The myths of technology and efficiency: A few thoughts for a sustainable energy future

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Abstract

Energy consumption continues to grow, as do CO_2 emissions. The energy efficiency community has created indicators and 'business-as-usual' scenarios to show large energy savings achieved compared to "what would have been if…" Technology development has been highlighted as the most successful achievement: "We have refrigerators that are ten times more efficient!" Yet technology is only one component of the equation, and unfortunately it alone cannot create sustainability. What's more, a focus on technical efficiency, especially market-based efficiency, may reproduce and encourage the very forms of consumption it purports to control.

The US-model of energy use, energy policy and behaviour is often what is offered as the paradigm of a successful energy efficiency policy package. Yet the US is a world leader in consumption as well, sporting a social-technical system fundamentally oriented toward defining and then fulfilling ever-greater "needs." However pleasant fulfilling these constructed needs may or may not be, energy consumption in the US continues to grow. Arguably the US-model has been exported to Europe, assisting rapid changes in the energy use (out of town supermarket and malls, A/C in houses and cars, larger and more appliances, driving children to schools in SUV's, abandoning city centres for "green" out-of-town villas). Worse, the same model is exported to fast developing economies such as China and other Asian countries: abandoning cycling to make space for cars, increased urbanisation, increased penetration of appliances and A/C. We are well aware of the argument that people in developing countries deserve freedom to consume too, yet this counterpoint is often oversimplified and is hardly an innocent protection. Moreover, it is these poorest countries that are most affected by the adverse impacts of climate change and increased energy consumption.

The paper presents details of present patterns of energy usage and its social, economic, and environmental impacts using examples from a few selected countries, and analyses policy response from energy policy makers and the energy efficiency community. The responses are analysed and classified e.g., "no hope: best we can do is deal with consequences", "more efficiency-technical", "more efficiency-social", "absolute caps on CO_2 emissions".

The authors propose some paths toward a sustainable energy future based on a mix of ambitious policies and new social and energy responsibilities that has the potential of resulting in a major change in energy using behaviour. It also advocates increased standards of policy critique, arguing that both the social and technical assumptions of policy models that promise savings must be made transparent.

Introduction

Global population will continue to grow reaching 8 Billions by 2030. This population growth is mainly located in developing countries and will be accompanied by economic growth, which is only affecting some areas of the developing world, and growth in global energy consumption. Global energy consumption will continue at a rate of 1.7% p.a., reaching 340 Million barrels a day of oil equivalent (MBDOE) in 2030. Less developed nations are still building infrastructure to serve their populations. More developed nations continue to increase their per capita consumption of energy. Global electric power capacity is forecast to add 3 000 GW of capacity over the next 25 years (EIA, 2004). Much of this capacity will be generated with fossil fuels. Power generation, together with increasing transport energy use will result in increased energy demand. All of this energy growth will occur in the context of increasing concern about the impacts energy systems have on the global environment and the security of energy supplies. The question facing policy makers, regulatory bodies, private corporations around the planet is how much to invest to mitigate the impact of our growing thirst for reliable energy.

The IEA's *World Energy Outlook* depicts a business-as-usual future "…in which energy use continues to grow inexorably, fossil fuels continue to dominate the energy mix and developing countries fast approach OECD countries as the largest consumers of commercial energy…[raising] serious concerns about the security of energy supplies, investment in energy infrastructure, the threat of environmental damage caused by energy production and use, and the unequal access of the world's population to modern energy" (IEA 2004). In short, today's energy systems are not sustainable.

To reach the sole new climate change targets, among all of the policies and measures to be developed and implemented, reducing the demand for energy should have the highest priority. Decoupling the economic growth from the total energy consumption needs to be organised at a rate never before experienced. To be precise, the rate of improvement in energy efficiency must exceed the rate at which demand for energy services grows, and that on a global scale, if we are to reduce total energy consumption. Short of accepting lower levels of energy services, only a dramatic improvement in energy efficiency can achieve this outcome.

The real questions that the authors are asking in this paper, concern the real impact of the energy consumption on the environment, on the social and human development and how to rethink the energy policies, including the necessary critique of current models and assumptions.

Is Energy Efficiency Enough?

