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Energy Efficiency: The Best Immediate Option for a Secure, Clean, Healthy Future

Richard L. Ottinger
Elisabeth Haub School of Law at Pace University

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Commentary

Energy efficiency: The best immediate option for a secure, clean, healthy future

Richard L. Ottinger

Abstract

The imperatives for reducing the world's dependence on fossil and nuclear fuels have multiplied manifold in recent years with the advent of worldwide terrorism. These new dangers come in addition to the imperatives of addressing the dire consequences of global warming and devastating pollution that accompany the use of these fossil fuels. Reducing dependence on these unsafe and unreliable energy resources should be a top global priority. Implementation of proven energy efficiency technologies offers the world the fastest, safest, most economic and most environmentally benign way to alleviate these threats. This article outlines available efficiency measures, their economic advantages and means by which they may be and have been implemented. While examples of efficiency applications from both developed and developing countries are given, the article relies heavily on experience with energy efficiency in the United States, where data on efficiency is particularly abundant.

Keywords: Energy efficiency; Vehicle efficiency; Appliance efficiency; Lighting efficiency; Building efficiency; Industrial and utility efficiency; Energy efficiency measures; Energy subsidies; Research and development.

1. Introduction

The risks associated with dependence on fossil and nuclear fuels have never been greater. Soaring prices of oil and natural gas threaten to bankrupt many developing countries and raise havoc with the world economy. Supplies of these fuels, on which the world's economy depends, are dangerously insecure. While coal is plentiful, the emissions of carbon dioxide from the burning of fossil fuels (especially) threaten to exacerbate climate change, and associated sulphuric and nitrous oxide emissions are an increasing health hazard for populations of many of the world's cities. Last but not least, the advent of terrorism requires re-evaluation of all nuclear plants, oil and natural gas pipelines, LPG/LNG ports, central electricity transmission systems and large dams with relation to their vulnerability to sabotage. Modern civilization and the world economy literally are sitting on the edge of an energy precipice.

It will take many years and an estimate of trillions of invested dollars for the world to convert from fossil and nuclear fuels to an economy driven primarily by the truly safe, environmentally sound renewable energy resources — solar, wind, geothermal, small hydro, oceans and biomass — even though these are the fastest growing energy media and should be expanded urgently. Indeed, we should pursue these objectives with the same kind of priority we give to combating terrorism.

Energy experts touting a hydrogen economy acknowledge that the improvements required to make it technologically and economically feasible will take an enormous research effort and at least 20 years. Hydrogen fuel faces some serious logistic roadblocks: it is difficult to store, it is difficult to transport, and although there is no shortage of hydrogen in the universe, there is no easy, efficient way to extract the element in usable form. Furthermore, successful solutions to those problems will be very expensive. Despite the priority placed on it by some political figures, hydrogen is a long way from being a viable energy source today (NRC, 2004).

Since the potential energy crises are imminent, it behoves the world to act immediately and vigorously promote energy efficiency by the fastest, most affordable, safest and cleanest of technologies. This is necessary to alleviate the immediate threats we face, in order to give the world time to develop economic, safe and clean alternative energy technologies.

Richard L. Ottinger is Dean Emeritus at the Pace University School of Law; Chair, Energy Law and Climate Specialist Group, World Conservation Union (IUCN) Commission on Environmental Law; and a former member of the US Congress. E-Mail: rottinger@law.pace.edu.

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1.1. Efficiency potential

Energy efficiency has enormous potential for reducing energy use and related carbon emissions. It has been calculated that about 60% of all primary energy is lost at various stages of conversion, and that at the end-use stage over 60% is again lost or wasted. In 1998, the IPCC made a similar calculation, finding that almost 71% of all primary energy is wasted.[1] Energy efficiency measures can economically avoid a large percentage of this waste.

Energy efficiency measures in the end-use, manufacturing and transmission of electricity replace the need for fossil fuel resources and often produce a net economic benefit, usually substantial (Repetto and Austin, 1997). Efficiency measures can also reduce the great costs and risks associated with dependence on oil imports.[2] Many of the products required for efficiency measures can be produced domestically and have the potential for substantial export marketing.[3] Moreover, by improving the efficiency of industrial processes, such measures often result in enhanced competitiveness of domestic production in our global economy (Lovins and Lovins, 1997).

1.2. Efficiency at a profit

A significant 2004 study by The Climate Group in London demonstrates the proven profitability of reducing carbon dioxide emissions, primarily through introduction of efficiency measures (Climate Group, 2004; Romm, 1999). The study is of great importance, because the principal reasons given for failure to pursue the carbon dioxide reduction goals of the Kyoto Protocol are assertions that doing so would be too economically burdensome.

The Climate Group study examined the experience of companies, countries, cities, states and municipalities: 5 of the 22 companies studied achieved reductions of 60% or more with combined savings of over $5.5 billion a year. Results from 13 cities include carbon intensity cuts of up to 80% and cuts in energy consumption of 50% at savings totalling over $1.5 billion a year. The UK reduced emissions to 15% below 1990 levels, exceeding its Kyoto commitment, stimulating savings of £650 million a year.

