White Paper: **Energy Efficiency**

September 2011

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Energy Efficiency in the Global Marketplace

There is no one definitive definition for energy efficiency. Merely reduction consumption by behavioural changes such as not using air conditioning is deemed by some as energy efficiency and not by others as it is easily reversible and usually in response to high energy prices, that can fall in no time. Economists define energy efficiency in a broad sense as 'changes that result in decreasing the amount of energy used to produce one unit of economic activity' e.g. energy used per unit of GDP or value added. Energy efficiency experts refer to improving energy efficiency as the result of an action the 'aims at reducing the amount of energy used for a given service e.g. lighting, heating, by the purchase of efficient equipment, retrofitting investment to reduce the consumption of existing buildings and facilities, or avoiding unnecessary consumption of energy'.

This is different from energy conservation which is a reduction in the total amount of energy consumed.

Energy intensity and its' change is often used as a measure of energy efficiency in the broadest sense as this includes structural and behavioural changes, an example of a structural change is changing weather. It is measured as a ratio of energy consumption to a measure of demand, e.g. energy consumption per unit of GDP, as mentioned above. Often countries with more energy intensive industries have a high energy intensity figure. So much so that it is thought that the reduction in energy intensity in some major western countries is due in part to a reduction in energy intensive industries, as many relocated to developing countries. Five of the top ten countries are island nations reliant on energy imports. The bottom ten countries are all classed as developing countries with a very low GDP.

Top ten and bottom ten countries in terms of energy intensity in 2008

Country	Energy Intensity, Btu per USD GDP (2005)
Top Ten	
US Virgin Islands	96,765
Turkmenistan	59,249
Netherlands Antilles	40,740
Uzbekistan	36,209
Bahrain	26,142
Brunei	24,189
Trinidad and Tobago	23,314
Cuba	21,666
Iceland	20,865
Ukraine	20,520
Bottom Ten	
Kiribati	1,091
Niger	1,091

Country	Energy Intensity, Btu per USD GDP (2005)
Burkina Faso	992
Ethiopia	986
Uganda	967
Afghanistan	737
Guinea	719
Rwanda	650
Mali	560

Source; Energy Information Association

Furthermore, in country's experiencing economic growth, their overall energy intensity may have increased not through any decline in energy use. For example, in Russia a decline in the reported energy intensity from 2000 to 2007, is more to do with increasing oil and gas prices rather than reduced consumption or more efficient operations.

In terms of energy efficiency the US's Energy Information Centre has identified several indices for measuring changes in energy efficiency:

Market-Basket Approach. The market basket approach estimates energy-consumption trends for a controlled set of energy services (the market basket) with individual categories of energy services controlled relative to their share in the index. This method of indexing is a type of "bottom-up" approach. Limitations: lack off efficiency measures for some services and nature of measures may not be derived in actual use conditions, updated regularly and so on, and consumers may substitute comparable products if prices change'.

Comprehensive Approach. The comprehensive approach attempts to take all energy use into account. The comprehensive approach starts the measurement process with the broadest available measures of energy use and demand indicators available. Over time, changes in such measures reflect changes such as changes in behaviour, weather, structure, and energy efficiency. The effects, unrelated to changes in energy efficiency, are then removed. This approach can be thought of as a "top-down" approach. It is like peeling away all the effects until energy efficiency is all that remains. Energy consumption is measured as primary energy (the amount of energy delivered to an end user adjusted to account for the energy that is lost in generation, transmission or distribution) or site energy (the amount of energy the is delivered to an end user that is not adjusted as for primary energy). The demand indicator is a measure of the number of energy-consuming units for which energy inputs are required. Limitations: deciding on which energy services should be included is difficult and separating out weather, structure and behavioural changes is challenging.

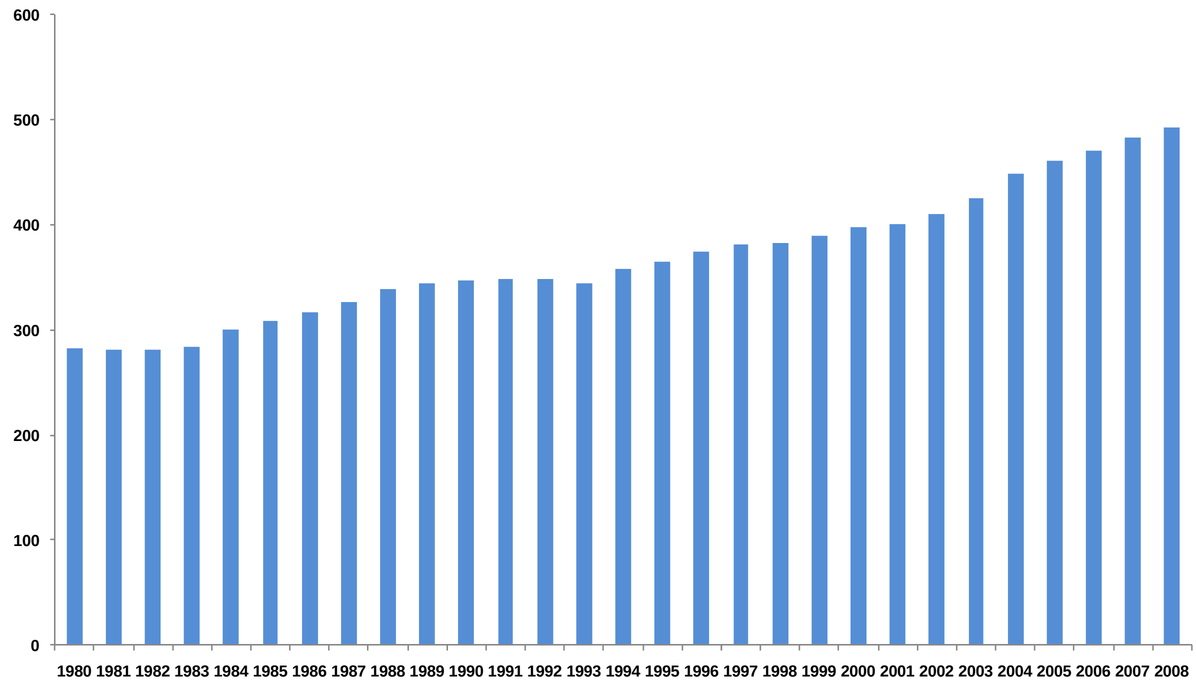
Factorial Decomposition Approach. The factorial decomposition approach applies Laspeyres indices to decomposing changes in energy use to produce growth rates of change in energy use for a particular effect. Energy use is decomposed into an activity effect, structural effect, and an intensity effect. Each of these effects is measured by holding the other two constants. As an example, this approach measures the relative change to a base year in the use of energy that would have occurred due to the intensity effect if there had been no changes in the activity or structural effect. This approach is widely used. A good example of its use is in *Indicators of Energy Use and Efficiency* published by the International Energy Agency. The decomposition approach is described in detail in the publication's appendix.

Divisia Index Approach. The Divisia index approach may be used to decompose time trends into the different factors such as structural and intensity. The results may measure energy savings over time and uses time trend data.

Best Practice Approach. According to this approach, the difference between the current or average practice of producing e.g. a ton of steel and the "best practice" of producing e.g. a ton of steel allows you to look at what is possible. Different types of "best practices" can be used as the reference case depending on what type analysis is being undertaken. It can be used to compare a single establishment or a single process within an establishment'.