Traditionally, energy efficiency policies and programmes have been designed to improve the ratio between the energy consumed and the service provided, e.g., to get more kilometres per litre of petrol or to consume less energy per square meter of space in buildings and homes. The challenge of mitigating climate change, as well as the need to achieve a sustainable and socially-equitable energy future, demands that we target absolute, and not just relative, reductions in energy demand. To this end, traditional energy efficiency policies and programmes need to be re-thought and re-focused to meet the goals of energy conservation and sustainable development.

Energy efficiency describes how much useful work, activity or service can be generated for each unit of energy consumed. From this simple definition, two important observations can be made about the nature of energy efficiency. First, what is 'useful' output is inherently subjective. What is judged useful by one person may be judged wasteful by another. Conversely, if personal utility is subjective, then it is not possible (based on a neo-classical understanding of market-based consumer behaviour) to sanction high, wasteful or 'conspicuous' energy consumption. *If the consumer is willing to pay, then the consumption is assumed to be justified.* Second, improving energy efficiency does not necessarily mean using less energy. Energy efficiency creates a range of direct benefits, or impacts, which range from less energy use to deliver the same service (energy savings), through to the same energy use to deliver more output (energy productivity). Indeed, with rebound effects (below) it is possible that energy efficiency may trigger more energy use over time, through a combination of direct and indirect effects, as the energy productivity effect of energy efficiency stimulates additional growth and energy consumption. This leads to a clear economic benefit, but also to a clear increase in greenhouse gas emissions.

As to the question of "Is energy efficiency enough?", we mean to highlight the rhetorical issues. If the goal is to reduce the rate of global carbon emissions to the level IPCC states is necessary to stave off global warming, then the answer seems obviously "no", short of a drastic reworking of what "energy efficiency" means. We anticipate that, if pressed, our colleagues in the energy policy field would offer little argument on this score. However, the immediate goals of energy efficiency policy are – though not directly stated as such – less ambitious, arguably more like "let's implement energy efficiency where we can, it's better for the environment than not doing so, and it's all that we can do." However, to implement these more modest goals, some grander claims for energy efficiency are usually mobilised. In the least case, in the name of honesty if not in the name of the environment, it is necessary to disentangle these issues.

SOME EXAMPLES OF MISSED OPPORTUNITIES, POLICIES AND REBOUND EFFECTS THAT RUN COUNTER TO THE GOAL OF REDUCING TOTAL ENERGY USE

1. Modern cars are often more energy efficient than the older cars they replace. However, there are more cars on the roads, we drive faster on the highways and experience more congestion in cities, we travel more and increasingly use cars also for shorter trips, and our cars are equipped with more and more energy consuming devices like air conditioners, onboard computers, etc. How can we expect to see energy demand in road transport go down?
2. Since 1995, Europe has had a mandatory energy label on cold appliances. The label displays a scale of seven energy efficiency categories, from A (most energy efficient) to G (least energy efficient). The energy efficiency rating takes into account the size of the different

compartments, as well as their indoor temperatures, and benchmarks against the energy consumption of the appliances. Despite these efforts to calibrate and compare refrigeration appliances in a unique format, there is a bias. It is easier for a larger unit to obtain a better energy efficiency category. Larger units therefore appear to consumers to be more energy efficient, even when they consume more energy.