Since energy efficiency measures cut energy use and the technologies employed are generally inexpensive, they almost always produce substantial net revenue benefits, often with just 2–3 year paybacks. The technologies employed range from the very inexpensive use of daylight in providing residential and commercial lighting, planting trees on the south side of buildings to reduce air conditioning loads, use of light-coloured "cool roofs" and "cool pavements", plugging leaks in ventilation systems, and insulation improvements in housing construction; to slightly more expensive initial investments in compact fluorescent lighting and use of LED (light emitting diode) lighting for signs, and converting vehicle fleets to more efficient hybrid vehicles; to those necessitating a considerably greater initial expense, such as variable speed drive motors for industry and improving the reliability of electricity transmission and distribution systems (which could be recovered through realistic pricing).

It has been asserted that the money saved through energy efficiency can result in a stimulus to use more energy, negating the savings achieved (Herring, 2006). This is a highly unlikely result and no evidence has been presented to show that the money saved is in fact spent on more energy.

2. Vehicle efficiency

The most dramatic energy savings can be effected in petroleum used for vehicles, which accounts for about 70% of US oil consumption. Under the Carter Administration, shortly after the 1973 Arab boycott of oil exports to the US that caused gasoline shortages and soaring prices, Congress passed the Energy Policy and Conservation Act of 1975 (EPCA). It established the corporate average fuel economy (CAFE) standards for vehicles, which required that the average fuel efficiency of all cars manufactured in the US could be no less than 27.5 miles per gallon, and for light trucks, 20.7 miles per gallon, with heavy penalties for failure to comply.

The results: from 1977–1985, while GDP rose by 27%, oil use fell 17%, net oil imports fell 50% (by 4.28 million barrels a day — 72% greater than US imports from the Persian Gulf), and gross imports from the Persian Gulf fell by 87%. That saving took away from OPEC one seventh of its market. The entire world oil market shrank by one tenth. OPEC's output fell by 48%, breaking its pricing power for a decade. If the US had continued those rapid oil savings starting in 2000, Persian Gulf net imports (at the 2000 rate) would have been entirely displaced within 28 months — in other words we could have been free of Persian Gulf imports by now (Lovins, 2003).

The most important part of these 1977–1985 oil savings came from a 7.6 mpg improvement in new domestically made cars. On average, each new car used 20% less gasoline, achieving 96% of that efficiency from smarter design and only 4% from smaller size. Contrary to fears expressed by the auto industry, neither auto safety nor auto prices were affected (Lovins, 2003).

Thus, vehicle efficiency has been proven to achieve enormous savings in practice, with a great positive effect on the economy and national security. Those same results

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[1] http://www.ipcc.ch/pub/reports.htm; http://www.ciesin.org/TG/HDP/ipcc.htm.

[2] US dependence on imported fuel is estimated to have cost the country's economy $4 trillion between 1972 and 1991. US oil imports reached an all-time high of 58% in 2004 and are projected to grow to 60–68% by 2025. http://www.eia.doe.gov/oiaf/aeo/pdf/overview.pdf.

[3] Lovins and Lovins (1997) estimate that aggressive adoption of energy efficiency measures could result in net gains of nearly 800,000 jobs in the US by 2010.

can readily be duplicated today. According to Lovins (2003), if 27% of cars in 2000 were the popular 48–49 mpg hybrid-electric models, or 15% were ultra-light hybrid SUVs, they could displace Gulf imports. Giving the owner of an average 1990 car (23 mpg) a $4,900 rebate — four times trade-in value — for scrapping it and replacing it with a new $21,000, 48 mpg, five-seat compact hybrid car would save enough gasoline to repay the rebate over its life at $1.25 a gallon. Since that was written in 2003, hybrid cars have raised their fuel efficiency to 61 mpg and the cost of gasoline is well above $2.00 per gallon, making the displacement much quicker.

Opponents have asserted, however, that the savings observed in 1977–1985 did not result from the CAFE standards, but were attributable mainly to high gasoline prices during the period and to industry and power generation switching from oil to natural gas. But oil consumption in the US is overwhelmingly for transportation and only minimally for industrial use and electricity generation — and the current high oil prices in the United States have not caused US drivers to significantly reduce their auto usage or to shift to more economical cars. Thus, the assertion seems primarily attributable to an ideological favouring of market instruments over command and control. In this case, the latter appears to have had by far the greater influence.

Other means of promoting fuel-efficient vehicles include:

- Requirements for labelling of the mpg performance of vehicles, an effective method of facilitating consumer choice. The principal examples are in the US, Europe and Australia;[4]
- Advertising disclosure requirements;[5]
- Differential sales taxes according to vehicle efficiency or weight;[6]
- "Feebates" charging a fee on inefficient vehicles with a rebate for purchase of vehicles with specified greater efficiency;[7]
- Differential registration fees dependent on vehicle fuel efficiency;
- Petroleum taxes;
- Employer incentives favouring efficient vehicles;
- Income tax incentives; and
- Fringe benefit tax differentials.

There are many other measures that can be and have been taken to achieve vehicle fuel efficiency. Many of them revolve around planning and use of regulatory measures, such as:

- Providing for high occupancy vehicle (HOV) lanes on highways and bicycle and pedestrian lanes on local roads;
- Designing urban areas around public transportation facilities;
- Restricting or taxing access to congested urban areas;
- Corporate parking restrictions and incentive payments for use of public transportation.[8]

3. Potential savings through efficiency in other sectors

While vehicle efficiency standards represent the quickest way to reduce our dependence on fossil fuels with proven technology, they are by no means the only ones.