Source: Energy Information Association's website

Worldwide primary energy consumption, Quadrillion Btu, 1980 to 2008

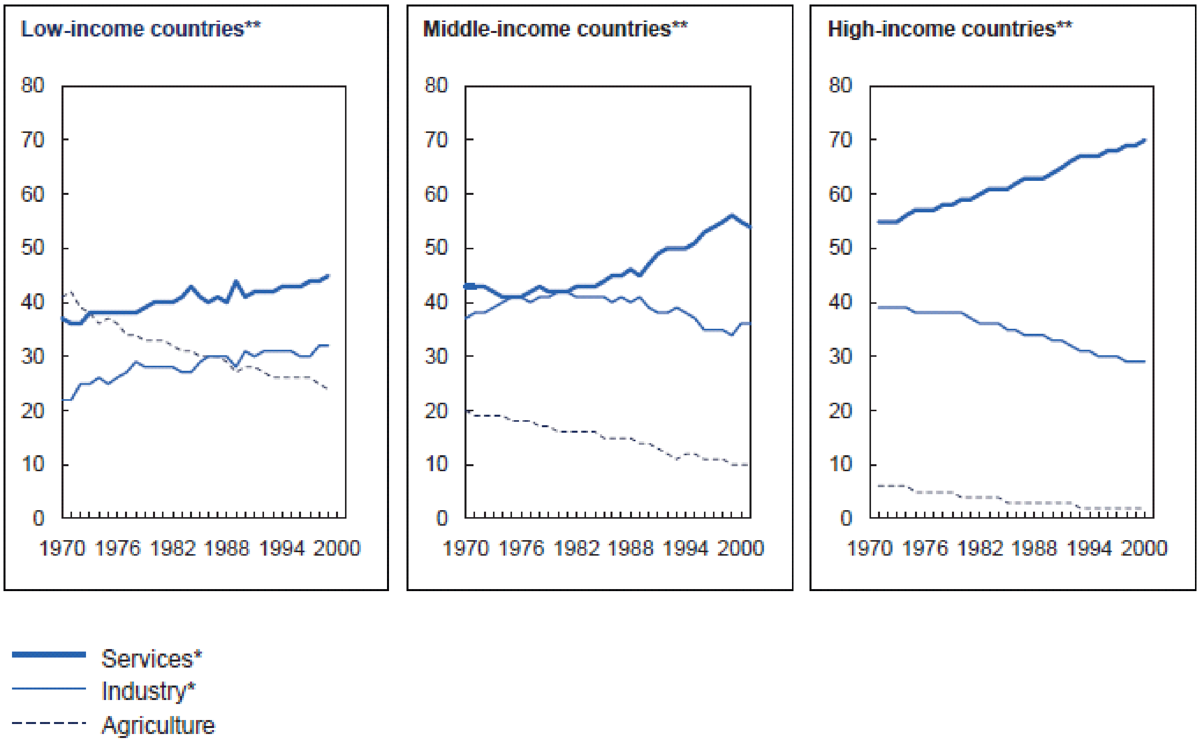


Source: NRG Expert Almanac

Overall energy intensity has declined in most of the major regions of the world over the review period. The exceptions to this are Central and South America and the Middle East, which only reported a slight decline in energy intensity in 2008 but a general trend of increasing energy intensity. The overall high energy intensity in Central & South America and the Middle East can in part be explained by oil and gas subsidies that do not encourage the efficient use of transportation fuels in the road transportation sector.

Studies on energy intensity by region found that different sectors contribute more to the overall energy intensity than others. In higher income countries, such as in North America and Europe, the increasing share of the service sector in terms of contributing to the overall GDP is high and increasing. By contrast the more energy intensive industrial and agricultural sectors are contributing less to the country's GDP. The reverse is true for low income countries and medium income countries stand somewhere in the middle.

Percentage contribution of services, industry and agriculture to the country's GDP in low-income, middle-income and high-income countries, 1970 to 2001



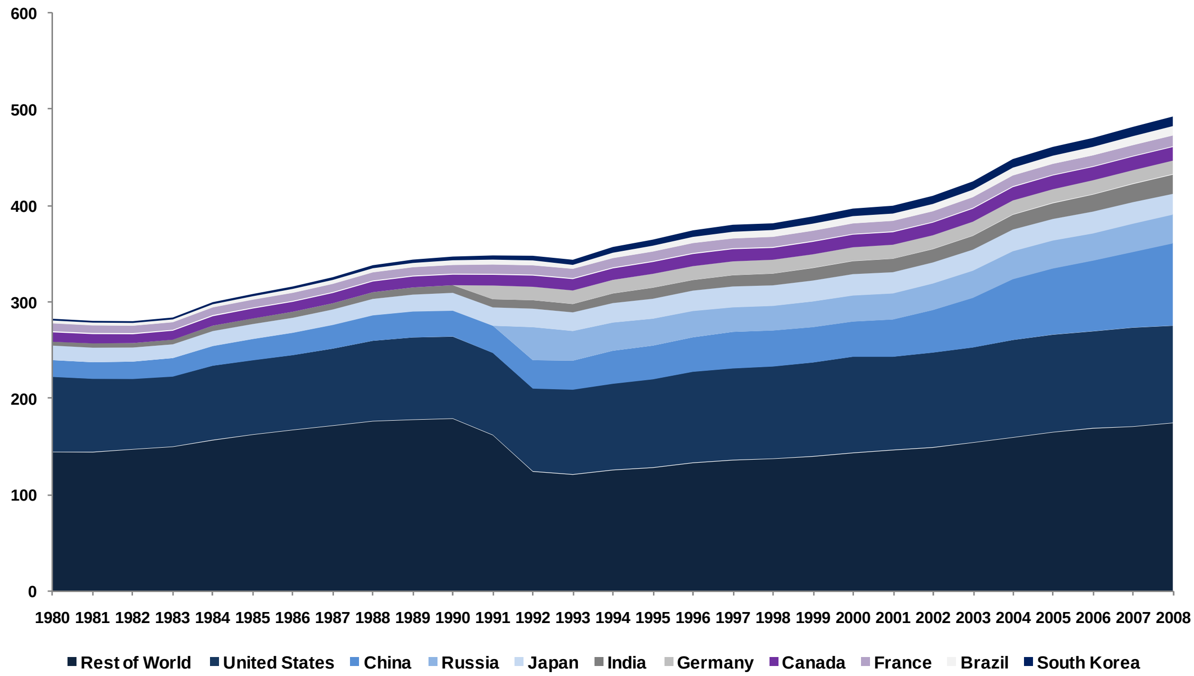
*Industry includes manufacturing, mining, and construction; services include personal, professional and public sector services and utilities.

**The World Bank defines middle-income economies as those with per capita GNI in 2003 between USD 766 and USD 9,385 measured with average exchange rate over the past two years.

Source; MGI Analysis, WDI, World Bank

Primary energy consumption has increased in all regions over the review with the exception of Eurasia (CIS countries).

Total primary energy consumption of the top ten consuming countries, 1980 to 2008, quadrillion Btu



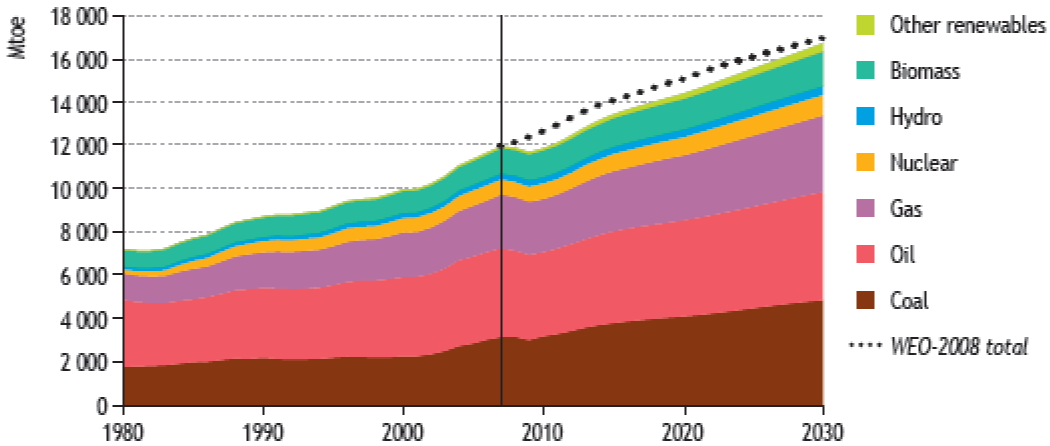
Source: NRG Expert Almanac

In the United States, the country's energy intensity has been decreasing year-on-year since 1980 to 7,603 Btu per unit dollar GDP. A decline in energy intensity was also reported in China until 2001. Then the reported rose then fell slightly to 11,087 Btu per unit dollar GDP. The third largest consumer of primary energy, Russia, has been reporting declining energy intensity from 2000, reaching 14,537 Btu per unit dollar GDP in 2008 - the highest of all the top five consumers. In part due to the fact that Russia does not have residential metering for natural gas consumption and thus there is no incentive to use natural gas efficiently. By comparison the energy intensity in Japan and India remained relatively constant and low over the review period. Japan has very high energy efficiency standards.

