government’s chief economist in 2006, projected that failure to address climate change over the course of the century could trigger economic recession and lead to up to a 20% reduction in global GDP. The world’s first international treaty on curbing climate change, the Kyoto protocol, came into legal effect in 2005 and despite the well documented problems and disputes that surround this treaty the large majority of OECD economies are now legally bound to reduce or restrain CO₂ emissions to some factor of their 1990 level by 2010-12. In the last year Australia has ratified the Kyoto treaty and a large number of US states have set CO₂ reduction targets and begun to develop cap and trade schemes. A bi-partisan draft bill on cap and trade is under discussion in the US Congress and all current presidential candidates support the establishment of a US federal emissions cap and trade scheme in the near future. Meanwhile the negotiations regarding the development of a successor to the Kyoto protocol in the post 2012 period are actively underway and many countries have begun to adopt ambitious longer-term emissions reductions objectives. The EU is committed to cutting regional emissions to 20% below 1990 levels by 2020 and has announced it will opt for a 30% reduction if other major economies join suit. Many major EU states and Japan have adopted factor 2 to 4 emissions reduction targets against 1990 levels by 2050. Furthermore the seriousness of intent behind many of these targets is firming-up. For example, the UK has passed a Climate Change Bill through a first vote in the House of Commons and which is now undergoing scrutiny in the House of Lords, that aims to make future governments legally liable for the delivery of the emissions reductions required on their watch to meet the UK’s target of minus 60% by 2050. As will be elaborated on in the rest of this paper these emissions policy objectives are driving root and branch reviews of energy policies in an effort to de-carbonise the energy system and are providing a major stimulus to the elaboration of energy efficiency policies in particular.

2 THE POTENTIAL FOR ENERGY SAVINGS

The search for acceptable solutions to these energy-related problems is not straightforward. Alternative indigenous non-fossil forms of clean energy supply exist for electricity and some transport fuels but each faces major issues regarding cost, acceptability and the speed at which it can be developed. Major efforts are underway to develop renewable energy sources and discussion continues about nuclear power, meanwhile new efforts are being considered to develop cleaner fossil fuel supplies such as “clean coal” power generation where the CO₂ emissions are captured and stored rather than released into the atmosphere; but all these options even when technically demonstrated imply higher energy costs, will take a very long time to deploy and only address localised parts of current energy demand.

But what of the potential to curb energy demand? Here the picture, while still challenging, is much more attractive. Numerous studies have identified very large cost-effective energy savings potentials remain to be accessed even with today's energy prices. For example, the Alternative Policy Scenario of the IEA's World Energy Outlook examines what could happen were carbon abatement and energy security policies currently under consideration to be fully implemented between here and 2030. The outcome is a 16% reduction in global CO₂ emissions in 2030 of which 2/3rds are avoided through end-use energy efficiency measures, Figure 1.

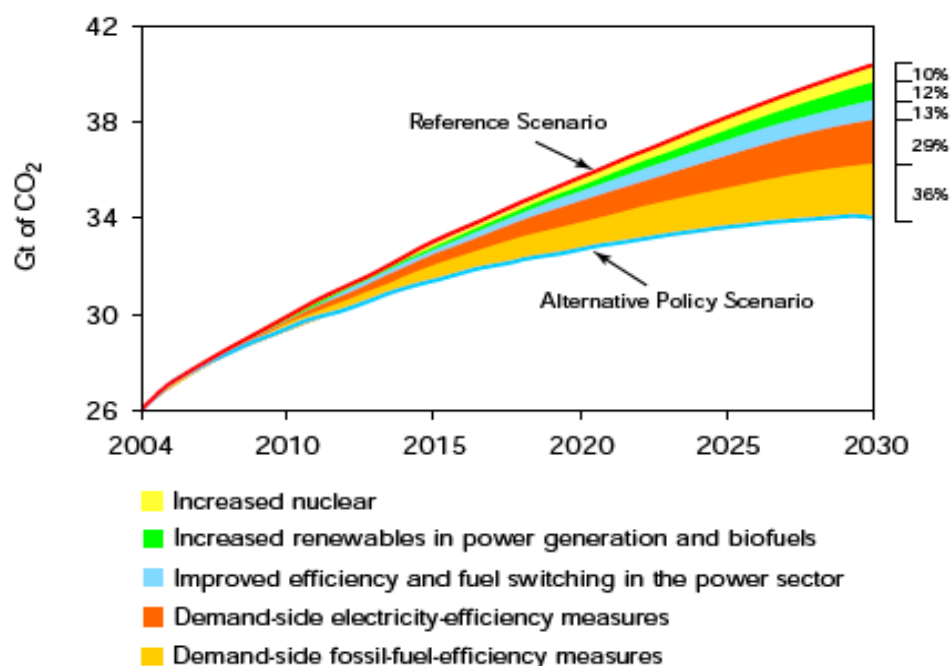


Figure 1: Global energy-related CO₂ emissions under the World Energy Outlook Reference and Alternative Policy Scenarios [IEA 2006a]

Despite a significantly higher share of more costly low-carbon energy supplies the overall investment needs in the alternative scenario are lower than in the reference scenario because of the high cost effectiveness of the energy efficiency options considered. In many areas the marginal cost of providing an energy service through extra energy supply is two to five times higher than the cost of providing the same service through increased energy efficiency. The reason these disparities occur is because of the existence of a number of significant market failures and imperfections, which inhibit the market's ability to achieve least-cost energy services. These include:

- missing or partial information regarding the energy performance of end-use equipment or energy-using systems
- lack of awareness regarding cost-effective energy-savings potentials
- principal agent barriers e.g. that the decision-makers for energy-efficiency investments (in buildings, appliances, equipment...) are not always the final users who have to pay the heating or cooling bill and thus the overall cost of energy services is not revealed by the market; this is sometimes known as the Landlord-Tenant split incentive. Other split incentives include: that the management of equipment acquisition budgets is typically separated from that of operating and maintenance budgets within companies and that the period of owner occupation of buildings is usually a small part of the building lifespan and thus occupiers have little incentive to minimise operating budgets over the longer term.

- energy efficiency is a minor determinant of a capital-acquisition decision and is bundled-in with numerous more important product and service factors
- the financial constraints of individual consumers are often far more severe than those implied by national discount rates or long-term interest rates, resulting in a preference for short-term profitability; e.g. implicit discount rates in industry are over 20%, compared to less than 10% for public discount rates, and 4-6% for long-term interest rates.

Of all of these, the lack of clear and coherent information about the energy performance of energy-using equipment and systems is still the most important. A market cannot operate effectively when the value of the goods or services being bought is unknown or unclear; despite numerous important policy-driven improvements in this regard over recent years, the energy performance of many energy-using systems is still either invisible or obscured to end-users.

3 BIGGER THAN OIL

Several landmark studies released over the last few years have, for the first time, clearly demonstrated the remarkable benefits society has already derived from improved energy efficiency and the very high magnitude of the benefits that still remain to be realised. The IEA's publication 30 Years of Energy Use in IEA Countries [IEA 2004a] and its recent update Energy Use in the New Millennium [IEA 2007] reveal that very substantial reductions in energy consumption per unit of economic output have occurred in IEA economies. In the year 2000, total final energy consumption per unit of GDP was only 60% of the 1973 level, while total primary energy supply per unit of GDP was about 67% of the 1973 level. These figures reveal a significant evolution in the nature of the economy and a strong shift toward less energy-intensive wealth creation; however, to what extent is this due to improving energy efficiency as opposed to structural changes in the overall blend of the economy? The 30 Years of Energy Use publication addresses this by separating the impact of changes in sub-sector energy intensities on energy use from the impacts of changes in economic structure and other factors that affect the demand for energy, but which are not directly measured by GDP. This showed that the overall decline in energy use per unit of GDP observed in 11 IEA economies was dominated by the decline in energy intensity effect for all countries except one where the shift in energy services predominated. For the 11 countries as a whole, the energy-intensity composite declined by about 1.6% per year on average, compared to 0.3% annual average decline in energy services per unit of GDP. Thus the effect of declining energy intensity (i.e. energy efficiency improvements) accounted for about 84% of the drop in energy use per unit of GDP in OECD nations over the 25-year period.

The collective contribution of falling energy intensities in the various sectors to the reduction in total energy use in these nations between 1973 and 2004 is shown in Figure 2. The lower area shows actual climate-corrected energy use, which includes the effect of changes in energy intensities. The upper line represents the hypothetical energy use that would have occurred if energy intensities had remained at the 1973 level in all sectors. By 1998 the savings amounted to 58.1 EJ, which corresponds to 56% of 2004 energy use. In other words, final energy use in these 11 OECD nations would have been 56% higher in 2004 if the energy intensities of the different sub-sectors and end-uses had remained at their 1973 levels. These efficiency improvements equate to a reduction in CO₂ emissions of roughly 5.5 Giga tonnes per year by 2004 which is almost as much as all US energy-related emissions in the same year.