3.1. Appliance efficiency

Furnaces, boilers, air conditioners, heat pumps, refrigerators, water heaters, clothes washers and dryers, stoves and dishwashers consume 85% of energy used in the US residential sector. In the commercial sector, 65% of energy use is for heating, cooling, lighting, water heating, refrigeration and office equipment. In the industrial sector, lighting equipment and electric motors account for more than 75% of electricity consumption (Geller *et al.*, 1998). The services obtained from these appliances can be furnished by much more efficient appliances, often using a fraction of the electricity. Replacing such inefficient, though widely used, models would offer substantial savings to companies, consumers and society, in addition to reducing emissions of carbon dioxide and other health-damaging pollutants (Kubo *et al.*, 2001).[9]

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[4] US: Title 49 section 32908 of the US Code, www4.law.cornell.edu/uscode/49/32908.html; The European Parliament: mandatory Directive (1999/94/EC), www.europa.eu.int/eur-lex; Australia: Australian Design Rule (ADR) 81/01 (http://www.greenhouse.gov.au/fuellabel/label.htm).

[5] For example, the Republic of Korea's Rational Energy Utilization Act (1995), article 18(4), www.unescap.org/esd/energy/publications/compend/ceccpart4chapter8.htm, requires the disclosure of the measure of efficiency on all equipment wherever an advertisement promotes its efficiency.

[6] See for example the US "gas guzzler tax" on inefficient vehicles, US Code, s 4064(a), http://assembler.law.cornell.edu/uscode.

[7] A system of this nature, entitled the Tax for Fuel Conservation, was introduced by the Ontario government in 1990 (Retail Sales Tax Act, RSO 1990, c R.31; www.e-laws.gov.on.ca).

[8] Cities that have taken legislative action in this area include Curitiba (Brazil), Singapore and Canberra (Australia). For the Curitiba local legislation, see www.curitiba.pr.gov.br (in Portuguese), and for a general discussion of the provisions in English, see www3.iclei.org/localstrategies/summary/curitiba2.html. The Singapore provisions are contained in Planning Act, Part II, §§ 5–11 statutes.agc.gov.sg. The Canberra provisions are made under the Planning and Land Act 2002 (ACT) www.legislation.act.gov.au/a/2002-55/current/pdf/2002-55.pdfs11(1)(d) and the Planning and Land Regulation 2003 (ACT) www.legislation.act.gov.au/sl/2003-16/current/pdf/2003-16.pdf.

[9] Kubo *et al.* (2001) describe potentially "enormous" savings and note that "as of 2000, efficiency standards for appliances had already cut electricity use by 2.5% and carbon emissions from fossil fuel in the US by nearly 2%. The total electricity savings are projected to reach … 7.8% of US electricity use … in 2020. Proposed new mandatory appliance and equipment efficiency standards could save another 3.8% in total US electricity".

The Collaborative Labelling and Appliance Standards Program (CLASP)[10] is an extraordinary resource, detailing worldwide appliance efficiency standards and labelling related methodologies. CLASP supports the design, drafting and implementation of efficiency standards and labels in developing and transitional countries through partnerships with agencies, stakeholders and relevant institutions in those countries. Its mission is to be "an independent, global, technical resource for governments and other organizations wanting assistance in developing energy efficiency standards and labels".[11] CLASP is developing globally applicable technical and policy support tools, conducting regional outreach, and providing technical support to partner countries. In each participating country, the project results in enhanced institutional capacity for implementing standards and labelling programmes, increased turnout of energy-efficient products by manufacturers, improved average energy efficiency of appliances and equipment, significant reductions in electricity consumption, and lower energy-related emissions of greenhouse gases and other pollutants.

CLASP also maintains a web-based international clearing-house of efficiency standards and labelling programmes,[12] has published a comprehensive manual for drafting efficiency standards and labels (Wiel and McMahon, 2001), has developed and makes available important analytical tools, and concretely assists interested nations in developing such programmes.

Legislated standards for appliance efficiency are particularly useful because many appliances are bought, not by bill payers, but by landlords, tract developers and public housing authorities who have no economic interest in saving energy; quite to the contrary, they are more likely to select the appliances that have the lowest initial cost, regardless of energy consumption. While incentives and appliance labelling for energy efficiency can be helpful in raising efficiency, only legally enforced standards can ensure that the most inefficient models are removed from the market. There are several reasons that the marketplace can and does not by itself attract the sale of the most efficient appliances. Lack of knowledge is a major factor, particularly in the residential sector. In the commercial and industrial sectors, purchasing decisions are often made by administrative or maintenance staff who have little knowledge about or interest in the efficiency of the equipment they order. They tend to purchase the equipment that is lowest first cost, regardless of the cost of the energy used by the equipment, and are judged by their superiors accordingly. Even were they to purchase efficient equipment, the savings would not accrue to their department. Furthermore, energy efficient equipment is often not stocked sufficiently by suppliers because of inadequate demand, thus requiring special orders and long lead times for delivery. These barriers are substantial and seriously hamper the introduction of energy efficient equipment into the marketplace. This is a principal reason for the need for legislated standards for appliance efficiency (Lovins and Lovins, 1997: 5, 6).

