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Article

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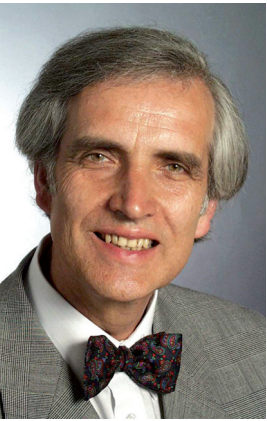
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ENERGY EFFICIENCY – THE FORGOTTEN SIDE OF SUPPLY SECURITY

EBERHARD JOCHEM AND HARALD BRADKE*

The energy demand of the world's countries is a derived demand, derived from people's direct needs like food, shelter, rooms with comfortable temperatures, health, mobility and communication that together with today's technology result in a demand for useful energy (e.g. heat, power, lighting). To be sure, far more than half of the world's population must make do with a standard of energy services which is lower than that necessary for humane conditions (UNDP et al. 2000, Ch. 6); in addition, about 2 billion people still have no access to electricity, not even for pumping water or to power hospital equipment. With today's technology, a humane lifestyle can be provided at around 35 GJ of primary energy per annum and capita, and those in Latin America, India or China, who have already reached that level, then pursue the goal of a western lifestyle with a present per capita primary energy demand of 165 GJ per annum in Europe.

High level of energy use – the dismantlement of supply security

In view of peaking crude oil production in the next 10 to 25 years and the change in the geopolitical line-up of the old and newly emerging superpowers – United States, China, and India – the question arises as to how much energy security will be threatened by the sheer level of energy demand in a few decades. This question is exacerbated because substitution in favour of alternative energy sources is proceeding

too slowly. Hydro power, with a share of around 5 percent of world primary energy use, will hardly be able to maintain its share; nuclear power, which has a comparable share, has been marking time for two decades because of acceptance problems (Europe) or political reservations (proliferation, e.g. in North Korea and Iran; terrorism). Renewable energy sources are often more expensive than the use of fossil fuels, and their contribution to reducing air pollution and avoiding the adaptation costs caused by climate change are not taken into account by the energy markets, especially in newly industrializing economies.

Observable energy policies that – at high levels of primary energy use – put their faith in energy substitution have serious dynamic drawbacks that strangely enough are rarely addressed in discussions of supply security. The substitution of energy sources

- initially leads to natural gas and back to coal, i.e. to the rapid exploitation of seemingly more cost effective non-renewable fossil energy sources,
- then, due to the decline in crude oil production, to foreseeable rapid increases in energy prices, as this decline cannot be fully offset by coal (which can only be used in large plants at low CO₂ levels by applying carbon capture and storage technologies), the low market shares of nuclear energy, or renewable energy sources;
- finally, this strategy of energy substitution precludes the possibility of gaining time via more intensive innovations in the efficiency of materials and energy. If energy were used more efficiently over decades, then the substitution processes would progress less rapidly, and there would be more time for technological learning and economies of scale.

Succinctly put: politics has to decide (and does decide) whether (or to what extent) it wants to spend its funds on wars to secure crude oil and natural gas sources in the Near East and Africa, or on supporting the technology development of materials and energy efficiency. What are the orders of magnitude we are discussing?

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The size of the efficiency potential as a gain in security

For the next five decades, assuming that world population will increase from the present 6.3 billion to 9 billion people, an average economic growth of 2 percent per capita and year, and an improvement in energy efficiency of 0.8 percent per annum (an average value that has been observed in many countries over several decades without particular energy policy efforts and hence also called “autonomous technological progress”), then the global primary energy demand in 2055 would be two and half times today’s level.

There are many analyses that show that energy efficiency could be doubled over such a period of time compared to the rate of autonomous technological progress assumed here (Jochem 2004). There is a high probability that this can even be done very profitably over several decades, even if energy prices do not continue to rise. The reason is that, in energy technology terms, industrialized countries incur very high energy losses in their use of energy at the various stages of transformation. These amount to about 25 to 30 percent in the transformation sector (all processes of transforming primary energy to final energy) with very high losses even in new thermal power plants (40 percent to 53 percent). They equal about one third when converting final energy into useful energy, with extremely high losses in the power systems of road motor vehicles (about 80 percent). At the level of useful energy, these are 30 to 35 percent with particularly large

losses in buildings and industrial processes (see Table).