3. In Europe a significant market transformation of household washing machines toward more energy efficient units have been observed as the result of the introduction of a mandatory energy label. But over the recent years, more and more of the so-called energy efficient washers are managed with some advanced electronic controls. Unfortunately, the electronics that allow the control is powered by an AC-DC power supply that constantly remains connected to the mains, drawing standby power round the clock. The test procedure of a clothes washer does not consider the energy being consumed when the appliance is not being used, so this consumption is not reflected in the energy label. As a result, new washers typically consume 10% more energy yearly compared to the figure indicated on the energy label. This 10% is comparable to the overall gain generated by the market transformation just mentioned.
4. It has been reported that some rebates provided by an electric utility company were given to purchasers of plasma screen TVs, because the standby power level of the appliance was supposed to be efficient. By doing so, the utility is encouraging the replacement of a regular 80 W TV set by a 300 W plasma screen TV set. Overall this switch to the new technology will generate more energy consumption.
5. Since the liberalisation of energy markets, it is common to see billboards and newspapers advertisements promoting the electricity of a given provider purely on its low rate. Even when a national energy market is dominated by state-owned utility monopoly, like in France, electricity is advertised as a cheap, abundant and non-polluting product. With such a market and societal environment, how can we expect the average consumer to pay attention to energy savings or energy efficiency? For example, one UK energy retailer credits the frequent-flyer account of its clients in proportion to the amount of energy they consumed.
6. In France, during the 90s, massive advertising campaigns to promote air conditioning were regularly launched at the end of the spring season. The campaign was co-financed on the one hand by manufacturers of air-conditioners and on the other hand by the state-owned monopoly utility. The rationale was simple: the company in question produces 80% of its electricity from nuclear reactors. During the summer, the load is below the electricity production. Advertising for a new seasonal end-use was for them a sound demand-side management strategy. And it worked. It is not rare in Europe to see advertisements of indoor winter comfort with lightly dressed people when snow is falling behind the windows. The image is not compatible with indoor temperatures recommended in energy efficiency campaigns that sometimes run simultaneously.
7. How can we expect the average consumer to pay attention to the fuel s/he consumes while driving, when it has become so easy and sometimes inexpensive to cross the country or travel overseas using low-cost airlines? Yet bunker fuels are exempted from scrutiny under the Kyoto Protocol and carry no taxes. How many people know that, even if they drive a highly energy efficient car, just one trip by air could emit more greenhouse gases than all those they have consciously mitigated that year? (Manicore 2005). How much do we think about it?
8. A European car manufacturer recently advertised one of its new models on TV as being so energy efficient in fact that you could justify driving to the mailbox around the corner only to drop off a letter. Fortunately, the message was shocking enough that several consumer groups complained and the commercial was withdrawn. But one can question why the commercial was developed and accepted by the advertising authorities in the first place? Who can assess how much effort it will take energy efficiency policy makers to just counter-balance the impact of this sole commercial? By the way, how many people have noticed that when cars are advertised, the streets and roads are always empty? How often does this image correspond to reality? Or might this image, instead, reflect rather than just project a nearly-innate type of human desire?

All these examples point to the inevitable "mixed messages" that consumers receive in their every day life.

Structural issues and trends in society working against energy efficiency

Our modern corporations are addicted to advertising. The examples above illustrate how commercials and advertisements pose a true challenge to energy efficiency and energy conservation, especially in the context of the radical shift that climate change imposes on us. Many other trends, and sometimes policies, in society are tending to pull in the opposite direction, weakening overall incentives for improved efficiency. Energy market reform stands as another example. By improving the productivity of energy supply, market reforms have tended to lower electricity prices, particularly for the most energy-intensive users, while the price of energy-using equipment is also falling in real terms. In addition, incomes are rising and new types of consumer products are continually entering the market.

The efficiency with which energy is used in a society is, at any given point in time, a function of literally millions of individually small decisions in the past – which refrigerator to buy, which heating system, which building design, which transport system, which process for an industrial plant. The information, incentives and policies that influenced each one of these millions of individual decisions over time eventually determine the sustainability of our human environment and social infrastructure. Once made, many of these decisions have very long-term consequences. Transport systems, patterns of urban development, and even buildings,

may last and continue to influence energy consumption and greenhouse gas emission patterns for hundreds of years – long after the decision-maker and the immediate incentives surrounding that decision are forgotten. As example the choices made right now by countries such as China or India to promote the use of individual cars by building roads and motorways, rather than public transport systems and correct spatial planning may have huge implications for CO_2 emission in the near future. In the mid-to-late 1980s, Hungary and Poland were well-served by strong public transportation systems , with a high proportion of trips made by organised transport (Urge-Vorsatz et al 2003:7), but these have subsequently been threatened, and partially fallen to a newfound reliance on cars and the infrastructure to support them.

If we are to evolve a fundamentally more energy efficient human infrastructure, without diminishing choice, then the long-term consequences of these choices must be immediately apparent to the decision-makers at the moment that they make their choices. Policy measures of differing types – from information provision through price incentives – can achieve this end. Further, minimum performance standards can set a limit to the impact that society is willing to accept, while other measures can encourage "beyond minimum" performance. Efficiency must be synonymous with quality (more efficient is better), and quality never sacrificed for efficiency.

For the case of energy efficiency regulations through norms, codes and standards, there is a discussion whether these policy tools encourage or not a greater penetration and use of the energy consuming goods they cover. They can become a common language for marketing such products more rapidly and more widely. If an air conditioner is known to pass the US or Japanese energy efficiency standards, then it's OK to purchase and use it wherever the customer is, in Europe or elsewhere. This may override the first question to be asked: has the customer done all that is possible to reduce cooling loads before installing an air conditioner? What creates the "need" for air conditioning in the first place?