Of the next five top energy consumers, energy intensity has been declining slowly in sixth placed Germany and in seventh placed Canada. Canada has a higher energy intensity overall than Germany, perhaps explained by the presence of more high energy consuming industries in Canada such as mining. Energy intensity has remained relatively constant in France. In ninth and tenth placed Brazil and South Korea, the country's energy intensity has increased and remained relatively constant over the past ten years.

Overall energy consumption is expected to increase by 2.5% over the 2010 to 2015 period, according to estimates by the IEA in its 2009 World Energy Outlook reference scenario, and then is projected to level out with an average of 1.5% growth up to 2030 with the maturing of emerging economies and slowing of population growth. Thus, creating an incentive to use energy more efficiently in the face of expected increasing hydrocarbon prices and demand in the mid-term. Even though actual demand may be less than this, growth in energy demand is inevitable, and the need for energy efficiency technologies.

World primary energy demand by fuel in the IEA's reference scenario

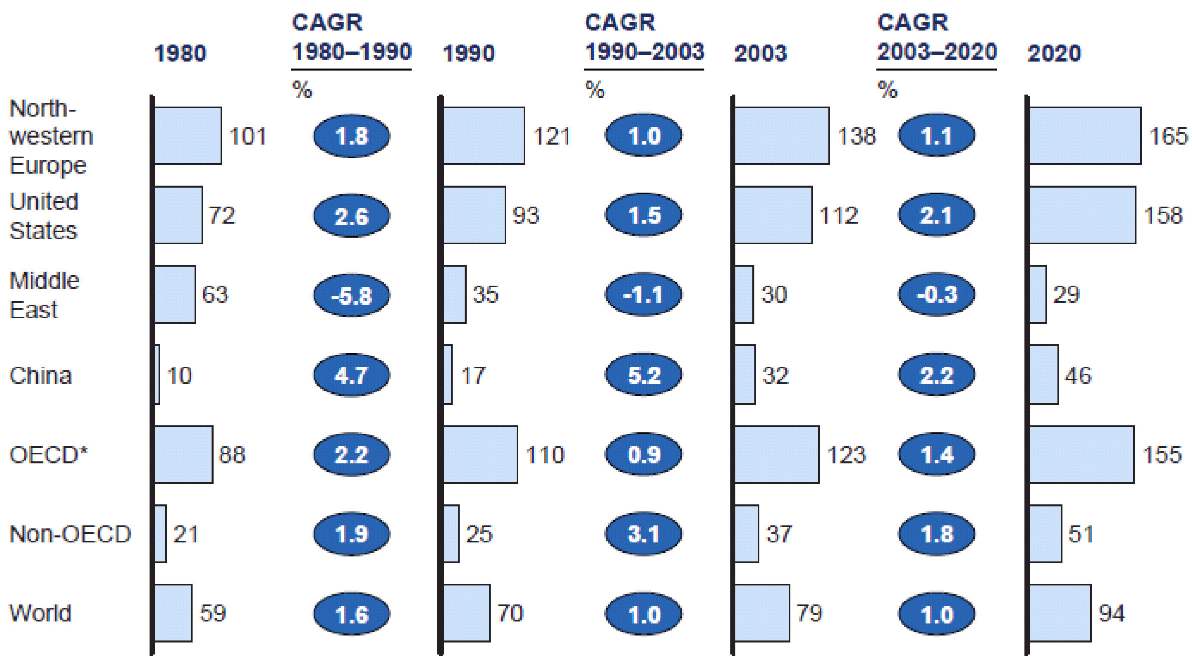


Source; IEA World Energy Outlook 2009

According to the IEA's World Energy Outlook growth in energy demand in the non-OECD countries up until 2030 is expected to be driven by China and India, and the Middle East.

The inverse of energy intensity, energy productivity, is often used to measure the ratio of value added in terms of GDP to energy outputs. A study by McKinsey expects that all regions globally will increase their energy productivity over the next eleven years, with the exception of the Middle East, due to energy efficiency measures. However, this seems unlikely to occur as countries in the Middle East region are focusing more on reducing their own consumption in order to free up more oil for the export market. Growth in energy productivity is expected by McKinsey to be driven by non-OECD countries, rather than the OECD.

Actual and projected energy productivity by region, Billion USD GDP per Quadrillion Btu, 1980 to 2020

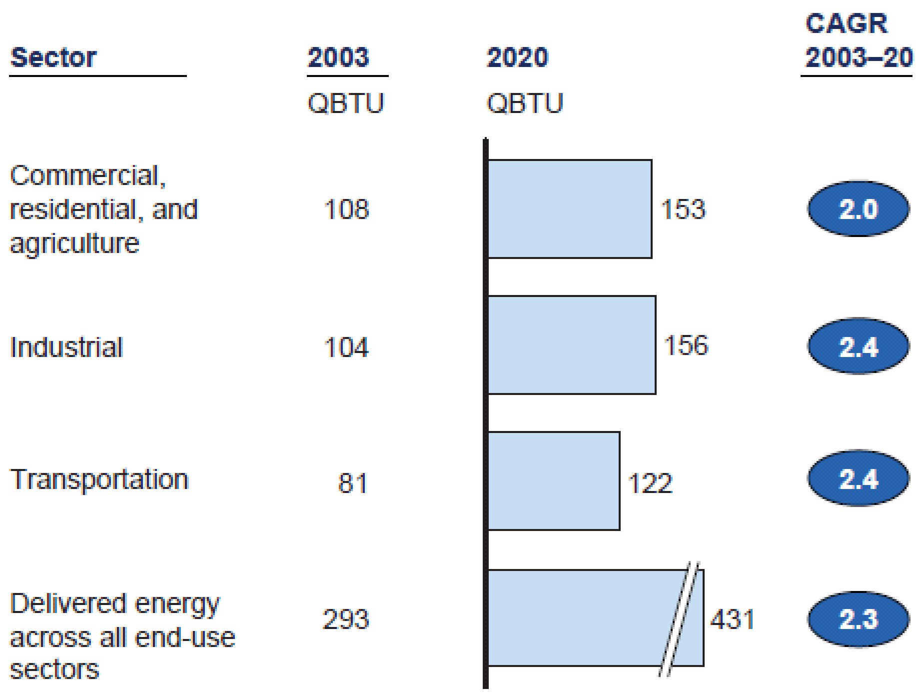


*including North Africa

Source; IEA, MEI, Global Insight, MGI Analysis

This projection is based on growth mainly in China and the Middle East, with low growth in OECD Europe. As oil subsidies are expected to continue to be used in the Middle East and in China increasing disposable income for cars and growth in the chemical and steel industry will increase energy demand. However, McKinsey's energy market projects are based an assumption of a real oil-price of USD 50 per barrel in 2020, which seems unlikely. Also, the Middle East is focusing more on energy efficiency, to increase the amount of revenue it can achieve from exports from the production of oil and gas.