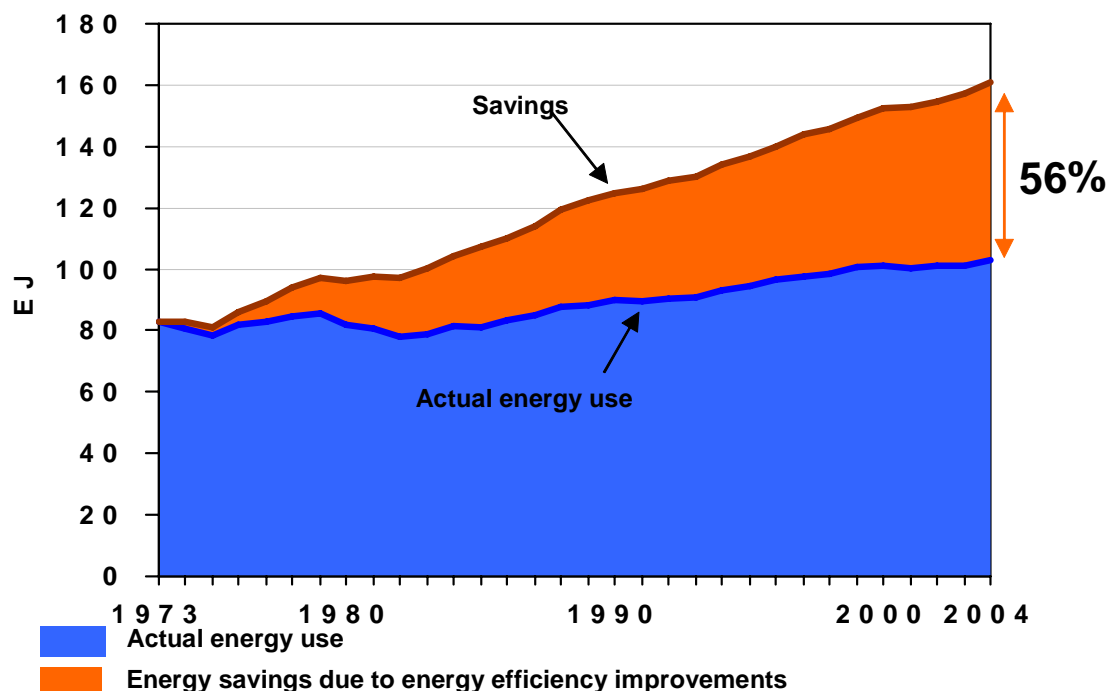


Figure 2: Actual energy use and hypothetical energy use without intensity reductions, for eleven IEA countries [IEA 2007]

Put another way, this finding means that energy efficiency improvements since 1973 contributed 40% more than oil to the provision of total energy services in IEA countries in 2004. This is a remarkable finding that warrants greater dissemination.

4 THE RISE OF ENERGY EFFICIENCY POLICY ACTIVITY

Through such studies energy ministries have become increasingly aware of the huge impact that demand side efficiency improvements has to offer and have moved to strengthen their policy portfolios. Measures addressed at the building sector are a very important part of this. In most OECD economies buildings account for about 40% of all energy use and are the largest single usage sector, greater than industry or transport. Within buildings the provision of thermal comfort and air quality is the greatest energy use so policy efforts to improve energy efficiency have naturally been focused on HVAC equipment as well as on the performance of building fabrics. Domestic and commercial refrigeration has also been a major policy target, especially the former, because of the large potential savings that can be realised in these sectors.

About 18 years ago only four countries in the world had energy efficiency regulations in place applying to cooling appliances (refrigerators, freezers, air conditioners etc.), but by 2005 there were 54 with more in the offing covering 80% of the world's population. A larger number of countries had some kind of energy performance building codes in place 18 years ago but very few had any requirements addressing space cooling. Now all countries in the OECD have such regulations. Furthermore until recently most building codes were concerned with the energy performance of the building fabric yet now they also include the performance of the fixed equipment such as the HVAC. Building codes are being further revised to apply to major retrofits of existing buildings and hence increasingly apply to the replacement equipment market as well as the new buildings case. These trends are clearly important for the heat pump industry because while minimum efficiency standards and energy labelling may apply to the performance of individual components such as room air conditioners, the

building code requirements apply to the function of the HVAC system within the building as a whole. This places a premium on the ability of HVAC equipment to contribute to the overall satisfaction of building energy performance requirements and potentially implies a much higher level of integrated performance.

But even prior to this activity the profile given to energy efficiency was already rising: in part because of demonstrated successes for past initiatives aimed at improving energy efficiency and in part through a realisation that the subject had historically been rather neglected and there was still a very large untapped potential to deliver.

5 RAPID GROWTH IN AIR CONDITIONING PRESENTS NEW CHALLENGES TO BUILDINGS AND UTILITIES

Europe's heat wave in the summer of 2003 led to more than 20000 deaths and greatly accelerated the demand for cooling equipment in European buildings. But Europe's response to the heat wave is only a part of a global trend toward air conditioning which is driven by higher demands for personal comfort, higher internal loads in buildings, growth of urban heat islands and heat waves. Within OECD countries about 41% of the occupied building floor area was air conditioned in 2001 and this level has been rising by 7% per year. In Japan, air-conditioned space in the service sector is estimated to be near 100%, followed by 63% in the USA, and 27% in Europe. The residential sector has experienced a strong rate of growth in the ownership of room air conditioners in Japan, the USA and Europe. Sales of room air conditioners are thought to have increased by up to 50% following the European heat waves in the summer of 2003.

This trend has profound implications for the design of buildings but also threatens the reliability of electricity supply systems. The growth in air conditioning (AC) has emerged as the single largest factor challenging the ability of electricity utilities to meet future demand. Even in some relatively northerly countries utilities have become summer peaking (Canada, USA, Italy) and in many cases the growth in AC is placing a considerable strain on the ability of electricity networks to meet peak power demands. In the newly industrialising countries such as China and India the growth in demand for air conditioning is a major contributory factor causing electricity peak power demand to continue to outstrip new supply. The problem is compounded because electricity supply is often constrained during summer heat waves (e.g. lower hydro output or reduced levels of cooling water for generating plant).

Around the world AC and consumer electronics are the fastest growing energy-using applications. However, because AC power demand is so much greater during intermittent high temperature periods than at other times of the year it has a disproportionate influence on the overall peak power demand of electricity systems. Consequently, AC is already responsible for over half of peak power demand in many regions of Japan, the United States, and Australia and its contribution to peak is growing everywhere.

Growth in AC demand is not just due to AC becoming more affordable and widely accepted. It is also the result of a tendency towards universal building styles that are poorly adapted to the local climate and an increase in internal heat due to electrical appliances and lighting equipment.