In exergetic terms, i.e. viewed in terms of their capability or temperature potential, the losses in the two transformation stages are even higher (on average a total of about 85 to 90 percent in an OECD country). According to this measurement criterion of the second major law of thermodynamics, the “oh so modern” industrial society is still functioning at the level of the iron age of energy history.

If it is therefore assumed that energy efficiency progress is doubled to 1.6 percent per annum, then global primary energy demand would only rise by two thirds instead of additional one and a half times by 2055. 23 years would be gained between the two conceivable developments, the maximum of crude oil production would be shifted substantially, and energy options would have time to develop and could also be supplied more cost effectively. As a consequence, energy security would be greatly increased.

The possible efficiency gains cover a number of areas, some of which are not even addressed by energy policy even though they concern a broad range of innovations of new technologies and services:

- Substantially improved efficiency in *both stages of the transformation* of primary into final energy and final energy into useful energy, often with new technologies (e.g. co-generation of electricity and heat, fuel cell technology, substitution of burners by gas turbines, heat pumps or heat trans-

Greater energy efficiency would shift out the time of maximum crude oil production

Energy services with the subsequent energy chain from useful to final and primary energy demand, Germany 2001 (exemplifying an industrialised country)

Demand for energy services					
Air conditioned rooms	Industrial products	Mobility (people and goods)	Automation, cooling, etc.	Illuminated areas	Information, communication
3.28 bill. m ²	e.g. 45 mill. tons of steel	e.g. 1070 bill. passenger-km		about 6 bill. m ²	about 20 mill. Internet connections
Useful energy required by energy services: a total of 4,715 peta joules (PJ), of which					
Space heat	Industry	Transportation	Electric drives	Lighting	PC, Internet
2,158 PJ	1,367 PJ	516 PJ	556 PJ	16 PJ	102 PJ
Final energy required by useful energy (e.g. electricity, natural gas, petrol): 9,184 PJ at today's technology and effectiveness (in % of energy transformation)					
76.5%	57.4%	19.5%	59.7%	8.4%	79%
2,828 PJ	2,394 PJ	2,713 PJ	935 PJ	185 PJ	129 PJ
Primary energy required for the production of final energy: a total of 14,590 PJ					
Crude oil and imported products	Natural gas	Black coal and brown coal	Nuclear energy	Hydro and wind power	others
5,577 PJ	3,124 PJ	3,558 PJ	1,873 PJ	111 PJ	346 PJ

Source: Federal Ministry for Economics and Labour, Energy data 2003, Berlin; Federal Statistical Office, Federal Ministry for Transportation, BMW, authors' calculations.

formers, sterling motors, or tri-generation of electricity, heat and cooling).

- A considerably reduced demand for useful energy per energy service (e.g. passive solar or low energy buildings, substitution of high-temperature thermal production processes by physical-chemical or biotechnology based processes, lighter design of movable parts and vehicles, recovery of motive energy using power electronics).
- Increased recycling and reuse of energy intensive materials as well as increased material efficiency through improved construction or material characteristics with the effect of substantially reducing the demand for primary energy per material service.
- More intensive use of durable capital and consumer goods through the leasing of machinery and equipment (e.g. in the construction sector), car-sharing and other product-related services. The intensification of use is in the order of a factor of three to six.
- The spatial configuration of new industrial and other settlement areas according to energy considerations as well as a better mix of settlement functions of housing, production, trade and leisure activities in order to prevent motorised mobility. This should be possible where the service sector dominates (two thirds of GDP in OECD-countries are generated by services) and where industrial production is almost non-polluting.

There are numerous areas of efficiency gains whose cost would be negative over two decades

The costs of additional efficiency potentials would tend to be negative in the coming two decades, i.e. there would actually be gains, as substantial, profitable hidden potentials would be realised. This is refuted by many people though, strangely enough, rarely by the consulting engineers who inspect plants and buildings. For example, over the past four years, the authors have observed 20 companies of various sizes and industries that have systematically exchanged positive experiences on energy efficiency in a regional learning network. On average, they have managed to improve their energy efficiency by 7 percent within four years and their specific CO₂ emissions by more than 10 percent at a net profit of 10 to 20 € per avoided ton of CO₂.