The US energy-Guzzler lifestyle

The US-model of energy use, energy policy and behaviour is sometimes offered as the paradigm of a successful energy efficiency policy package. Yet the US is a world leader in consumption as well, sporting a social-technical system fundamentally oriented toward defining and then fulfilling ever-greater "needs." However pleasant fulfilling these constructed needs may or may not be, energy consumption in the US continues to grow. Yet arguably the US-model has been exported to Europe, assisting rapid changes in the energy use (out of town supermarket and malls, A/C in houses and cars, larger and more appliances, driving children to schools in SUVs, abandoning city centres for "green" out-of-town villas). Technology innovation seems the only paradigm of energy efficiency. As Jackson and Michaelis (2003:4) write about sustainable consumption more generally:

"The current institutional consensus has tended to settle for a position which implies consuming differently rather than consuming less, and in which this is to be achieved primarily by the production and sale of more sustainable products. This position is problematic because it collapses the distinction between sustainable consumption and sustainable production. It also fails to address important questions about the scale of consumption, the nature of consumer behaviour and the relevance of lifestyle change."

Indeed, in the US at least, the idea that consumption *should* be limited is one that may be far less accepted by the populace, even as ideology, than environmentalists assume. The US is founded not on thrift but on expansion, and it has long commanded the resources and the space to achieve this. It is perhaps not fundamentally consumer demand but a systematic demand for consumers that makes consumption grow. The American lifestyle evidently has considerable consumer appeal worldwide, even as much of this appeal might be considered imposed rather than organic. From an environmental standpoint, this trope toward Americanization threatens to corrupt ideas of "normality" worldwide, escalating demand, along the lines of the mechanisms suggested by Shove (2003). The US-model of energy policy must be considered part and parcel of the US-model of energy consumption, rather than an innocent counterforce to it.

A EUROPEAN CASE: ENERGY-USE AND POLICY IN NORWAY

Like in the US, energy consumption in Norway continues to grow, but the goal is not to reduce the total consumption of energy but rather to reduce its rate of growth. Electricity is generated mostly from hydro power, which is marketed by electric utilities as clean and environmentally friendly. Publicly funded energy conservation campaigns targeting households have in the past mostly coincided with tight supply side situations. Thus the efforts have been designed to address security of supply issues and to reduce winter peak loads in dry years rather than to alter energy consuming behaviour that might result in more efficient or lower energy use in the long term. Price is the main factor of interest when media talk and write about electricity, and high levels of electricity use is not considered a problem as long as the market can meet the supply. Consumers are given virtually no signals that tell them that reducing energy use – direct or indirect - is desirable or necessary to achieve sustainable development, and few critical voices are raising questions as a means of challenging the current paradigm

Since the publication of the Brundtland Commission Report, "Our Common Future", (WCED 1987), sustainable development has been a declared policy goal of the Norwegian government. A recent study that evaluated the implementation of sustainable development and the follow-up of the Rio Declaration of 1992 and "Our Common Future" in developed countries, concluded that although the WCED has been successful in putting sustainable development on the political agenda the follow-up in Norway for one has not necessarily resulted in actual changes in policies or action (Lafferty and Meadowcroft 2001; Langhelle 2001). It seems that although the political rhetoric reflects a commitment to sustainable development it is not necessarily implemented or operationalized 'on the ground' leaving us with not much more than ambitious, but rather empty, commitments.

One major problem seems to be the lack of integration of environmental and equity issues and goals into policies governing other areas of society, including energy. Environmen-

tal policy integration was one of the recommendations put forth by the Brundtland Commission, but its one that Norway seems not to have heeded or been able to implement (see discussion in Ruud and Larsen 2004).

The social equity issue

The Equity Issues have been discussed in the framework of the international climate policy and in particular during the negotiations or agreements on the future reduction of global greenhouse gas emissions. As there is a strong link between energy use and climate change the ongoing discussion on the equity issue should also involve the discussion of future sustainable energy systems. There are different equity criteria which may serve as a rule for distributing emission entitlements for greenhouse gas emissions or future energy savings targets:

Egalitarian rule: Principle of equal per capita emissions in climate policy. This means that a country whose population amounts to x% of the global population should get x% of the global energy saving targets or energy use,

Sovereignty rule: Principle of equal percentage reduction of current emissions in climate policy. This means that a country whose energy consumption amount to x% of the global energy consumption should get x% of the global energy saving target,

Polluter-pays rule: Principle of equal ratio between abatement costs and emissions. This means that a country whose energy consumption amounts to x% of the global energy consumption should bear x% of the global abatement costs for reductions of greenhouse gas emissions.