Another contributing factor is the increase in peak ambient temperatures in many locations. Part of this increase is associated with the urban heat island effect: a phenomenon under which urban centres have markedly higher average temperatures than surrounding regions due to heat being trapped within the materials from which the city is constructed. The widespread use of dark construction materials combined with high rise buildings (forming urban canyons) and a predominance of local heat sources all contribute to this effect.

In response to these developments the International Energy Agency staged a two day conference “Cooling Buildings in a Warming Climate” in Sophia Antipolis, France on 21-22 June 2004 [IEA 2004b]. This event was attended by over 140 people from 22 countries and was organised within the rubric of the IEA’s Future Building Forum. The conference addressed the remarkable growth in AC, the factors driving this growth and the means by which energy consumption and peak power demand associated with AC could be curbed. Counter measures to urban heat islands were the subject of a first international conference on this topic supported by the IEA and Japanese government in 2006 [IEA 2006b].

6 ENERGY EFFICIENCY POTENTIALS

Despite the substantial improvements in energy efficiency recorded in the last few decades, there are still very substantial opportunities to realise greater cost-effective savings. These opportunities are found in every energy-using sector of the economy and in every economy. Unfortunately, to date there is no comprehensive international appraisal of what these cost-effective savings may amount to overall, but there are appraisals by sector and/or by economy, some examples of which are reported below.

6.1.1 Residential electricity use

The IEA’s publication *Cool Appliances: Policy Strategies for Energy Efficient Homes* [IEA 2003] presents results from a detailed analysis of the cost-effective savings potentials in the residential-electric sector. It concludes that despite the implementation in IEA member states of a raft of policy measures aimed at improving the energy efficiency of specific appliances, most notably energy labelling and efficiency standards, much deeper cost-effective savings potentials remain to be realised (Figure 3). These savings arise because current policies address only a subset of all appliance and equipment types and are rarely set at levels that encourage equipment with least life-cycle cost-efficiency levels to be produced and purchased.

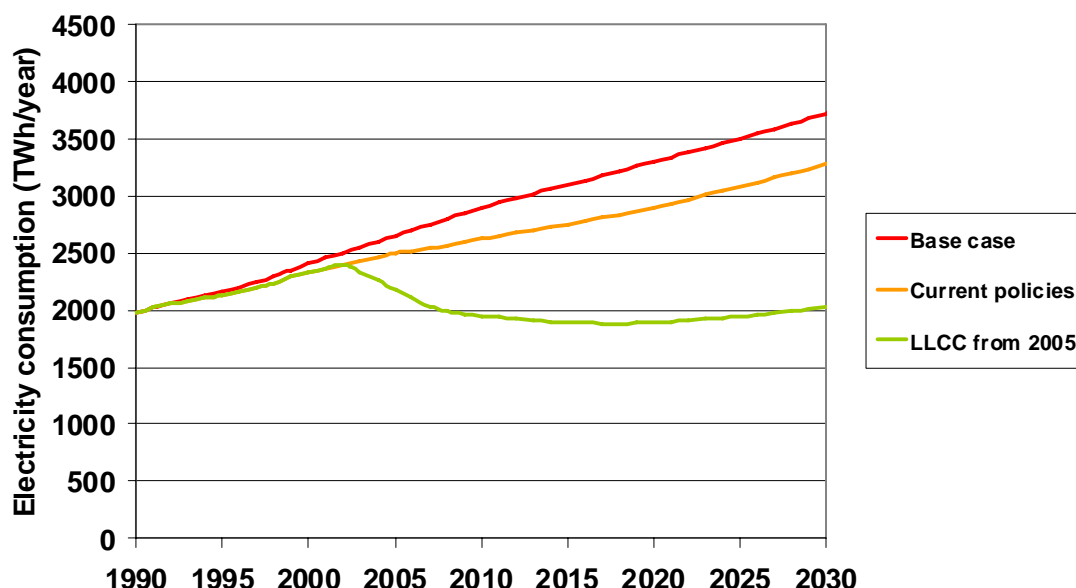


Figure 3: IEA residential electrical appliance electricity consumption under ‘No Policies’, ‘Current Policies’ and ‘Least Life-Cycle Costs from 2005’ scenarios, 1990-2030. [IEA 2003]

The IEA’s analysis shows that, on current policy settings, total residential electricity demand in IEA member states is set to rise from 1850 TWh in 1990 to 3314 TWh by 2030. Already, existing policy measures such as energy labelling, voluntary agreements and selected

minimum energy performance standards are estimated to have saved about 12% of the energy that would have been demanded in the absence of these measures. However, the study also indicates that significant and cost-effective additional savings are available if existing policies are strengthened.

For example, one scenario examines the impact of strengthening policies to the point where the efficiencies of average electrical equipment sold in IEA countries were at the level equal to the lowest life-cycle cost for the consumer (i.e. the minimum of the sum of the equipment price and discounted life-cycle operating costs). If this scenario were converted into policy, which is both technically and economically feasible, IEA-wide residential electricity demand would fall to 2205 TWh in 2030. This would also avoid 523 Mt of carbon emissions in the same year. Since these savings are achieved through cost-effective efficiency improvements, the cost of avoided CO₂ is actually negative, meaning that it is less expensive to conserve the energy and related CO₂ emissions than not to do so. In OECD Europe, for example, the figure is estimated to be -€169/t-CO₂ in 2030.