Globally, both labels and standards have been adopted as valuable tools for setting and implementing national energy efficiency policy. A universal requirement has been adopted by the EU for all its member States, and some 35 nations around the world have adopted some form of energy efficiency label or standard.[13]

There are good examples of workable appliance efficiency standards in developing countries. For instance, the Philippines' mandatory standards and labelling programme resulted in a 25% increase in average efficiency of all air conditioners, which translates into an energy saving of 6 MW in demand and 17 GWh in consumption. Thailand, which instituted a voluntary programme, recorded a 14% decrease in energy consumption for refrigerators (after 3 years) and a 65 MW decrease in energy demand and a 643 GWh drop in consumption.[14]

3.2. Lighting efficiency

In areas that have grid electricity, great savings to the consumer and to society can be achieved by replacing incandescent light bulbs with compact fluorescent bulbs, which last four times longer and use one quarter of the electricity. Task lighting, reflectors and use of daylight also result in significant savings at low or no cost. In many countries, utilities invest in lighting efficiency measures for residential and business customers, sometimes repayable out of the savings from the conversion. Many countries have started to produce their own compact fluorescent lights for domestic use and for export, creating important

[10] CLASP is managed by the Lawrence Berkeley National Laboratory, the Alliance to Save Energy, and the International Institute for Energy Conservation, acting with the support of USAID, the UN Foundation, the Energy Foundation, the US Department of Energy, the US Environmental Protection Agency, the US Department of State, the Global Environmental Facility, The World Bank, the Australian Greenhouse Office and others. See www.CLASPonline.org. For additional background on the need for and creation of CLASP, see Della Cava *et al.* (2000).

[11] http://www.clasponline.org/about.php?nnx=2.

[12] CLASP's worldwide standards and label programmes database, at www.CLASPonline.org, contains materials on 87 different products, across 60 nations and the European Community; the database is searchable by product, nation, region, standard, or label programme type.

[13] Harrington and Damnics (2004) detail the labelling and standards programmes, with references and pictures of labels used by each programme in Argentina, Australia, Brazil, Canada, Chile, China, Colombia, Costa Rica, Croatia, European Union (25 nations), Ghana, Hong Kong (China), India, Indonesia, Iran, Israel, Jamaica, Japan, Korea, Malaysia, Mexico, New Zealand, Norway, Peru, Philippines, Russia, Saudi Arabia, Singapore, South Africa, Sri Lanka, Switzerland, Chinese Taipei, Thailand, Tunisia, and the United States. They also provide a summary of the International Energy Star® programme.

[14] CLASP Success Stories, www.clasponline.org/resource.php3?nnx=6&no=13.

business, revenue and job opportunities. Conversion of incandescent street lighting to sodium vapour or other efficient alternatives again creates considerable savings to municipal taxpayers and to the environment, and produces much improved lighting to boot (Goldemberg and Reid, 1998).

In the rural areas of most developing countries that lack grid electricity, night lighting is provided by kerosene at high cost and with severe pollution consequences. Thus, about one third of the world's population uses fuel-based lighting with very significant greenhouse gas emissions and unnecessary expense. A recent study shows that between 15 and 88 billion litres of kerosene are consumed each year to provide residential fuel-based lighting in developing countries. The cost of this energy ranges from $15 to $88 billion per year. This fuel-based lighting results in between 37 and 223 million metric tons of carbon dioxide emissions per year. The energy services provided are 1/80th of the level of electric light sources and the lumens of light provided are approximately 1/1000th that enjoyed in households in the industrialized world (Mills, 1999).

Alternatives to kerosene lighting include electric lighting through the use of solar voltaic, wind, geothermal, biomass, natural gas, propane or methane, or small hydro installations, including batteries for storage for solar and wind installations. The most frequently used alternative in rural areas is propane or methane, though solar voltaic use is growing rapidly.

Lighting efficiency can be addressed through legislated standards. In China, the official efficiency standard for lighting energy in new buildings sets mandatory limits on wattage per m^2 and recommends using natural daylight and controlling the use of electric lighting. It also makes recommendations as to design methods, equipment efficiencies, and equipment selections for different applications for both commercial ("public") and residential buildings (China, 2004).

3.3. Building efficiency

Most countries have adopted standards for the construction of new buildings, many of which now include specifications for energy use. All the International Energy Agency (IEA) countries include energy requirements in their building codes and many have recently raised them. For example, France is adopting more stringent thermal regulations for new residential and commercial buildings with the aim of improving energy efficiency by 25%.[15]