Forecast of delivered energy demand growth, 2003 to 2020

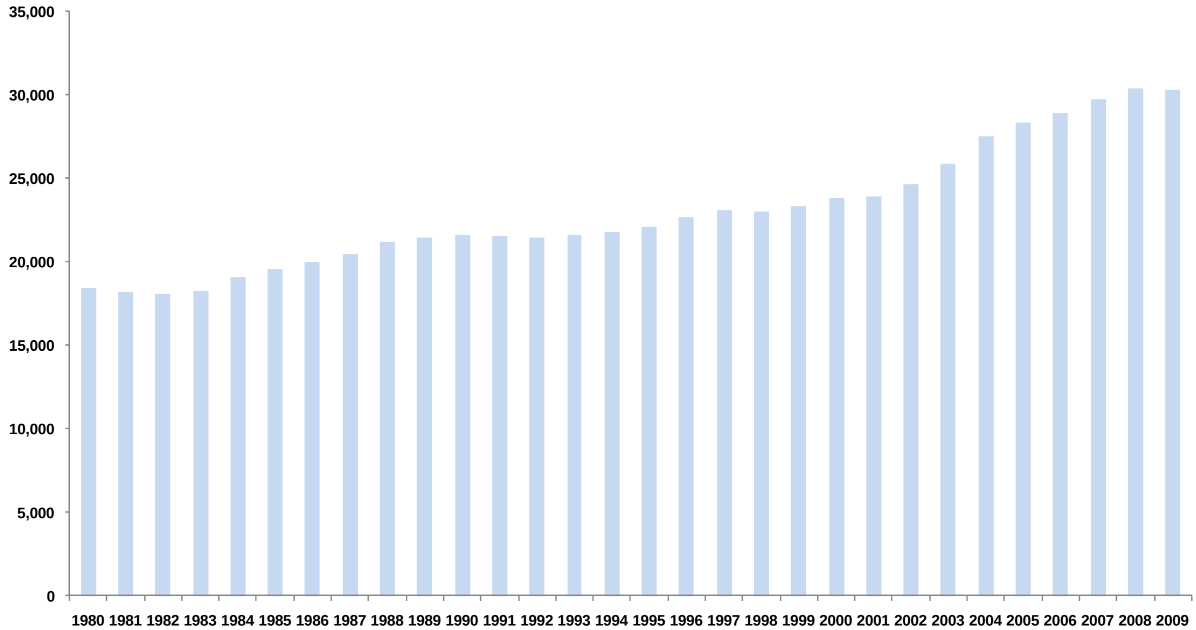


Source: MGI Global Energy Demand Model

Another measure of energy demand and intensity could be emissions of CO_2, but actual CO_2 emissions depends upon the carbon content of the energy sources used and the energy source mix. For example, countries which use coal-fired power plants for electricity generation may have high carbon dioxide emissions per unit of GDP, but low energy consumption per unit of GDP.

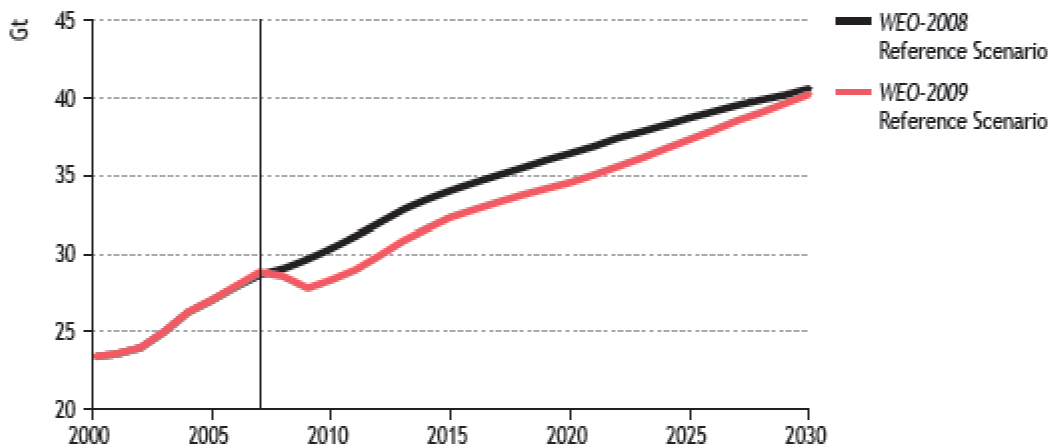
Globally carbon dioxide emissions from the consumption of energy have increased since 1980.For the IEA's 2009 reference 'business-as-usual' scenario global CO_2 emissions are expected to increase by 1.5% annually until 2030. By 'business-as-usual' this refers to no new emission policies being implemented other than those in mid-2009 and takes into account low emissions in 2009. Thus, this projection seems rather low considering 2009 was a weak year in terms of economic growth, and lack of growth, and a higher rate of growth similar to the 2008 projection is more likely

Global CO_2 emissions from the consumption of energy, million tonnes, 1980 to 2009



Source: NRG Expert Almanac

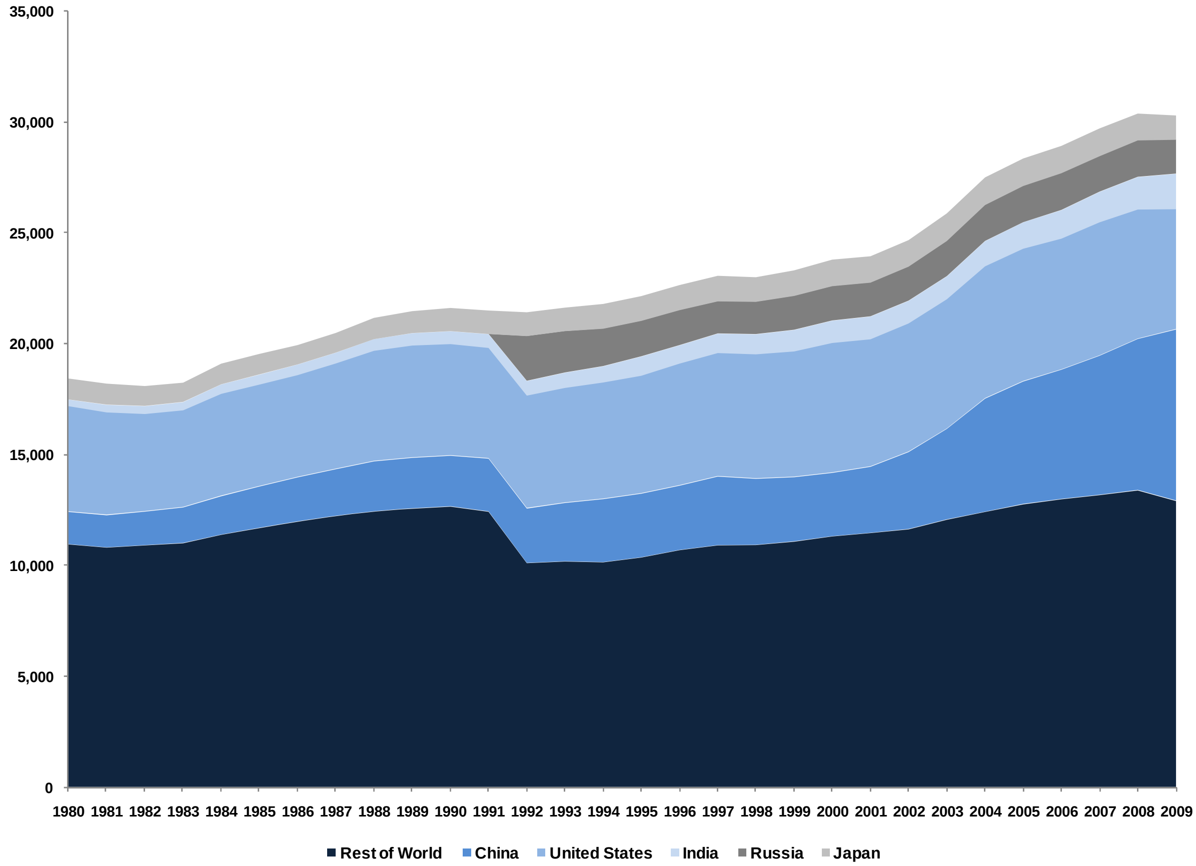
World energy-related CO_2 emissions for the IEA's World Energy Outlook 2008 and 2009 scenarios



Source; IEA World Energy Outlook

The top five countries in terms of carbon emissions are China, the United States, India, Russia and Japan, with China and India reporting the highest increase in emissions over the review period. Carbon emissions in China are expected to continue to increase with a projected increase in GDP.