6.1.2 Service-sector buildings and air conditioning

There are many ways to improve the energy efficiency of commercial and service-sector buildings that pertain to raising the efficiency of the lighting, heating, ventilation, air conditioning, hot water supply and distribution systems. The energy efficiency of office equipment and other plug loads can also be significantly improved. There are a number of studies that address the options to improve the efficiency of these services on a whole-building, end-use, sector or regional basis, but very little that documents the aggregate savings potentials for economies as a whole. Nonetheless, simple benchmarking of peer buildings when normalising for occupied area, climate, functionality and service issues provides a swift and effective means of assessing savings potentials. Work in the USA suggests that, for a given consistent economic region, all of the following factors are important: floor area, climate (weather variables), amount of building area cooled and heated and the levels of space conditioning provided, worker density, personal-computer density, extent of food service and education/training facilities, hours open each week and, for national models, average adjustments for specific types of building-space uses [Hinge et al. 2004].

A paper presented at the IEECB conference [Hicks & Von Neida 2004] showed the relative performance of commercial buildings achieving the US EPA's Energy Star certification compared with the general office building stock. Table 1 shows the wide range of energy use and costs for office buildings in the USA, exhibiting a factor-of-four spread in energy-cost intensity for very similar types of buildings. From this it is clear that Energy Star certified buildings use 39% less energy than their average peers in the US building stock. Similar differences have been shown to exist in the building stock of other IEA countries.

Table 1: Comparison of US office energy-use intensity and energy-cost intensity

	Site/delivered energy intensity (kBtu/ft ² -year)	Site/delivered energy intensity (kWh/m ² -year)	Energy-cost intensity (\$/ft ²)	Energy-cost intensity (\$/m ²)
Energy Star offices	61.4	194	\$1.23	\$ 13.24
CBECS average	101.1	319	\$2.03	\$ 21.85
CBECS top 25%	48.2	152	\$1.02	\$ 10.98
CBECS bottom 25%	217.0	684	\$3.51	\$ 37.78

CBECS = Commercial Building Energy Consumption Survey; <http://www.eia.doe.gov/commercial.html>

7 LOW ENERGY TECHNIQUES TO REDUCE AND MEET COOLING DEMANDS

There are many ways in which AC energy consumption can be reduced including the use of more efficient conventional AC systems that can lower energy consumption by up to 75%. Other means apply to the built environment e.g. improved shading, better choice of materials to reflect heat and solar radiation, superior glazing, use of natural ventilation, thermal storage, optimised insulation; or involve the usage of alternative cooling technologies, such as district cooling schemes and systems exploiting natural cool energy sources.

Many of the best techniques for delivering summertime comfort in buildings do not involve the use of active cooling systems. For example, a study of passive means for reducing cooling demand in UK housing [Palmer 2004] found that the most effective approaches were:

- Use thermal mass with natural night cooling ventilation. With proper control, this is the single most effective strategy
- External shading is the most effective form of shading, but it should not be allowed to conflict with natural ventilation provisions.
- Give the occupants some form of solar control
- A solution combining all three strategies will provide the greatest possibility to reduce overheating.

In office buildings there is great potential to maximise daylight while minimising unwanted summer solar gains or winter thermal losses by using intelligent passive glazing designs as demonstrated in the International Solar Center building in Germany for example, Figure 4.