Emissions from heating and cooling existing buildings, which account for approximately two thirds of the energy used in the buildings sector, can also be substantially reduced through cost-effective retrofits. For example, an evaluation of the US national weatherization assistance programme found that retrofits of low-income housing carried out during 1990–1996 typically reduced natural gas consumption for space heating by 34%. Also, retrofits of 15 office buildings as a part of EPA's Energy Star© Showcase Buildings partnership reduced energy consumption by 30% on average. Ways to upgrade efficiency include adding insulation to walls and attics, replacing older windows with energy efficient windows,[16] sealing leaky air ducts and leaks in the building envelope, upgrading heating and cooling systems, replacing inefficient lighting fixtures, and installing control systems (Lovins and Lovins, 1997: 5). Ordinances requiring retrofits of existing buildings have been adopted in certain US cities, such as San Francisco, Minneapolis, and Burlington (Lovins and Lovins, 1997). Some countries, for example Luxembourg, have also adopted voluntary energy audits for buildings.[17]

The planting of deciduous trees on the south side of buildings and painting the buildings in light colours, routinely done in many tropical countries, are inexpensive ways of achieving substantial savings in the energy used for air conditioning in hot climates. Thus, owners of buildings in Haifa and Tel Aviv are required to whitewash their roofs each spring (Konopacki *et al.*, 1998; Rosenfeld *et al.*, 1997; Rosenfeld and Taha, 1990). The use of light coloured materials for roads and highways can also achieve substantial energy savings: direct savings in air conditioning and indirect savings from lowering the external temperature which affects surrounding buildings (Mills, 1999).

Tree-planting aimed at lowering air temperatures in so-called 'urban heat islands' can achieve multiple savings as the trees reduce the need for air conditioning and absorb carbon dioxide. It is estimated that a tree in Los Angeles will save 3 kg of carbon per year by lowering citywide air conditioning requirements plus 15 kg per year in air conditioning savings in buildings if planted to shade a building (Mills, 1999). An urban tree reduces carbon dioxide emissions about nine times more than a tree in the forest, due to air conditioning savings (Lovins and Lovins, 1997). A single tree can evaporate 40 gallons of water a day, offsetting the heat equivalent to that produced by 100 100-watt lamps burning eight hours per day (Rosenfeld *et al.*, 1997).

A legal measure worth pursuing is a law, adopted in some US states, requiring that homes or commercial buildings be inspected at the time of resale, with a retrofit requirement for buildings that are found not to be up to energy efficiency standards.

[15] See http://www.iea.org/pubs/newslett/eneef/intro.htm.

[16] Efficient windows can insulate four times better and let in six times as much daylight but a tenth of the unwanted heat than conventional unglazed windows, while at the same time cutting air conditioning energy needs fourfold. This saves about enough money to pay for the extra costs of the windows. The retrofit, saving of three quarters of the energy, then costs essentially the same as a routine renovation that saves nothing (Lovins and Lovins, 1997: 6).

[17] See http://www.iea.org/pubs/newslett/eneeff/intro.htm.

3.4. Industrial efficiency

Several countries have passed comprehensive legislation promoting industrial efficiency. Thailand, for example, has implemented a number of measures to increase energy efficiency in the industrial sector, including: demand management, financial incentives, minimum efficiency standards for machinery, and the provision of support structures.[18] China has passed a comprehensive Cleaner Production Promotion Law,[19] with fairly broad terms, leaving the implementation of the policy to administrative bodies.[20] China has also passed a law setting industrial energy efficiency standards.

Electric motors consume more than half of the electricity in the US and almost 70% of manufacturing sector electricity (Suozzo and Thorne, 1999). Replacement of standard electric motors with smaller variable speed motors (comparable to the gear shift in a vehicle), matching output to actual load, can save electricity, avoid pollution and offer economic benefits.[21] It has been estimated that conversion to variable speed electric motors would result in short-term reductions in carbon emission of nearly 10 million tons per year in the US, nearly 8 million tons in Japan and over 14 million tons in the European Community. Technological improvements have also raised the efficiency of motors (Lovins and Lovins, 1997).

The greatest industrial energy savings, though, frequently occur in improving the efficiency of industrial processes themselves, e.g., using continuous casting of steel and utilizing waste products for electricity and heat generation, as is often done in paper, lumber and plywood manufacturing in the United States. The US chemical industry saved nearly half its energy per unit of product from 1973–1990 by plugging steam leaks, installing insulation and recovering lost heat.[22] These kinds of improvements can usually be financed through commercial loans repayable from the savings achieved. Some US utilities do industrial efficiency audits, provide technical assistance and participate in the financing of efficiency improvements.

At least 25 countries, including some European countries, Canada, the US, Australia, New Zealand, South Korea and Taiwan have voluntary agreements with particular companies or industries to implement industrial efficiency measures.

A few countries have worked with energy manager programmes, including Korea, Japan, Thailand, Finland and Portugal, as well as Denmark and Italy.[23] These programmes require companies to keep a dedicated energy manager on site when their energy use exceeds a certain level.

Utilization of the waste heat from electricity generation for industrial or district heating purposes converts as much as 90% of fuel input into useful energy, compared to 30–35% for a conventional power plant, thus saving significant amounts of fuel and avoiding pollution (Lovins and Lovins, 1997). Conversely, some manufacturing facilities that produce substantial amounts of high temperature fluid or steam wastes have used this waste heat for electricity production. Roughly 52 GW of combined heat and power (CHP) was installed in the US as of 1998, providing about 9% of total electricity production (Lovins and Lovins, 1997). Europe is far ahead of the US in CHP installation, exceeding 30% in the Scandinavian countries and being widely used in the climate strategies of the UK, Denmark, Sweden, the Netherlands and Germany (Geller *et al.*, 1998).