CO_2 emissions from the consumption of energy in the top five emitting countries, 1980 to 2009, million tonnes

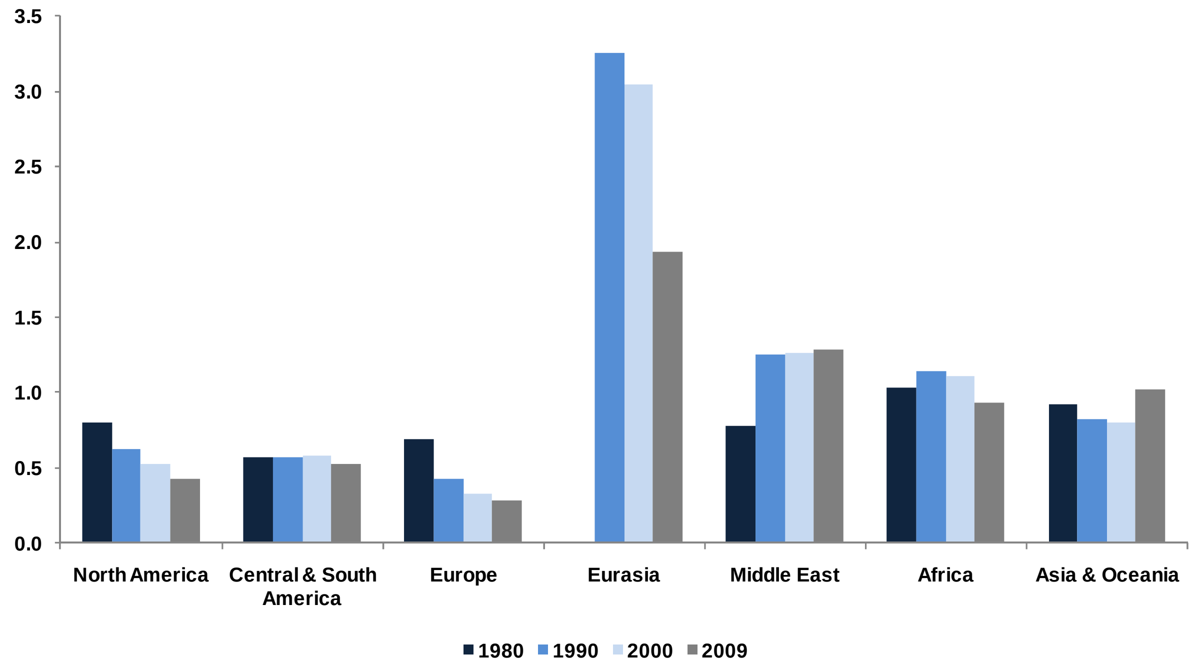


Source: NRG Expert Almanac

Over the review period overall emissions of CO_2 have increased most in Asia and Oceania (274%), accounted for by growth in China and other emerging economies, and the Middle East (244%). Growth was also reported in Africa (108%), Central and South America (93%) and North America (17%). In Eurasia and Europe emissions actually fell by 24% and 8% respectively.

However, the carbon intensity measure in emissions of CO_2 per unit of GDP is not particularly high in Asia & Oceania when compared to Eurasia, which has the highest carbon intensity. If we can assume high carbon intensity equates to low overall energy efficiency, then Eurasia has low energy efficiency, despite comparatively low overall CO_2 emissions, and Europe and North America have high energy efficiency. This is very similar to reported figures for energy intensity.

Carbon intensity from the consumption of energy by region, tonnes of CO2 per thousand USD GDP (2005 USD), 1980, 1990, 2000 and 2009



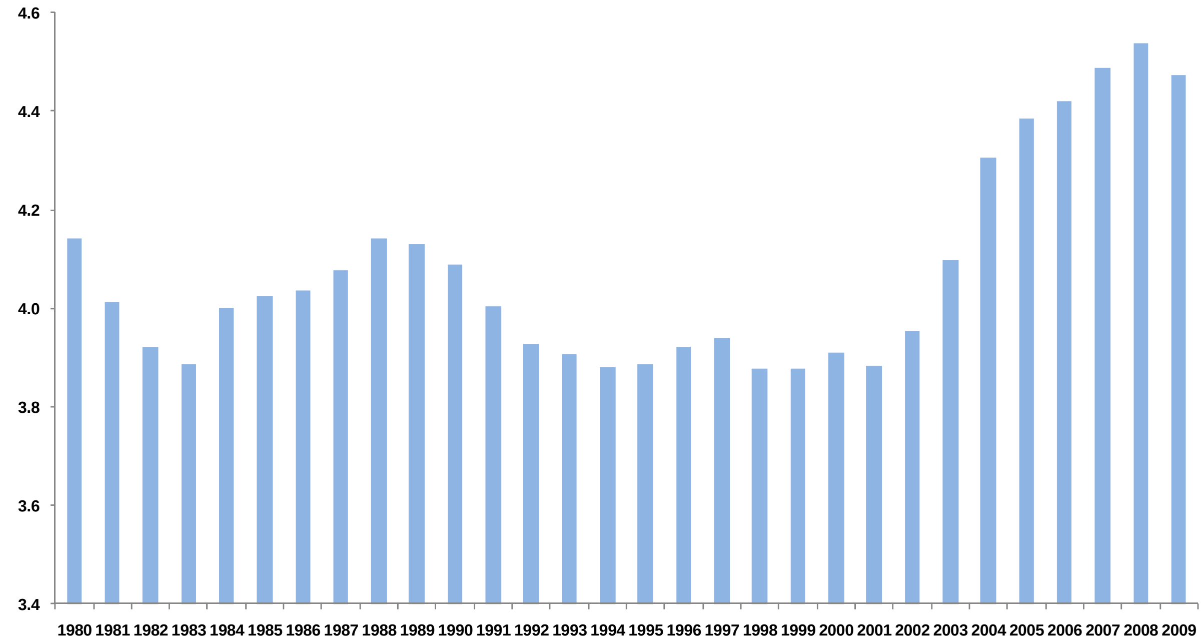
Source; Energy Information Association

Furthermore, the carbon intensity in Japan and the United States is below the world average and the carbon intensity in China and Russia is declining.

Overall global carbon intensity declined over the review period, but has remained relatively constant for the past ten years.

However, carbon emissions per capita have actually increased since 2002, with a slight decline in 2009. Maybe this is due to less carbon intensive industries contributing more towards an increase in unit GDP than more carbon intensive industries.

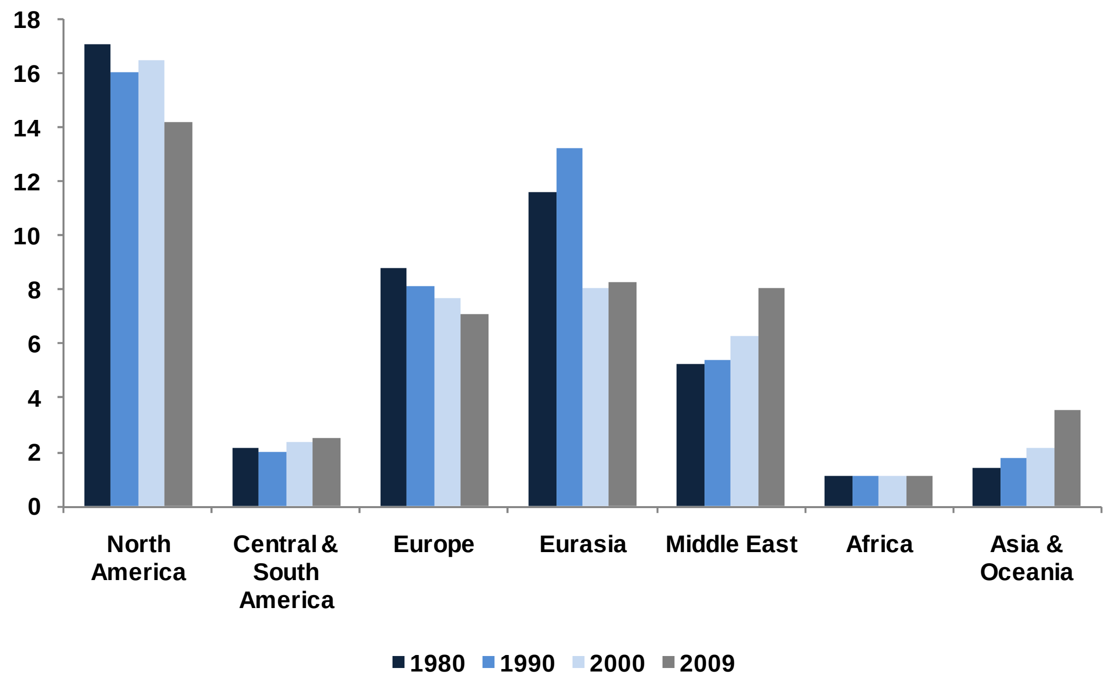
Global carbon emissions per capita, tonnes CO_2 per capita, 1980 to 2009



Source: NRG Expert Almanac

The highest CO_2 emissions per capita were reported in North America, but have been declining over the review period as well as in Europe and Eurasia. Emissions per capita have been increasing in the Middle East and Asia & Oceania.