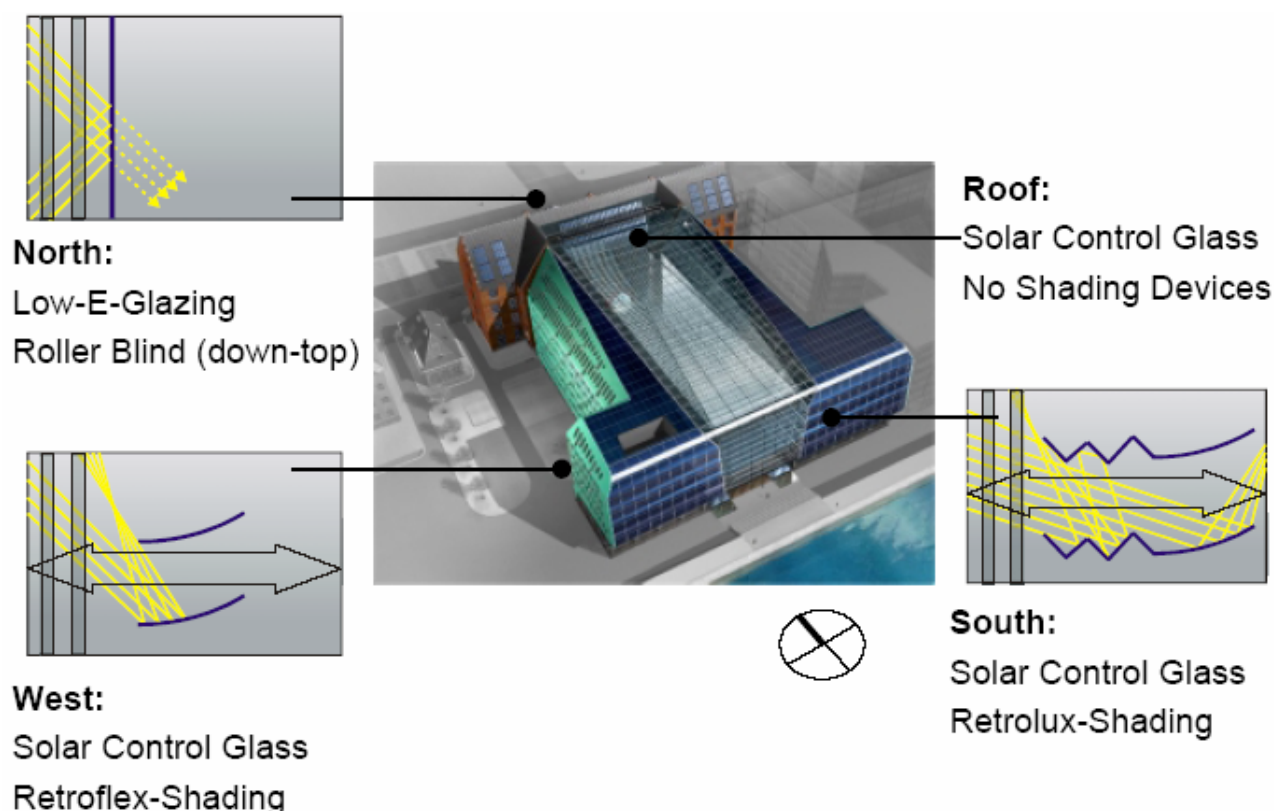


Figure 4: Use of intelligent low energy glazing and solar/daylight control in the International Solar Center building in Berlin [Himmeler 2004]

In mixed cooling and heating environments it is often possible to produce thermal comfort without resorting to active air conditioning provided: more thought is given to the issue in the initial building conception, building operation is optimised and internal and solar gains are

minimised. However, if active air conditioning is needed there is much that can be done to minimise its energy requirements especially by selecting the right type of system for the job and by exploiting natural energy flows through thermal storage systems and night time cooling etc. For example, a survey of air conditioning energy loads in UK office buildings found that the most common option of chiller and fan-coil based solutions used the most energy to provide the cooling service. All air AC systems required 25% less energy on average, variable-flow or volume AC systems used 35% less energy and chilled beam systems used 75% less energy to provide equivalent comfort [Knight & Dunn 2004].

Evaporative cooling can be far more energy efficient than conventional AC systems when a water supply is available and the wet bulb cooling requirements are not too high [Kinney 2004]. Desiccant cooling, district cooling and systems using natural coolth stores such as lakes and oceans are other promising low energy cooling systems that are highly appropriate in some instances. Selecting the best adapted type of cooling system for the local circumstances is probably the easiest means of minimising cooling energy consumption short of exhausting passive building and site design solutions, but the choice is not at all evident for a non-expert. Unfortunately, most countries have not established the taxonomy of cooling options that can help guide those looking for low energy cooling services to identify the best generic technology choice for their microenvironment and building function. Even if such measures have been taken there is a need to ensure that a local industry exists to supply and service the appropriate technology. In the absence of these steps traditional AC systems (all air and air to water) fill the void, but even here there is considerable potential to choose a higher efficiency solution in favour of the less efficient alternatives, especially if part-load performance is considered.

8 THE ON-GOING NEED FOR POLICY MEASURES

Policy measures are therefore necessary in market economies to reinforce the role of energy prices and to lower the transaction costs involved in accessing least-cost energy services. Most policy measures are designed to help overcome some or all of the market failures that prevent this from happening. Energy efficiency policy is also often driven by environmental concerns, and within this wider rubric policy measures may aim to minimise overall energy-service costs once environmental externalities have been factored into the equation.

To date a wide range of policy instruments have been used in IEA member states to stimulate higher energy efficiency. These include: the development of standard test procedures to define and measure energy efficiency, energy labelling, regulatory standards (building codes, equipment energy efficiency standards, etc.), energy consumption taxes, voluntary agreements, fiscal incentives (capital allowances, reduced VAT, lower corporate taxes, etc.), public information campaigns, provision of energy audits, training and technical support programmes, public and bulk procurement initiatives, energy efficiency R&D, regulatory incentives for energy utilities to provide energy efficiency services, efficiency targets, voluntary agreements with industry, white certificates, etc.

The relative merits of these policy measures are not discussed here nor are the policy driven energy efficiency achievements of IEA countries compared; however, the newer initiatives of the Italian white certificate programme and the Japanese Top Runner programme are briefly described to highlight some of the range of options.

White certificates are one of a raft of new policy measures that some IEA member states have begun to implement to promote energy efficiency. In the case of Italy designated energy suppliers are required to achieve mandatory efficiency improvement targets. These efficiency gains can either be realised within the concerned enterprise, among its clients or elsewhere; however, wherever the savings take place they can only be accepted towards

achieving the targets if they have been certified by the regulatory body and a “white certificate” has been issued. To facilitate least cost efficiency improvements the certificates may be traded on the open market in much the same manner as CO₂ permits can be traded in some national, or regional carbon trading schemes [Pavan 2004].

Japan's Top Runner programme introduces mandatory fleet-average energy efficiency requirements set at the level of the most efficient product on the Japanese market at the time the requirement was formulated. Affected products must satisfy the requirements by a specified date (mostly between 2003 and 2007), which is typically about 4 years after the regulation was first issued. Requirements, which in some cases will result in average efficiency improvements of over 50%, have been set for some 21 products including: cars, trucks, room air-conditioners, TVs, lighting and refrigerators [IEA 2002]. Figure 5 shows the requirements for air to air heat pumps. The Top Runner Programme is expected to achieve 0.35 EJ of energy savings by 2010 [IEA 2002].