There is enormous potential to expand the use of CHP. For example, the US chemicals industry uses only about 30% of its CHP potential and has used only 10% of possible sites (Geller *et al.*, 1998). A CHP plant in Stockholm has a net overall efficiency of 86% compared to an average efficiency of just 36% for non-CHP plants in the European Union (Geller *et al.*, 1998; Smith *et al.*, 1994).

All US conventional power plants together convert only one third of their fuel into electricity, thus wasting two thirds as waste heat, which is equivalent to the total energy use of Japan. The cogeneration installation of the US Trigen Corporation[24] increases system efficiency 2.8 times, harnessing 90–91% of the fuel's energy content, providing electricity costing only 0.52 cents/kWh. Fully adopting this one innovation would profitably reduce total US carbon dioxide emissions by about 23%. Selling waste heat from industrial processes to others within affordable distances could cost-effectively save about 45% of Japanese and 30% of US industrial energy, or 11% of US total energy (Lovins and Lovins, 1997).

However, a variety of barriers including hostile utility policies, excessively onerous environmental permitting requirements, lack of regulatory recognition of CHP benefits and unfavourable tax treatment, has limited CHP expansion in the US. It has been estimated that legislative and regulatory action to remove these barriers could result in an additional 50 GW of installed CHP by 2010 and 144 GW by 2020 in the US, with a net saving that pays back the first cost in an average of four to five years. The reduction in carbon emissions that would result from such

[18] See generally: http://www.aseanenergy.org/energy_organisations/eecssn/thailand/eec_ssn_th.htm, and http://www.eppo.go.th/doc/.

[19] See generally, http://www.chinacp.com/eng/cnenvleg.html.

[20] See also, Compendium on Energy Conservation Legislation in Countries of the Asia and Pacific Region 1997 at http://www.unescap.org/esd/energy/publications/compend/ceccpart4chapter4.htm#Chapter%203.

[21] For a general review of motor efficiency regulations, See: http://oee.nrcan.gc.ca/regulations/html/Factsheet6.cfm?text=N&printview=N.

[22] Better catalysts with matching heat to temperature needs can save 70% of the remainder with a 2-year payback (Lovins and Lovins, 1997: 6).

[23] For Thailand's law, see The Energy Conservation Promotion Act B.E. 2535, http://www.unescap.org/esd/energy/publications/compend/ceccpart4chapter10.htm.

[24] See http://www.trigen.com/.

policy changes is estimated at about 27 million tons/year in the industrial sector and 7 million tons in other sectors by 2010 (Geller *et al.*, 1998).

The 2003 EU directive on combined heat and power (CHP)[25] promotes cogeneration based on useful heat demand in the internal energy market. It provides a legal basis for CHP, obliges member States to address key market barriers, such as grid access and authorization procedures, provides a framework to support CHP, and gives a standard method for ensuring that energy savings and environmental benefits are achieved. The CHP directive (see article 2) builds on a more general EU directive[26] concerning common rules for the internal market in electricity.[27] Within the scope of the federal structure of Europe, the CHP directive is probably the strongest piece of legislation that can be achieved centrally for the promotion of CHP. The directive does not prevent member nations from developing their own, more specific or ambitious, legislation as well. Indeed, the directive compels member nations to undertake initiatives to promote CHP in their specific jurisdiction.[28]

In Brazil, on the 15th of March 2004, the government passed Law 10848 with regards to electricity sector reform (http://www.in.gov.br/). The law in effect created two separate market structures for electricity exchange: the bilateral contract environment (ACL), where individual generators and consumers can negotiate power purchase agreements (PPAs), and the regulated contract environment (ACR) where distribution companies must purchase the power they need to meet their contract from public auctions. Decree 5163 deals specifically with distributed generation, and states that in the ACR scenario distribution companies must also buy power from "alternative sources" at prices set by the government and are permitted to buy up to 10% of their required supply.[29] The clause was designed to create incentives for CHP and other designated alternative sources. The decree states specifically that cogeneration plants with an efficiency of over 75%, as well as hydro plants with a capacity below 30,000 kW and other renewable sources, all qualify as "alternative energy" for the purposes of the law (UNEP, forthcoming).

In 2002, Maharashtra State in India introduced new regulatory arrangements that provide incentives — such as attractive buyback rates for any surplus electricity — for owners of CHP operations using biomass, e.g., sugar mills, to upgrade and improve the efficiency of their plants. This step raises prospects for CHP significantly in Maharashtra and represents one of the most effective tools to spur investments in CHP.[30]

3.5. *Utility sector*

A recent study by the American Council for an Energy-Efficient Economy (ACEEE) focused on the potential energy savings from efficiency measures in the electricity and natural gas sectors in 11 US states and regions. The study found a median technical potential of 33% for electricity and 40% for gas, and median economic potentials of 20% and 21.5% respectively for electricity and gas. "Achievable potential" showing the effects of adopting building and appliance codes, etc. was slightly less than the economic potential, though several studies confused the two. Across the studies examined, the median technical potential for electricity was 32% for the residential sector, 36% for the commercial sector and 21% for the industrial sector, for gas, 48% in the residential sector and 20% in the commercial sector. These studies are stated to be comparable to actual savings achieved by recent state efficiency programme results. The maximum savings achievable in practice may have been accomplished by California after its energy crisis in 2001, reducing electricity use by 6% in that year through very aggressive efficiency programmes (Nadel *et al.*, 2004).