Ability-to-pay rule: Principle of equal ratio between abatement costs and GDP. This means that a country whose GDP amounts to x% of the global gross product should bear x% of the global abatement costs for reductions of greenhouse gas emissions.

As accompanying equity rules besides the aforementioned main equity rules, two more principles concerning the international distribution of emission entitlements have been discussed, this could also be transferred to the energy sector:

Poor losers rule: Principle of exemption due to GDP. This means that a poor country is exempted from any obligation for energy savings until a certain level of GDP per capita compared with the respective average of developed countries is reached.

Stand alone rule: Principle of no excessive energy consumption entitlements. This means that the entitlements for energy consumption of a country are not higher than its energy efficiency scenario.

Whatever the principles to be used, practice usually falls far short of obeisance to or satisfaction of ideology. So there is some danger in stating principles that will not be kept, and some danger of negotiating a scheme that amounts to an elaborate accounting exercise rather than mobilising real change.

New energy efficiency policies for a sustainable future

Time has come to design energy efficiency policies that will contribute to an equitable and sustainable energy future. A key element to create a sustainable energy future is absolute reduction targets in energy demand in developed countries. To this end, energy efficiency will have to be more than a minor element in a wider energy policy package. Very likely, energy efficiency and energy conservation should come in a global policy package that comprises all dimensions – such as the technology, the price signal, the behaviour, etc. Moreover the answer to the "truly" sustainable energy future goes far beyond energy efficiency and energy policies. It is rather sustainable development policies that should address energy production and energy use (both direct and indirect as in resource use) as an integral part.

Furthermore it must be fully integrated not only within energy policies in general (vertical integration), but more importantly, into policies at the international, national and sectoral levels (horizontal integration), including in city planning, transport, housing, building, industry and wider fiscal policies. It is when communities are planned, a house is being designed and built, or when a decision to link two cities with a road or with a railway is being taken, or when an appliance is being manufactured, that we can secure a lower level of energy demand for the future.

There certainly exist many different ways to revisit energy efficiency policies. One of the emerging ideas is to introduce caps on energy consumption or a "hard" target for energy savings (which may however lead to higher energy consumption, in an economic expansion cycle). Caps or targets can then be translated at the sectoral level (e.g. for transport, industry, households) or even down to the personal level. An interesting solution could be to develop ways to allocate personal energy consumption (household plus private cars) to individuals, while for business energy consumption (including transport and air-travel) cap and trade mechanism for energy consumption could be introduced, to reflect the real energy cost, including all the externalities, in the prices of product and services. Country, sectoral or personal caps would cause discussion on the equity issue: i.e. how to avoid penalising some less developed countries or poorer social groups, while at the same time allowing them to be part of a sustainable energy future.

The following five points are proposed to structure the efforts to be made. Each point corresponds to a given dimension of the renewed ambition for a more energy efficient economy; that is, aiming for an absolute reduction in energy demand. They each represent a component of the policy package. They are of course complementary and do overlap at some level. They are:

- Enhanced knowledge
- Information, education and motivation
- Stimulate research & development
- Set energy efficiency norms
- Use price signals

1. ENHANCED KNOWLEDGE

Analysing where and why we use energy (what form, which quantity, etc…) is a prerequisite to any sound programme. Resources are lacking to just understand our relation to energy. The two oil shocks in the 70s taught us how to collect information on oil production, and we do so in real time. Statistical analyses on the supply side have become a routine everywhere. They are used to understand where the market is, where the prices for supplying electricity, oil, gas or coal go. Energy efficiency, by contrast, suffers from a lack of data that would enable both a global picture, as well as a detailed view at the level where policy makers or market actors could make informed decisions in order to maintain or choose an energy efficient path. This dimension comprises efforts to be made on data collection on the end-use sector, develop energy efficiency indicators and understand the respective impact of human behaviour and technology in a given energy service. Governments should therefore take responsibility for maintaining and enhancing research on that side of the economy of energy.