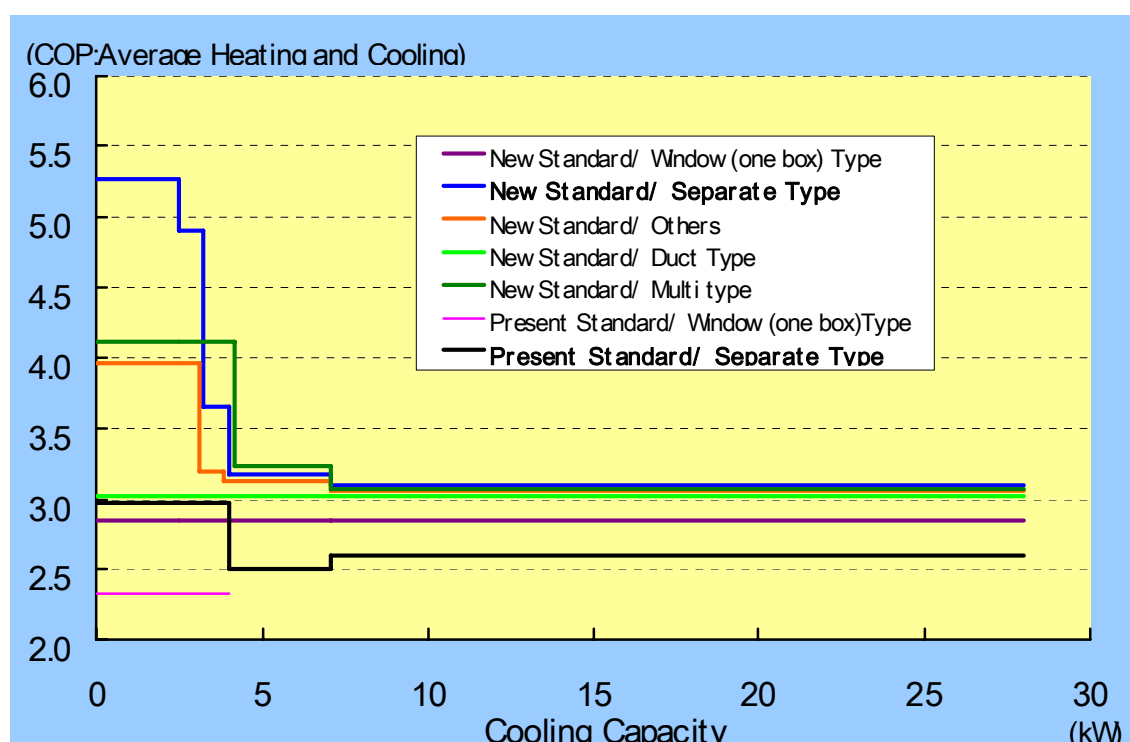


Figure 5: Japan's Top Runner requirements for reversible air conditioners (Minimum COP requirements are the average of the cooling EER (W/W) and heating COP (W/W))
[Murakoshi et al 2005]

There are many estimates of the expected savings from energy efficiency policy measures, but how can we be sure that policy measures work and achieve the desired end? The following section provides examples of evaluations of energy efficiency policy impacts in IEA countries.

9 WHAT'S ROUND THE CORNER?

The recent macro energy-sector developments outlined at the beginning of this paper have considerably raised the profile of energy efficiency policy and the need for more rigorous policy settings. The first public manifestation of a renewed focus came in the meeting of the G8 at Gleneagles in July 2005. The G8 communiqué mandated the International Energy Agency to lead a number of initiatives aimed at lowering the CO₂ content of energy services:

most of them focused on energy efficiency activity. The agency will report on these at the G8 energy ministers meeting in Japan in June 2008; however, as apart of this process the agency has been making concrete recommendations on energy efficiency policy. Up to the 2007 Heiligendamm G8 summit the IEA had made sixteen policy recommendations amongst which are those that encourage government to:

- set mandatory building energy codes for new buildings and major retrofits that aim to minimise the lifecycle energy costs of the building over a minimum of 30 years
- set objectives for passive energy homes and zero energy buildings market share of all new construction by 2020
- adopt a portfolio of policy measures to address the energy efficiency of existing buildings
- adopt mandatory energy performance standards and labels for all major energy using equipment
- increase investment in energy efficiency
- produce national energy efficiency action plans

The meeting of IEA ministers in May 2005 had already made it clear that energy efficiency would be the main focus of new energy policy efforts and this has begun to become visible in renewed national policy measures such as: a revision of the Japanese Energy Conservation Law, the adoption of the European Energy Services and Energy Performance in Buildings Directives, the renewal and doubling of the UK's Energy Efficiency Commitment requirements that require utilities to implement energy savings; the tripling of the value of French tax incentives for energy efficiency measures in residential buildings and adoption of a white-certificates energy efficiency cap and trade scheme; the implementation of the Italian white-certificates scheme; the strengthening and broadening of European, North American and Japanese energy performance building codes e.g via the EU Energy Performance in Buildings Directive; the introduction of many more equipment energy efficiency standards in the 2005 US Energy Policy Act and provision of new tax incentives for efficient building solutions (also applying to HVAC) and the on-going development of many new equipment energy performance requirements via the EU Eco-design of Energy Using Products Directive; the adoption of a raft of new energy efficiency policy measures in China, India, Australia and Korea to name but a few of the developments that took place in recent years. In 2006 Japan strengthened and extended their building codes to include a whole building approach and also apply to major retrofits. In 2007 European countries developed and published their national energy efficiency action plans under the terms of the energy services Directive.