In many developing countries, current transmission and distribution systems are inadequate, causing not only large losses of power but also frequent blackouts or brownouts costly to businesses. Even in developed countries, these systems are often neglected, resulting in outages at times of system stress — as with the blackout in the entire Northeast of the US in the summer of 2004. Upgrading inadequate transmission or distribution systems should be a high priority. Costs are normally borne by the utility company and recovered through raised electricity charges, but financial assistance may be needed in developing countries.

Most power plants around the world are grievously inefficient, converting most of their fuel into waste heat rather than electricity. While the US average power plant efficiency has increased from about 23% in 1949 to about 35% now, due to the introduction of 52% efficient combined cycle natural gas power plants, energy use and power sector

[25] Directive 2004/8/EC of the European Parliament and of the Council.

[26] Directive 2003/54/EC, Concerning Common Rules For The Internal Market In Electricity And Repealing Directive 96/92/EC.

[27] See http://europa.eu.int/comm/energy/demand/legislation/heat_power_en.htm.

[28] The text of the Directive is available at http://europa.eu.int/comm/energy/demand/legislation/heat_power_en.htm. The information above on the EU Directive and below on CHP in other countries is quoted from a draft of the Industrial Efficiency section of a UNEP Handbook for Draftsmen of Environmentally Sound Legislation on Energy Efficiency and Renewable Energy to be published shortly (UNEP forthcoming), authored by Ernst Worrell, Lynn Price (senior staff at Lawrence Berkeley Laboratories, Berkeley California), Michael Brown (Director, World Alliance for Decentralized Energy, WADE, Edinburgh, Scotland) and Jeffrey Bell, his assistant.

[29] See http://www.in.gov.br/ to view a copy of the decree.

[30] Cleaner Production Promotion Law. See generally http://www.chinacp.com/eng/cnenvleg.html. The terms of the law are fairly broad, leaving the implementation of the policy to administrative bodies. See also Energy Conservation Law 1997 at http://www.unescap.org/esd/energy/publications/compend/ceccpart4chapter4.htm#Chapter%203.

pollutants could decline by a further 30% by 2010 if all plants were as efficient as the combined cycle plants.

4. Measures to promote efficiency

Some of the most effective measures to raise energy efficiency are discussed in the following sections.

4.1. Subsidy removal

First and foremost, removal of subsides for fossil fuel, nuclear and electricity systems, which were estimated at about $250–300 billion a year in the mid-1990s. This does not include the huge US subsidies to secure oil imports that have been estimated to raise the true cost of oil to over $100/barrel (Lovins and Lovins, 1997). These subsidies put energy efficiency measures — as well as alternative energy resources — at a serious disadvantage in the market place. Enacted under the pretext of assisting the poor, these subsidies generally benefit primarily wealthy consumers and large industries that are the principal users of fuel and electricity (Reddy *et al.*, 1997).

The political difficulties of eliminating subsidies cannot be minimized. Nevertheless, countries such as Brazil, China, the Czech Republic, India, the Netherlands, Poland, the United Kingdom and Russia have reduced or eliminated fossil subsidies successfully (Reddy *et al.*, 1997).

4.2. Incentives

A compliment to the removal of subsidies is short-term incentives for efficiency measures to assist their introduction. Such incentives should be phased out as the measures become known and accepted. Building and enterprise managers and sales people should be rewarded for promoting such measures.

4.3. Education and training

Educating the public and those responsible for setting energy policy and making decisions about efficiency measures is essential. Architects, engineers, municipal planners, landlords, developers, building and enterprise managers and others who deal with energy-related matters need to be made aware of energy efficiency programmes, and trained in related technologies, their application and maintenance.

4.4. Use of externality costs and life-cycle costing

The costs to society of the burning of fossil fuels in terms of the associated health hazards and early mortality are considerable, sometimes exceeding the cost of their use for electricity generation and industrial processes (Ottinger *et al.*, 1991). Ignoring these costs places energy efficiency at a disadvantage in the market place. However, once efficiency measures are installed, they continue to accumulate savings over their long lifetime, an important factor when comparing them to traditional systems. Realistic comparisons should always be made on the basis of life-cycle costs, including externalities, rather than initial cost alone.

4.5. Taxes on pollution and inefficient products

Taxes on pollution or polluting fuels should be applied in view of the high externality costs of these fuels. If such taxes are applied, non-polluting efficiency investments will be even more profitable in comparison. Similarly, taxes on inefficient products would promote investment in raising efficiency. The revenues from such taxes could be used for additional efficiency measures. Taxes on harmful pollution and inefficiency are a far better alternative, and more acceptable to taxpayers, than taxes on labour, sales and income. Pollution taxes — often carbon taxes — are widely used in the EU.