Global carbon emissions per capita, tonnes CO_2 per capita, 1980 to 2009



Source: NRG Expert Almanac

Of the top five carbon emitters, emissions per capita are below the world average in India; slightly higher and rising in China; and significantly higher in the United States, Russia and Japan.

Negawatts

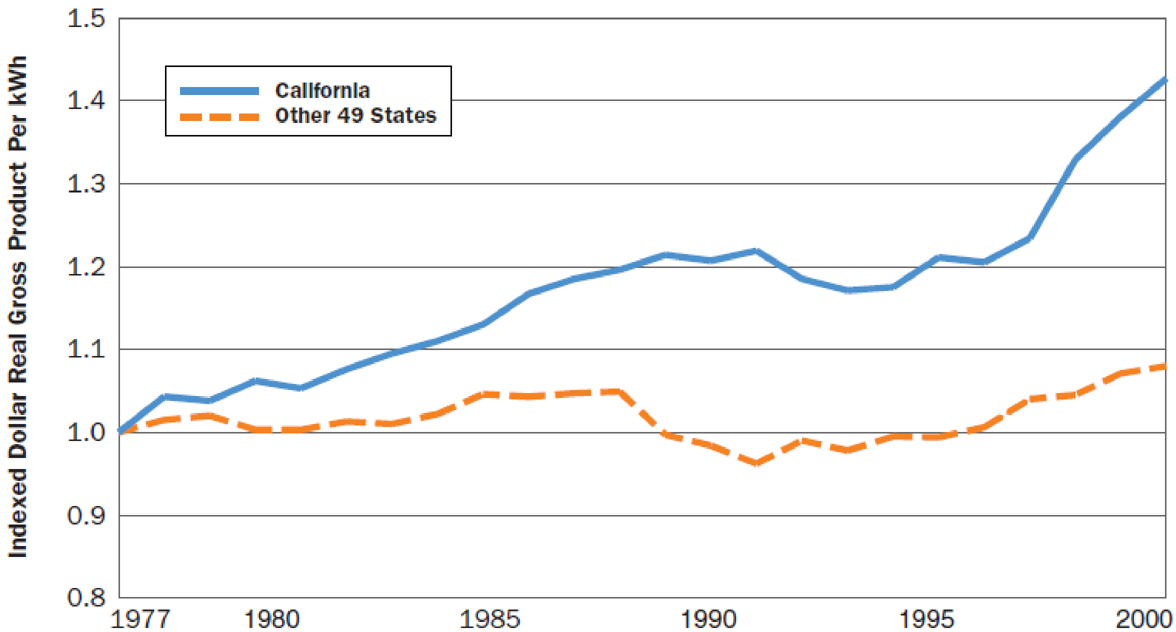
Along with the above, 'negawatts', the displacement of the equivalent amount of energy capacity in megawatts, has been used as a measure of energy efficiency. Therefore, 1 'negawatt' equates to 1 megawatt (MW) of avoided electric capacity.

Usually energy efficiency is often referred to as the 'lowest hanging fruit', both in terms of meeting CO_2 emission reduction targets and reducing energy consumption. As in the context of the electric grid, energy efficiency can delay or reduce the need for investment in new generation capacity and slow demand growth. For a business energy efficiency can reduce costs from having to purchase less energy from external suppliers, it can reduce costs from having to buy electricity during expensive peak periods for electricity and can postpone or avoid investment in new energy consuming assets. In the context of transportation, energy efficiency can be used to reduce fuel consumption and thus fuel costs per mile travelled. For power generators, energy efficiency can reduce fuel consumption per kWh of electricity generated and overall fuel costs per kWh of electricity generated. This is especially important as in the long term costs of gas and coal, and oil (mainly used for transportation), are projected to rise, creating a greater incentive to use fuels more conservatively.

An example of the use of energy efficiency is in California, it is estimated that in the first six months of 2001 the state's energy efficiency measures saved up to USD 20 billion in projected costs for summertime rolling blackouts and USD 660 million in spot market electricity purchases. Measures introduced in the 1970s have resulted in California being the most energy efficient state in the United States in terms of GDP per kWh and per capita electricity usage.

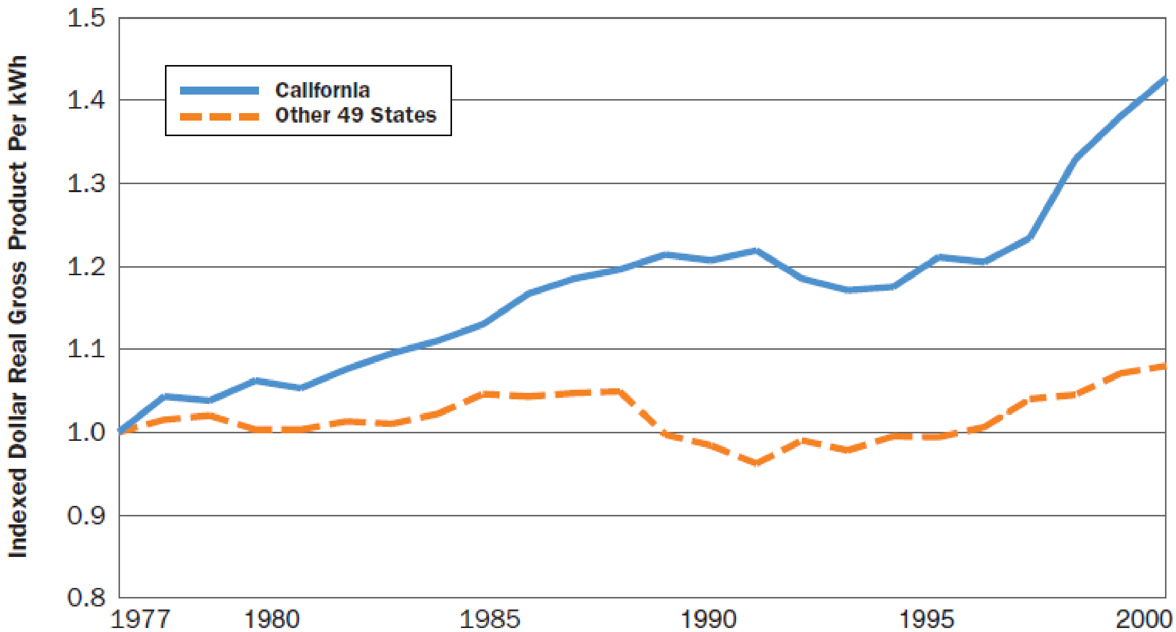
Learning from the United States:

Change in Economic Productivity of Electricity Use: California vs. Other 49 States



Sources; U.S. Bureau of Economic Analysis, U.S. Energy Information Administration, Edison Electric Institute, California Energy Commission