Energy efficiency policy, for so long ignored in energy ministries, is now experiencing a new lease of life derived from its unique characteristics. What other energy service options can reduce greenhouse gas emissions, reduce energy service costs and improve energy security? As shown in this paper recent analyses have illustrated the huge benefits already attributable to past energy efficiency improvements and have demonstrated the clear role that policy can play in delivering these. But analyses also continue to show that very large untapped cost-effective savings potentials remain. Efficiency is the cheapest and the greenest choice.

Given this it's clear that energy efficiency measures are going to be strengthened in all OECD and non-OECD economies over the coming years. In the case of heat pumps, refrigeration and air conditioning we can expect the following:

- Tougher regulations (more stringent MEPs and labels applied to all end-use equipment, including niche products)
- Tougher building codes setting out minimum energy performance requirements

- Cleverer building codes which combine whole building performance requirements with requirements for each end-use type and include multiple compliance pathways
- Specific compliance rewards in building codes for building design measures that reduce peak power requirements (specific focus on those that reduce AC needs at peak; already happening in California)
- Stronger enforcement of standards and codes
- Mandatory building energy certification (already happening in Europe)
- Mandatory performance certification of air conditioning equipment via on-site inspections (already happening in Europe)
- Greater requirements for use of building energy management systems
- Greater fiscal and financial incentives to encourage efficient buildings and equipment
- Regulatory requirements for commercial refrigeration
- Utility savings obligations and tradable permits in energy efficiency (already happening in Europe and some US states)
- Intensification of other types of utility financed energy efficiency programmes
- Bulk public procurement of efficient equipment and services
- Obligations on government to lead by example – e.g. compulsory adoption of cost effective savings opportunities in public sector buildings (already implemented in Denmark)
- Increased sophistication in time of use metering, feedback and demand response
- Greater promotion and encouragement of energy service companies (ESCOs) and performance contracting
- Awareness raising and user behaviour programmes
- Targeted support for efficient heat pump based solutions for water heating, space heating and clothes drying (both for commercialised products and for RD&D) and disincentives to the continued use of electric resistance heating
- Measures that target the performance of AC in vehicles including efforts to design a viable energy performance test procedure

The progressive adoption of these and similar measures is going to have a profound impact on the nature of the heat pump industry. Not only will the energy performance of factory assembled equipment be tightly regulated, but there will be a shift in the incentive structures applying in the construction and building services sectors. Contractors will not just be competing on first cost to meet a minimum functional requirement, but will increasingly be competing on the competence with which they are able to provide least life cycle cost building services – e.g. thermal comfort and indoor air quality at lowest life cycle cost. This will require new and more sophisticated relationships to be established between designers, construction contractors, equipment suppliers, installers and commissioners, and operation and maintenance contractors, so that all can be seen to play their part in providing the most efficient building energy services. Ultimately, the greatest market rewards will go to those that have organised themselves to the degree that they can provide seamless, reliable, integrated low-energy building services from design through to operation. Industry and building service practitioners therefore face a challenge to develop the necessary competences to exploit the evolving market conditions as policy is strengthened. All these developments present a major opportunity for efficient heat pump-based heating and cooling solutions but will penalise less efficient heat pumps within given product classes.

10 CONCLUSIONS

Over the last few decades, energy efficiency improvements have made a very significant contribution to the provision of energy services in OECD economies and have played a major role in dampening overall energy service costs. The benefits of energy efficiency have mostly been delivered at very low cost compared with competing supply-side options; nonetheless,

there are plenty of documented cases where energy efficiency potentials are not being fulfilled. A variety of market failures and imperfections are limiting the uptake of cost-effective energy efficiency measures, and as a result the response of energy efficiency investments to energy price signals is weak. This underlines the need for the public and private sectors to increase their efforts to access energy efficiency resources.

Government policy measures appear to have played an important role in realising historical efficiency improvements, but the fact that these have been achieved with limited resources suggests that more could be done. Total cost-effective energy efficiency resources are still unknown and the policy tools needed to exploit them have not been fully appraised. Many important market failures and imperfections are currently inadequately addressed. In particular, the energy efficiency of end-use equipment and systems needs to be made more transparent to end-users. Further efforts are needed to ensure that the energy performance of all end-use equipment and systems is presented to users in a consistent and comparable manner so that market forces are able to operate in an effective manner.

In this paper, the energy reserves made available through increased efficiency have been explored. The available evidence shows that very large efficiency reserves have already been exploited. By tapping these resources, the world has greatly reduced the economic and environmental pressure that would have been caused by increased use of fossil fuels and other energy sources. However, recent studies also show that still more efficiency reserves are available for exploitation, which are both large and economic to tap. Energy services based on efficient heat pumps will play an important part in their development.

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