2. INFORMATION, EDUCATION, MOTIVATION

Information, education and motivation are often quoted as pillars of any energy efficiency programme. However the time has come to revisit them in the market environment that we described earlier, acknowledging for instance the excess of advertising of all sorts in our daily life, in order to identify how to build a proper communication campaign. As an illustration, a concrete and simple idea would be to oblige advertisers to display the level of energy efficiency performance of an appliance, a car, a building, when the product is being advertised. In Europe, appliances, cars and buildings are progressively being labelled under the same format (7 categories from A – more energy efficient to G – least energy efficient). The category could be displayed as mandatory information on the advertisement support. Some retailers already do so in their commercial brochures.

The 20-years of anti-smoking campaigns in OECD countries can teach energy efficiency advocates a lot about how to make people abandon bad habits and adopt more responsible ones. First, direct promotion of cigarettes and cigars have been banned from any advertising campaign, then messages such as "smoking kills" have been placed on the packages. Many countries have adopted some format for labelling appliances and cars. An extension of that could be to oblige the manufacturers and the retailers to display similar information. To push the idea even further, we could envisage that the energy efficiency category, identified in Europe with a coloured arrow could be tattooed onto the appliances or the cars so that the information would also be available when traded on the second-hand market.

3. STIMULATE RESEARCH & DEVELOPMENT

Many supply side options for producing energy have been heavily supported by public research funding and activities. More should be done to promote research and development activities aimed at improving the energy efficiency of end-use technologies. For instance, top of the line fluorescent lighting represent an energy efficiency of 100 lumens/Watt. It is recognized that in theory, the efficiency could reach twice that figure. Encouraging R&D activities to explore further how energy efficiency could be improved and to design a new generation of fluorescent lighting at level above 150 lumens/Watt or the new Light Emitting Diodes (LED) lighting technologies may have an overall important impact on our economies.

In addition, and with much less public funding than the nuclear fusion research, multiple R&D programmes could encourage the design of new generation of energy efficient end-use technologies in the field of combustion, enhanced heat exchange, enhanced electricity transformation (DC/DC, AC /AC, and AC/DC), reduce motor losses, enhanced motor drives, cooling compressors, lighting, computing, telecommunication as a complement to R&D efforts in renewable energy.

As mentioned earlier, there is a need to reinforce research activities on the socio-economic impact of past and present energy efficiency programmes, including the consumer behaviour and the rebound effect of energy efficiency. This is to better understand the relationships and elasticities between energy efficiency, energy price and energy consumption in order to introduce or adjust, for instance, sound financial incentive such as a tax on energy to assure that energy conservation and related greenhouse gas reduction are achieved.

4. SET ENERGY EFFICIENCY NORMS, DEVELOP ENERGY SAVINGS STANDARDS AND CODES

Let's take the case of a house or an appliance. When being designed and built, the home builders or the appliance manufacturers have to respect safety norms. They do so by default. Safety norms have been designed and set, sometimes long ago, often times through international standards. They have been set at level that protects human life from accident, from casualty. Society accepts the costs of meeting the safety norms. In effect, they are insurances that we collectively pay to protect ourselves and future generations.

Safety norms do save human life. Energy saving norms can be designed and implemented to alleviate planet earth's risk vis-à-vis climate change. Hence energy conservation norms should be generalized in all sectors of the economy. New buildings should by default be energy efficient, the same should hold true for new cars or new end-use equipment.

As discussed earlier, energy efficiency is not enough and energy savings must become the policy goal. This can be translated when setting regulation, codes, norms and standards. For instance, for a new refrigerator, a house, or a car – and on top of a mandatory energy label and a minimum energy efficiency requirement – policy makers should also think about setting a maximum energy consumption target, regardless of the size of the product or the service that is provided. A new house could not consume, for instance, more than 10 000 kWh in primary energy per year, comprising all end-use; a car no more than 150 gCO_2/km; a refrigerator no more than 100 kWh/year; etc. This would counteract the tendency of current energy efficiency regulations that make larger energy systems (appliances, houses) appear more energy efficient than smaller ones. For each end-use and each energy system, maximum consumption limits could be introduced.