Change in Per Capita Electricity Use: California vs. Other 49 States

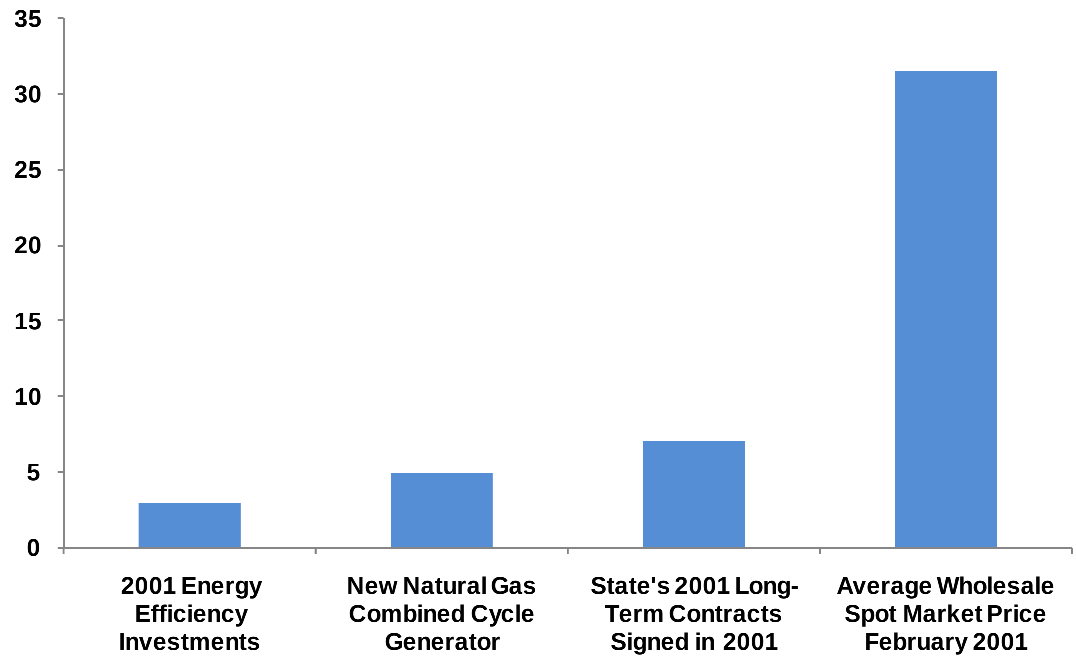


Sources; U.S. Census Bureau, California Department of Finance, U.S. Energy Information Administration, Edison Electric Institute, California Energy Commission

A strategy of extra funding for energy efficiency, programme to reduce peak demand and a 20/20 programme (20% bill reductions for customers that reduced their energy use by 20%) shaved the state's peak electricity demand by 10,000 MW in 2001. This has resulted in the state not needing to construct 20 large-scale power plants, and the effects of these measures persisted into 2002. Key areas for energy efficiency were the replacement of halogen torchiere lamps with more efficient lamps and reductions in energy demand from refrigerated vending machines for drinks, traffic lights, exit signs, coin-operated laundrettes and commercial air conditioners.

On balance the economic benefit of reduced energy consumption as a result of energy efficiency measures in California outweighed the cost of energy efficiency measures. Due to the fact that the construction of new gas-fired plants was avoided and less electricity needed to be purchased on the spot market.

Cost Comparison of Energy Efficiency and Electricity Investments, average USD cents per kWh



Sources; California Measurement Advisory Council, California Energy Commission, Lawrence Berkeley National Laboratory, California State Auditor, and California Department of Water Resources

It is estimated that as of 2001 California could quadruple its investments in energy efficiency projects and still produce cost savings and reduce its energy intensity. Specifically it is estimated that if USD 1.03 billion was invested, energy demand could be reduced by 5,900 MW over ten years. Thus, avoiding the need to construct 12 large-scale power plants and producing an estimated net benefit of USD 12 billion.

In California, Applied Materials, a supplier of wafer fabrication solutions for the semiconductor industry, installed efficient pumps and motors, including Integrated Point-of-Use Pumps (iPUP^{Tm}), and motion sensors to turn off non-critical devices which reduced the company's energy demand at critical times by up to 2.2 MW. In 2001, Hewlett Packard implemented lighting upgrades, energy-efficient chillers and power monitoring systems, to assess the effectiveness of the company's energy efficiency measures.

Oracle also introduced energy efficiency measures such as lighting upgrades and lamp removal, the installation of more energy efficient HVAC (*Heating, Ventilation, and Air Conditioning), efficient fan motor upgrades and occupancy sensors* which can potentially reduce demand by up to 18%.

However, despite the clear advantages, energy efficiency is less talked about that renewable energy and investment in it is less than expected. In part due to the high upfront costs of energy efficient measures and technologies, and a true understanding of the return on investment (ROI).

A study by Green Mondays and Ernst and Young of UK corporations, suppliers and NGOs/charities found that energy cost savings was the biggest driver for energy efficiency decisions within the corporations surveyed, with 18% citing this as a major driver. This was followed by protection against the rising costs of energy (15%), enhanced corporate reputation (15%), commercial attractiveness of energy efficiency (14%), reducing greenhouse gas emissions (13%), and existing regulation or in anticipation of the implementation of regulation on energy efficiency (11%), and other drivers (13%).

These same corporations cited uncertainty on paybacks and return on investment (ROI) as a major barrier to making investment in the sector at 19% of participants, with the following initiatives expected to have be best paybacks:

Initiative	**Percentage of participants that believe it has the best payback**
HVAC Control	12%
Voltage Power Optimisation	8%
Installing lighting sensors	8%
Boiler Controls	8%
Negotiating energy contracts	8%
Improving building insulation	7%
Variable Speed Drives	6%
Increased frequency of consumption	6%
Optimising the performance of large capacity	6%
Introducing a centralised control system	5%
Remote Energy Controls	4%
Installing time clocks to control lighting	4%
Installing renewable energy systems	4%
Capturing waste energy	3%
Installing dimmable lighting	3%
Introducing energy price hedging	2%

Installing energy-saving glass in windows	1%
Other	4%

Source; Green Mondays

Around three quarters of corporate participants reported that senior management's interest in the sector was higher now than one year ago.

This does tie in with the findings of the Institute for Building Efficiency's fifth annual global energy efficiency indicator, which studied the responses of 3,868 companies in North America, Australia, India, China, the EU, South Africa and Brazil in 2011. More respondents in China and India viewed energy efficiency as extremely important or very important compared to the other countries. Energy cost savings was cited as the main driver for energy efficiency investments for another year running. Other drivers that were considered to be important in order of importance were government or utility incentives or rebates, an enhanced brand or public image, increased energy security, greenhouse gas reduction and existing government policy, with significant country variation.

