Energy conservation: who is concerned?

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Conservation de l'énergie—Qui Concerne-t-elle?

Energiesparen—Wessen Aufgabe?

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SUMMARY
Energy conservation is both, a necessity and an opportunity. However, many different obstacles impede a quick breakthrough. The highly desirable progress has primarily to rely on the efficiency of the price mechanism. It should be supplemented by proper information and—as a last resort only—by government interventions. Of the four possible steps to energy conservation—avoiding obvious waste of energy, rational use of energy, (governmentally) forced savings and self restraint—the rational use of energy which relies mainly on the price mechanism, seems to be the most promising. Professional engineers, architects and economists have to play a major role in promoting it.

RESUME
La conservation de l'énergie est aussi bein une nécessite qu'une chance. Toutefois, différents obstacles s'opposent à un développment rapide. Le progrés hautement désirable doit en premier lieu reposer sur l'efficacité du mécanisme des prix. Il doit être complété par une information judicieuse et—en dernier ressort seulement—par des interventions gouvernementales. Des quatre étappes possibles vers la conservation de l'énergie—éviter des dilapidations flagrantes, utilisation rationnelle, restrictions forcés (par état), restrictions voluntaires—l'utilisation rationnelle de l'énergie, qui repose essentiellement sur le mécanisme des prix, semble la plus prometteuse. Des ingénieurs, architects et économistes ont un rôle décisif à jouer dans sa promotion.

ZUSAMMENFASSUNG
Energiesparen ist sowohl eine Notwendigkeit als auch eine Chance. Verschiedene Hindernisse stehen indessen einem schnellen Durchbruch entgegen. Der höchst wünschbare Fortschritt sollte in erster Linie auf die Wirksamkeit des Preismechanismus abgestützt werden. Er sollte ergänzt werden durch geeingnete Information und—aber nur als ultima ratio—durch staatliche Massnahmen. Von den vier Stufen zum Energiesparen—Vermeidung von offensichtlicher Energieverschwendung, rationelle Energienutzung, (staatlich) verordnetes Energiesparen und freiwilliger Konsumverzicht—erscheint die rationelle Energienutzung, welche im Prinzip auf dem Preismechanismus beruht, am vielversprechendsten. Ingenieuren, Architekten und Oekonomen fällt bei ihrer Förderung eine entscheidende Rolle zu.

1. THE CHALLENGE OF THE PRESENT ENERGY SITUATION

Energy is likely to remain one of the most-discussed topics for many years ahead because the range of problems it brings, is enormous. One has to recognize that, worldwide, the energy problem is basically an oil problem. Oil is by far the most important form of energy. It provides 46 % (1978) of the total world energy consumption. Including natural gas, with its share of 19 %, the hydrocarbons represent two thirds of the total world energy supply (Ref. 9, p. 111). However , this highly valuable source of energy is - as everybody knows - not renewable and hence finite. According to the findings of the World Energy Conference in Munich (1980), the production of conventional oil is at or near its all time maximum level (Ref. 2, p. 4). Due partly to this fact, and partly to political reasons, it has become very expensive in the last decade. Besides being expensive and scarce, it constitutes a political and economic risk of highest concern for most of the oil-importing countries. These considerations concerning the supply side already provide a good many reasons to wish that the world economy should do with less oil.

But how does the demand side appear? Industrialized countries such as the OECD members want to maintain or even increase their economic growth rates. But nowhere in the world has it been proved that a substantial economic growth can be obtained without increased energy input, not to speak of the developing countries, where per-capita consumption of energy amounts to approximately a seventeenth of the amount of that of the OECD-countries (Ref. 2, p. 2). These are the countries most-seriously affected by the oil and energy crisis. Their standard of living is very low and the need to catch up is enormous. And if, in addition, their fast-growing population is taken into account, their energy demand turns out to be tremendous. It is, therefore, not surprising that most world energy scenarios expect that the global energy demand will increase in the next four to five decades by a factor of three to four (Ref. 5, p. 171; Ref. 4, p. 31/32). If these levels of energy production cannot be reached, it will become very likely that the economic growth rates, which were assumed for these scenarios, also cannot be achieved. Economic growth will then be curtailed by insufficient physical availability of energy and that means depression, unemployment and extending the phase of misery in the poor countries.

With respect to this serious background of the demand and supply situation of energy it is evident that there are two energy strategies which form the main options for all countries throughout the world:

- the first one is substitution of oil (or hydrocarbons in general) by other forms of energy such as coal, nuclear, hydro, unconventional oil and all kinds of new energies.
- the second, and not less important, strategy is the one that has to be dealt with in more detail - energy conservation.