4.6. Standards

The adoption of minimum efficiency standards for building construction, appliances, vehicles, industrial motors, lights and other energy-using equipment, and the banning of the most inefficient equipment, has been proven to produce remarkable energy savings. Pollution standards enhance efficiency measures that produce virtually no pollution. Standards should be updated periodically to reflect new technologies that may create even greater efficiencies. Enforcement is critical to the success of any standards programme. Since government regulatory agencies too often identify with the entities they regulate and are under political pressures to weaken enforcement, a particularly effective enforcement measure is to allow citizens to sue, including providing for recovery of attorney's fees.

4.7. Disclosure, labelling, ratings and awards

Mandatory disclosure of the toxic contents of products and the pollution of natural resources during their manufacture serves to inform the public of possible hazards to their health associated with the product. This builds public support for efficiency measures that can mitigate such hazards. Labelling and efficiency ratings of products helps purchasers select the most efficient, economic and advantageous products. Awards programmes that recognize companies and government agencies for their efficiency accomplishments can also be helpful.

4.8. Environmental impact assessments and audits

An environmental impact assessment requires the revelation of any pollution or degradation of natural resources. This gives the public a valuable opportunity to opt for alternative policies. It is important that assessments be subject to judicial review for their adequacy. Environmental audits can reveal inefficient and costly practices in an enterprise and educate managers about more efficient alternatives. More than 175 countries have enacted environmental impact legislation and assessments have been required by a number of international environmental treaties, such as article 206 of the UN Convention on the Law of the Sea (UNCLOS). The administrative procedures of the World Bank and other multilateral agencies also require such assessments (Robinson, 2000).

4.9. Research, development and technology transfer

Many of the most advantageous efficiency technologies have come from R&D programmes; many performed by US government or industry laboratories. An example is the Lawrence Berkeley National Laboratory (LBNL) operated by the University of California.[31] This laboratory perfected highly efficient windows and compact fluorescent lights, which have paid for themselves many times over. It is also vital to transfer proven efficiency technologies to developing countries.

4.10. Government procurement

Government agencies at all levels are major purchasers of buildings, appliances, vehicles and other energy-consuming items. Purchasing standards for government agencies, requiring them to purchase only the most efficient, can create markets for energy-saving products, bring down their prices, and help to educate the public about their advantages. A requirement for utilities to procure efficient equipment can have a similar effect.

The Government of the US is the world's largest single buyer of energy-using products, accounting for over $10 billion of such purchases each year (McCane and Harris, 1996). US legislation requires all federal agencies to cut energy used in buildings by 30% compared to 1985, and by 35% by 2010. In implementing these requirements, the Federal Energy Management Programme requires[32] all federal agencies to purchase only products that qualify for the Energy Star label, or, where there is no label, are among the most efficient 25% of products on the market. The US Government is also including energy-efficiency criteria in its contracting specifications for construction and renovation projects.

4.11. Utility programmes

Since electricity and gas utilities are knowledgeable about energy and have relationships with their customers, they are in a good position to help educate customers about savings achievable through energy efficiency and encourage the purchase of efficient products. Regulatory provisions can foster such action.

In Brazil, for example, a federal utility regulatory agency established in July 1998 requires all distribution utilities to spend at least 1% of their revenues on energy-efficiency improvements, with at least one quarter (about $50 million/year) on end-use efficiency projects (Geller *et al.*, 1999).

Investments in efficiency are generally far cheaper than investments in new supply. Ontario Hydro of Canada placed its primary emphasis on end-use efficiency and distribution planning to displace building transmission and generating capacity. Its first three experimental programmes cut investment needs by up to 90%, saving it $600 million (Lovins and Lovins, 1997).

In the US states that have decentralized their electricity generation, environmental advocates have been quite successful in convincing regulators or legislators to impose a "systems benefit charge" on distribution utilities that remain regulated monopolies. Revenues from these charges are often placed in independently administered public funds, and are to be used for efficiency, renewables and other public benefits. A new entrepreneurship of energy service companies (ESCOs) has emerged to perform energy efficiency retrofits for homes and businesses as a profitable enterprise. Such ESCOs are often contracted by the public benefit funds to install efficiency measures. Sometimes the cost to the customers is paid out of the savings realised (Eto *et al.*, 1998).

A number of utilities in the US offer an option to customers to purchase a package of green generation products at a slight premium in cost. Other countries, such as The Netherlands, have created a green pricing programme, permitting consumers to purchase renewables at a small premium (Moore and Ihle, 1999).

5. Conclusion

This article has argued that proven energy efficiency technologies provide the quickest, most economic, safest way out of the looming nexus of crises related to energy, environment and global warming.

The efficiency measures described above and many others achieve substantial fuel and energy savings, usually with substantial long-term, and often short-term, savings. Energy-efficiency should also be the first line of defence against the known vulnerabilities of the current energy delivery systems based on fossil and nuclear fuels.

As demonstrated by the US energy savings achievements of the 1970s and 1980s, and equally dramatically by the California experience in meeting its 1990 supply crisis, energy efficiency can produce very large reductions in usage without impairing energy service quality. For many developing countries, it provides one of the few truly affordable options.

[31] See www.lbl.gov.

[32] Executive Orders 13123 and 12902, See, http://www.nara.gov/fedreg/eo.html.

The technologies and results are proven and available. What is needed now is the political will and commitment to proceed in view of the urgency that the energy situation requires.

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