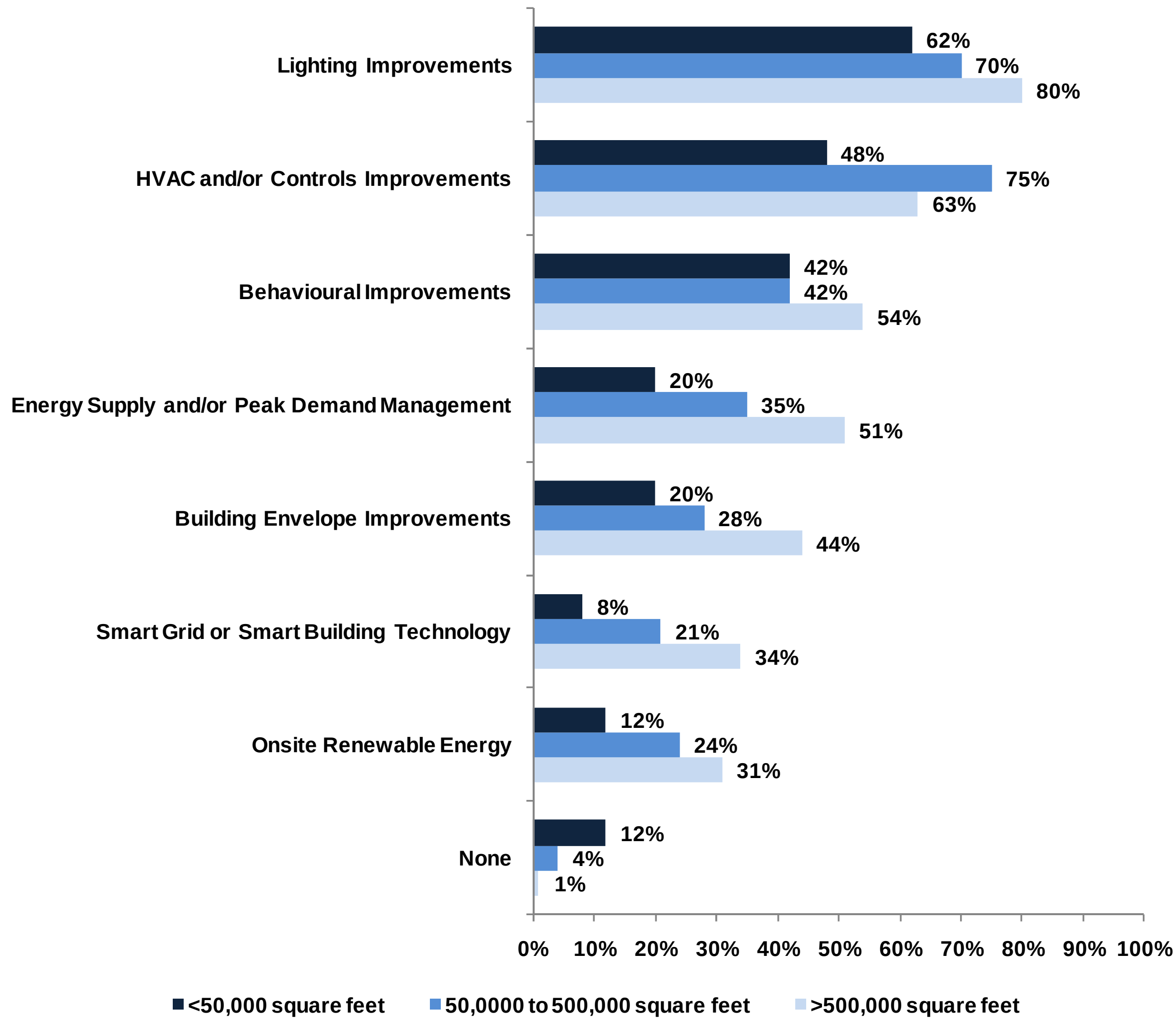
Responses to the question 'How significant are the following in your organization's energy efficiency decisions?'

2010 Global	2011 Global	Drivers of efficiency	Europe	India	China	US/ Canada
1	1	Energy cost savings	1	1	1	1
4	2	Government/utility incentives/rebates	2	3		2
3	3	Enhanced brand or public image				3
N/A	4	Increasing energy security	3	2	2	
2	4	Greenhouse gas reduction				
6	6	Existing policy			3	

Source; Institute for Building Efficiency's fifth annual global energy efficiency indicator

Areas where companies are likely to invest in are lighting improvements; heating, ventilation air conditioning (HVAC) and/or controls improvements and low or no-cost behavioural improvements. Less than half of respondents said they are likely to invest in energy supply and/or peak demand management, building envelope improvements, onsite renewable energy and smart grid or smart building technology in the next 12 months. This matches responses by survey participants to the energy efficiency measures adopted in the past 12 months.

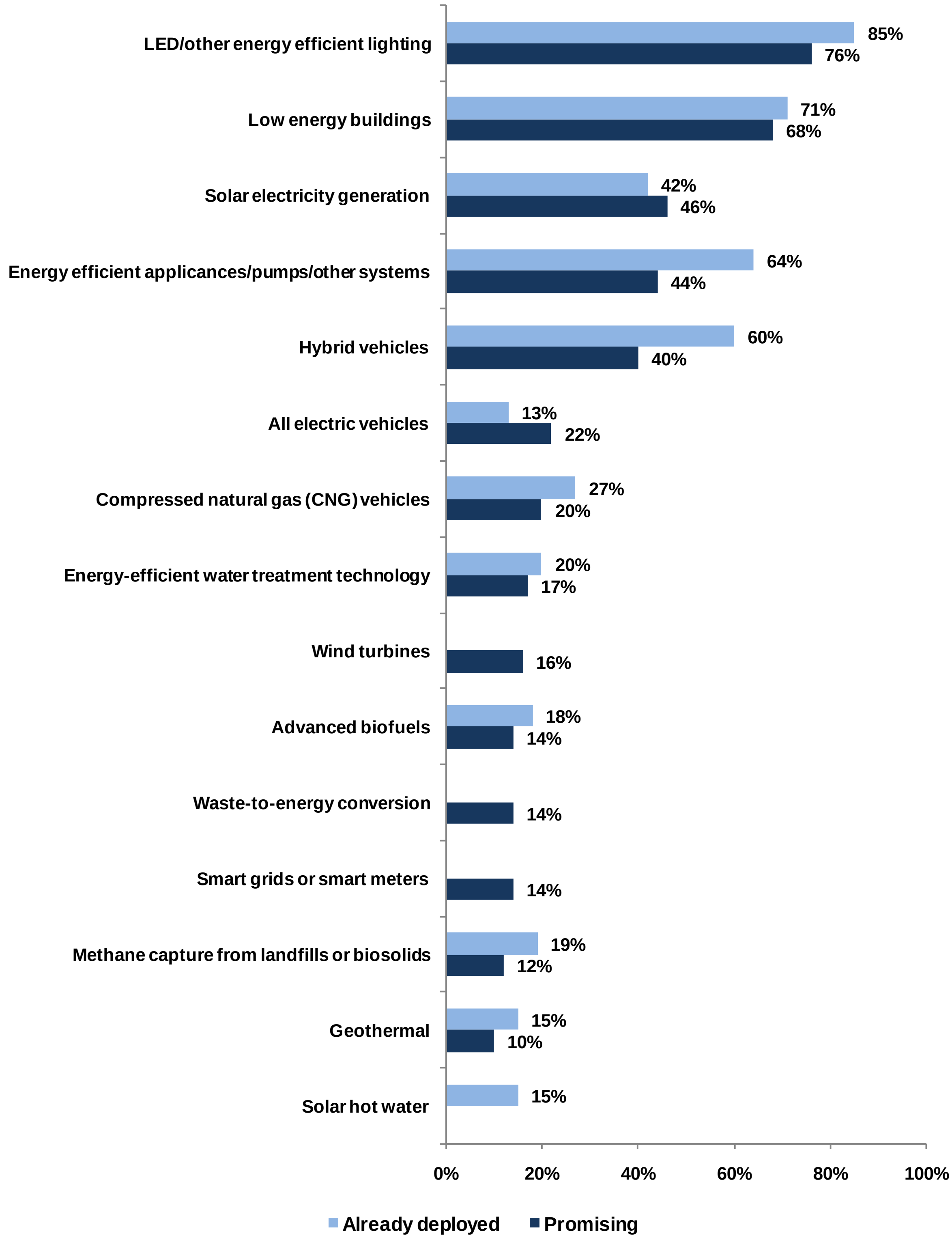
Responses to the question 'Which of the following energy efficiency measures has your company/organization adopted in the last 12 months?'



Source; Institute for Building Efficiency's fifth annual global energy efficiency indicator

This does tie in with a 2010 study of the opinion of city majors in the US on clean energy solutions for America's cities. In this study mayors identified LED and other efficient light as the most promising technology for reducing city energy use at 76%, followed by 68% for low-energy building technologies and 46% for solar power. Energy efficient lighting and some of the other solutions can be funded by Energy Efficiency and Conservation Block Grants (EECBG).

Findings for US major survey on most promising and already deployed technologies for reducing energy use and carbon emissions, % cities



Note: Includes up to five responses per city

Source; United States Conference of Mayors Clean Energy Solutions for America's Cities survey, prepared by GlobeScan Incorporated and sponsored by Siemens.

Energy efficiency also dominates the cities' energy strategies, with 94% of cities citing it as an important component of the strategy. Of all of the cities surveyed, more than 25% of 396 cities surveyed are targeting public buildings (86%) and outdoor lighting (44%) for energy efficiency improvements.

Smaller companies are more likely to implement no energy efficiency measures.

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NRG Expert
103 Latymer Court
Hammersmith Road
London W6 7JF
United Kingdom
Tel: + 44 020 8432 3059
info@NRGExpert.com
www.nrgexpert.com

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