2. POTENTIAL AND ADVANTAGES OF ENERGY CONSERVATION

Energy conservation means a reduction of energy consumption, be it in relative or in absolute terms. A reduction in relative terms can be defined as a decreased ratio between used energy and unit of activity. This definition is identical with improved energy efficiency. A better energy efficiency does not necessarily lead to reduced energy consumption in absolute terms. The answer

depends on the question whether the respective activity is increasing faster than energy efficiency. But in any case, improved energy efficiency leads to a lower level of total energy consumption than otherwise would have been obtained. Under "ceteris paribus" conditions, a reduction in absolute terms is always obtained.

The proposed definition of energy conservation - namely reduction of energy consumption in relative or absolute terms - clearly demonstrates that energy conservation can also be obtained without improved energy efficiency, simply by a reduction of the denominator, e.g. the requested comfort, consumption or the economic activity in general. Whereas the first version - improved energy efficiency - means doing things better, the second one means, not doing things at all or at a lower quality (Ref. 2, p. 5).

If energy conservation is to be one of the most-important strategies of world-wide energy policies, its potential should be of a considerable magnitude. In fact, in most known energy scenarios of countries or enterprises, energy conservation plays a key role and the energy-conservation potential is very significant. According to a review of several studies, which has been prepared for the European Community (Ref. 7), the potential, which could be harnessed up to the year 2000 (based on oil prices before 1979), was estimated at:

- 20 - 25 % in transportation
- 15 - 35 % in industry
- up to 50 % in the residential and commercial sector

According to the Federal Energy Committee of Switzerland, it is possible to reduce energy consumption by 20 to 30 % compared with the reference case up to the year 2000 (Ref. 3, p. 22).

Even if energy conservation is limited to a contribution of about 20 percent within the next twenty years and even if progress cannot go on endlessly, due to the law of the diminishing returns, we have to be aware of the fact that within the next few decades there does not exist any single new form of energy with the same potential. Energy conservation has therefore rightly been called an "invisible resource" (Ref. 2). Unlike many other forms of energy, this invisible resource presents further advantages:

1. Being an "indigenous" resource, it eases the balance of payment problems of energy-importing countries and replaces imported energy by capital and indigenous skills and manpower.

2. It reduces the risks of a possible oil-supply disruption with very severe economic and political consequences.

3. Energy conservation enables - at least relatively - a lower level of energy consumption and affects therefore the environment to a much lesser extent. Energy conservation is so-to-say clean.

4. As energy prices have risen drastically in the last few years, energy conservation is in most cases also economically attractive.

5. Energy conservation is, in practice, a renewable resource, i.e. it is limited in extent but it does not rely on limited resources and its fruits can be

earned every year; it is renewable.

We can therefore conclude that energy conservation is not only a necessity from the point of view of the world energy supply and demand situation as pointed out at the beginning, but that it is also one of the most-attractive options for any energy policy; be it in developed or developing countries and even for oil exporting countries because, one day, their resources will also be depleted. Among all the possible and necessary energy-policy measures, energy conservation is by far the least-controversial one.

If energy conservation is the most-attractive option of energy policy, it is surprising that the results are rather modest - at least up to the present time. The figures of the OECD-countries (Ref. 6, p. 3) show that from 1973 to 1978 total energy consumption still increased by 1.3 % per year. This is, of course, a considerable progress if compared with the energy-growth rate of 5.2 % from 1960 to 1970. But the progress is, to a great extent, due to the reduced economic activity, which dropped from an annual GDP growth rate of 5 % to 2.6 % in the two respective periods. Thus, only about one and a half percent of the diminished energy growth rate can be attributed to improved energy efficiency. Apparently, we are still in a phase of little steps, painful details and tiny successes. Is that not astonishing for a period in which the oil crisis and the limits to growth were the most vigorously discussed topics?

3. THE DIFFICULTIES OF ENERGY CONSERVATION

An examination of the way energy conservation must be implemented soon identifies a great variety of factors which impede rapid and effective progress. Some of these factors are of a practical nature and some are more psychological.

3.1 Lack of Information and Awareness

Lack of public information, awareness and concern belong to this latter category. Human behaviour and attitudes cannot be changed if people do not have a clear understanding of the energy problem. Although progress in this matter would have substantial effects, this improvement is hard to achieve. For the man on the street, the energy problem is not his only problem. The energy issue is competing with other and possibly not less important ones, such as labour conditions, family questions, health, housing, hobbies, social security, cultural and lots of subjective topics, which reflect the complexity of our life.