Reasons for neglecting and repressing efficiency potentials

The existence of such hidden yet profitable energy efficiency potentials is denied time and again by rep-

resentatives of business associations, but has been proven by consulting engineers. When internal CO₂-certificate trading began, even large, energy-intensive companies like BP discovered efficiency potentials of more than 3 percent per annum over four years. There are numerous reasons for these missed opportunities (Jochem 2003):

- There are thousands of technologies and millions of decision-makers in households, companies, and offices involved in making investment decisions, dealing quickly with disruptions due to failed machinery and operating all kinds of machines, vehicles, heaters and energy-powered equipment. The diversity also encompasses technological aspects across the entire capital stock of an economy, decisions regarding new or replacement investments at the various technological levels of energy transformation and use, and decisions about material efficiency and material substitution. These also include the behavioural decisions with respect to the day-to-day operation made by almost all the members of a society. This diversity is perhaps the major reason why efficient energy and material use is neither attractive to the media nor conducive to a “natural” clear formation of interests. On the contrary, there are sufficient conflicts of interests between the producers of technology, planners, architects, building owners, leasing companies, primary contractors and energy suppliers.
- Technology producers could install highly efficient motors in their equipment, but customers usually only look at investment costs, not at life-cycle costs when making purchasing decisions. The same is true of tradesmen submitting proposals for highly efficient boiler plants, window systems or heat insulation.
- Investors decide – despite the long lifetimes of most energy transformers – according to the risk criterion of the payback period (e.g. up to three years) and thus ignore highly profitable investments with internal rates of return of up to 25 percent. Many households and small firms make their decisions based purely on investment costs without ever considering a life-cycle analysis.
- Planners and architects are paid according to standards that do not include knowledge about or the planning time needed for energy-efficient construction. The principal or the building owner must explicitly request this, usually without being able to assess the effects.

- Energy suppliers, too, want to make a sale. A more efficient solution is often not mentioned and customers' attention is drawn to a second-best solution instead; customers tend to be satisfied with this as they have no knowledge of the best solution themselves.
- Adverse effects on international competition is often put forward as an argument against internalising the external effects of energy use. However, this argument only applies to a fraction of energy-intensive industries (in the order of a few percent of a country's value added) and confuses the discussion of internalising external costs when using fossil energy sources.

To summarise: in a society with little consciousness of the issues of sustainability and resource conservation, not only the multitude of possible energy efficiency solutions, but also simply wrong decisions on the part of businesses due to industry traditions or conflicts of use, preferences, status decisions and lack of day-to-day market insights result in the opportunities for efficient energy use not being recognized or practically acted upon. This is also true of newly industrialising and developing countries that in their (understandable) quest for economic development tend to adopt the decision patterns of industrialised countries and possibly also their discarded technologies as second-hand purchases. These countries then follow poor building standards because of a lack of available capital that result in high heating costs in the winter and a high demand for air conditioning in the summer (Janischweski et al. 2003).

Conclusions and outlook on improved energy security via energy efficiency

Depending on energy use and energy source, object-related efficiency potentials range from a few percentage points (e.g. in very energy-intensive processes of the basic materials industries) up to 80 to 90 percent (e.g. in passive housing standards, modern lighting, switching to membrane technology in thermal separation processes). Overall, the rise in worldwide energy demand could be halved within 50 years. This would extend the production maximum of crude oil by one to two decades, reduce the costs of using renewable energy sources due to the lower energy demand per service and initiate a substantially broader innovation wave in all areas of business and society than if energy policy were con-

centrated solely on the supply of energy via substitution processes.

The multitude of efficiency potentials and obstacles results in a comparable number of instruments and measures. At first glance, this may seem an unmanageable task, causing politics to focus once again on energy supply and substitution possibilities. But this course of action surrenders several degrees of supply security and also the chance to steer development from the start in the direction of sustainable energy use. Energy and material efficiency transform the entire capital stock of an economy, not just the sector of energy suppliers with all its increasing risks to supply security. The security of supply objective of energy policy is not likely to be reached by military interventions or market theories, but by a highly efficient use of energy and materials on the part of a system relying on renewable energies to a large extent and offering a large portfolio of energy supply options.

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Energy efficiency potentials are not utilised for short-term cost reasons