There is no reason for not implementing specific energy savings regulation for some existing energy consuming systems such as buildings. In Europe, the Directive 2002/91/EC introduced the notion of mandatory energy performance obligation when large buildings (above 1000 m²) are renovated. Germany has recently introduced thermal buildings codes for building renovation; for instance, a maximum of 120 kWh primary energy/m². In France a consortium from the building industry is lobbying the government to request a mandatory energy savings target of 50 kWh primary energy/m² for space heating for the renovation of 400 000 residential buildings per year, corresponding to the annual number of transactions. They argue that it is the only path for France to bring the building sector close to the 2050 greenhouse gas official target (Isolons la Terre contre le CO_2 2004). However, even these targets could still allow buildings to continue to consume more energy over time. In the long run CO_2 maximum budget for each household/buildings shall be introduced, leaving choice on how to meet it. It could be that people/buildings going beyond their allocated limit would have to pay to a fund that could be used to help the fuel-poor households to achieve low energy bills through energy efficiency measures.

There are numerous synergies between a renewed policy for setting energy efficiency and energy savings regulations and an enhanced scheme for energy labelling described in previous sections. In Europe, the Directive 2002/91/EC also introduce the concept of energy performance labelling and certification. Policy makers have the opportunity to link the future labelling and certification to energy performance obligation in both new buildings and the existing stock.

As most of the energy challenges that we are facing are global, energy saving norms (or standards or codes or regulation, whatever their nature) should be designed through international collaboration. At the least, international benchmarking of energy efficiency or energy savings norms can stimulate and influence the decision of analysts and policy makers. Also, standards, codes, norms and energy savings regulations could first be implemented in government procurement – this would allow the market, in a second step, to prepare for the energy efficiency requirement on a wider scale.

5. USE PRICE SIGNALS

There exists an extensive literature on the impact of price signals on energy consumption. Of course, much more should be done to reinforce the role and the impact of the consumer's reaction to the price signal. The price of energy should at least reflect the known environmental externalities. As the cost to access conventional energy is likely to grow in the decades to come, countries could introduce a progressive tax on non-renewable energy resources. For instance a 2% tax per year for the next 20 years could help our economy progressively accommodate for the foreseen increase of fossil fuel, as proposed by Jean-Marc Jancocivi (Jancovici 2004). The amount collected could easily be recycled by government back into the economy in investment in energy efficiency policies and clean energy technologies. Hence the introduction of such a tax can be neutral to the global economy. The tax collected on fuel transport could be recycled for building and maintaining clean public transport systems, a tax collected on electricity could fuel demand-side management programmes and energy efficient measures and technologies. A tax collected on stationary fossil fuel systems could be invested in building renovations. Of course, since taxation affects the overall economy and can disturb market competition it should best be applied in a coordinated way across all nations. International taxation of energy products could start with taxing kerosene for air travel.

The more energy efficiency labelling is enforced on energy consuming systems and equipment, the easier it is to invent variable Value Added Taxes (VAT) according to the energy performance or to organise some rebate schemes: the less energy efficient systems could be taxed heavier than the average ones and the money collected could alleviate the cost of the most energy efficient system. Similarly, labels and norms facilitate the obligations that governments can impose on energy utility companies to deliver energy savings at their clients' level, as is currently being discussed in Europe in the elaboration of an energy efficiency and energy services directive.

There exist many other possibilities to reinforce the role of price signals in order to reinforce overall energy savings strategies.

Last but not least, a personal carbon allowance could be considered to make individuals directly accountable for the CO_2 emission they cause through energy use (and in the case of electricity due the 'bad' choices of their suppliers). Individuals could be educated to privilege low carbon choices in their electricity and heat purchases, as well as in their general energy uses.

Conclusion

More than ever, the challenge of mitigating climate change demands that we revisit the use of energy and the role of energy efficiency in our economies. Energy efficiency will always be a preferred mechanism for managing our energy future. However, energy efficiency is but part of the solution. Drastic changes in consumption patterns will be necessary to achieve ambitious, long-term CO_2 emission reductions necessary to stabilise atmospheric concentrations. More than energy efficiency, the objective now is to aim for absolute reductions in energy demand. A technical strategy would be to privilege innovation, new technology, new services and new ways of doing business and, make full use of the price signal through energy or carbon taxation. At the same time, the right of every country to develop, and have high levels of services, can hardly be sacrificed in the name of sustainability. Right now the solutions are not all known, but certainly the climate and energy debate must be fully integrated with the sustainable development agenda and the discussion be about sustainable consumption behaviour in general, including consumption of material resources, water and food – not just the direct consumption of energy.

We need an "energy conservation revolution" to respond to the important challenges facing our societies. However, only modest steps have been taken. We need to understand why if we are to do better in the future. If developed nations do not do it, how can we even think that developing nations

will not duplicate the mistake we have made in our past and that still constitute a burden for our economies?

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