3.2 Diffuse Appearance

Moreover, consumption of energy is often hidden from the eyes of the individual and diffuse in appearance. Turning off the lights, which saves very little energy, unfortunately appears as the most-obvious kind of saving energy. But when somebody opens a window to get fresh air, sits in a car and enjoys a beautiful landscape, eats deepfrozen food or drinks beer out of aluminium cans, he is rarely aware of the fact that he is indirectly consuming considerable amounts of energy. And even if he were willing to seriously save energy, he would be almost powerless in many respects. What can he do if he lives in a building which is badly insulated, if his route to his working place urges him to use an energy-consuming transportation vehicle or if he has to buy energy-intensive products? He is not totally powerless but energy conservation would need many little and non-spectacular actions, which are not very attractive.

Energy conservation is difficult, mainly because it is a very diffuse and not a concentrated matter.

3.3 Too Short Time Horizons

Another well-known difficulty is the time horizon perceived by consumers. Private as well as industrial users expect that investments are paid back in a well foreseeable future, e.g. in the next two to five years, regardless of the fact that the physical lifetime of the investment may be ten to twenty years. Although this attitude is not justified, it represents another real difficulty for energy conservation.

3.4 Important Role of Indirect Use of Energy

The more indirectly energy is used, the less is the chance that it can be saved explicitly by the final consumers. The relationships in this respect are quite impressive. In industrial countries, energy used as an intermediate good within the economy, accounts on the average for 60 % of total energy consumption. About 40 % only is used directly by households as consumptive energy (Ref. 1, p. 524). This does not mean that in the industrial sector energy conservation is neglected. On the contrary, the efforts in industry in favour of a rational use of energy are considerable. Nevertheless, the consumption patterns of private consumers are only indirectly influenced by energy-related arguments.

3.5 Institutional Impediments

Other impediments are of an institutional characteristic. The best example is the housing sector where the landlord is basically interested in low investment costs because he wants to compete with a low rent on the market. This excludes in general that much attention is paid to the question of energy conservation, e.g. insulation, optimal size of heating devices, etc.

3.6 Low Rate of Renewal in Energy Infrastructure

Energy is largely used in conjunction with durable capital goods such as houses factory equipment, vehicles, etc. An adjustment of the energy-related equipment to a new energy situation and prices requires, therefore, a massive change in the capital stock. This must reasonably be spread over a long period of time. Rising energy prices will undoubtly bring forward the economic threshold of replacement investments. This means a chance for an earlier adjustment to the new situation. However, it will be years before the adaptation will fully have taken place.

3.7 Complexity of Proper Calculation

Finally, we have to take into account that rational decisions on energy conservation are highly complex.

a) Theory

In general, this is a classical optimization problem which looks - al least for engineers and economists - rather simple. It can easily be illustrated by a simplified example of optimal insulation of a building by Figure 1.

There exist:

- fixed costs,
- insulation costs, which are roughly proportional to the insulation level, and
- energy costs, which decrease more or less hyperbolically.

By superposition of the three functions, the total cost curve is obtained, the minimum of which indicates the optimum insulation level. This is the theory.

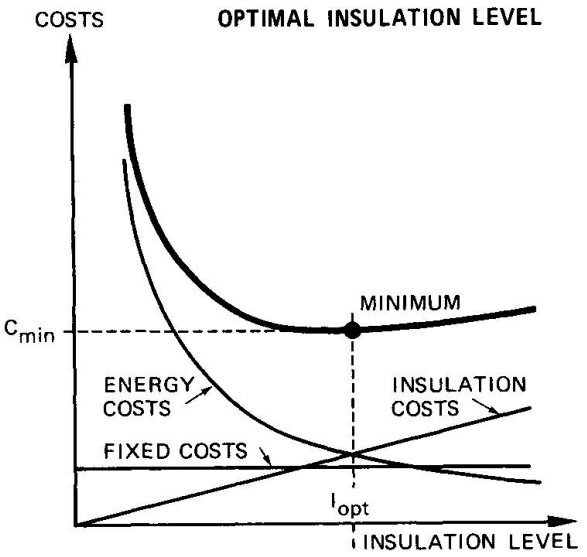

FIGURE 1

b) Estimating Parameters

In reality, some major problems have to be solved in order to make a proper calculation.

- One has to apply a reasonable interest rate level; (in correct relation to inflation)
- one must take into account the future maintenance costs of the building;
- one has to estimate the physical lifetime of insulation materials, of the building and of the heating installations;
- one has to argue about future energy prices and
- if one applies sophisticated calculation methods, one has to do all these cost-benefit considerations on the basis of a risk analysis.

c) Comprehensive Approach Needed

Even if all the calculations are properly done, the danger has to be faced that only a small fraction of the problem is treated with accuracy, that the bigger part of the problem remains in the dark and the question arises whether this accuracy is worthwhile. When considering material questions one has to ask what happens before the material is used and what happens after its useful lifetime. If a certain success in energy conservation in the context of space heating in a building is only obtained at the cost of a bigger energy input in preceding or succeeding processes, the result is very dubious. Figure 2 shows the whole complexity during the life circle of an industrial material (Ref. 11, p. 112). This demonstrates that a valid answer can only be obtained by extending the energy-balance calculations on the whole energy chain of a certain product. It often happens that the energetically bad reputation of some energy-intensive products like aluminium or plastics is not so bad after all. E.g., in the transport sector, the energy balance of aluminium may well be positive if the high energy content of the construction material is compared with the energy savings of the vehicle during its lifetime due to its lighter weight.

d) Human Factors

Not even the aforementioned level of knowledge is sufficient because the energy consumption of a certain system is not only determined by its hard-

ware configuration but also by its use by human beings. If one looks at the energy-consumption determinants of a building, it is seen that insulation is an important, but by far not the only decisive factor. The total energy consumption depends on factors such as:

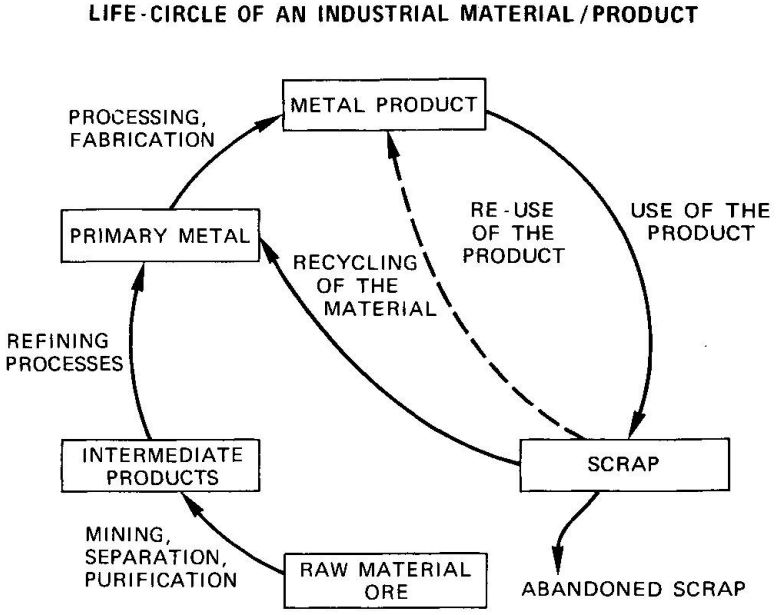

FIGURE 2

- climate (which cannot be influenced)
- dimensions of the building
- position and exposure of the building
- configuration of the building
- insulation, not only of walls but also of the roof, windows, doors and the ground floor
- sealing of joints
- efficiency of the heating system (dimensioning, layout, heat recovery)
- demand for comfort (temperature level, air-conditioning)
- behaviour of inhabitants

3.8 Conclusion

To sum up, it has to be recognised that many difficulties and impediments exist, which make progress in energy conservation very difficult. In view of all these difficulties, a good deal of optimism is required if one is not to give up. However, as has been pointed out, energy conservation is a necessity as well as a major opportunity.

4. AN EFFICIENT APPROACH IS NEEDED

In order to surmount all these obstacles in the interest of energy conservation, a strategy is needed, which is simple enough to be applied and effective enough to provide good results. First of all the strategy has to be efficient.

In this respect, the overriding role of the price mechanism has to be stressed. Its main advantage lies in two effects. First, the price mechanism automatically accumulates all energy inputs at the different levels of production. If this mechanism is not hindered, an investor does not have to worry about the energy balance of the whole energy chain of his products. The second advantage lies in the fact that all the decisions can be taken without any government interference or other administrative efforts. More than 200 years ago, Adam Smith called

this phenomenon the "invisible hand". Now, it can be concluded that his "invisible hand" plays a most-decisive role in utilizing the "invisible resource" of energy.

One may object that in the costs of a product the energy price plays a minor or an even neglectable role. This may have been true for the years before 1973. However, it is no longer the case today as Figure 3 clearly shows. The nominal price of crude oil has since then increased by a factor of 20 and even in real terms by a considerable factor of 4 - 5. As far as future energy prices are concerned, it is better to err on the high side in making projections. If it could be assumed that the free market prices of energy reflected the real costs of energy, including all possible external costs, the decisions on the use of energy could well be based on a pure rational cost calculation, which indicates a certain solution giving minimum costs. This is justified because finally, energy conservation is not a goal in itself but a means to find the solution with the least costs. The consideration which has to be the starting point is as follows: The price mechanism is, as a first approach, the most-efficient and most-reliable allocation mechanism for the rational use of energy.

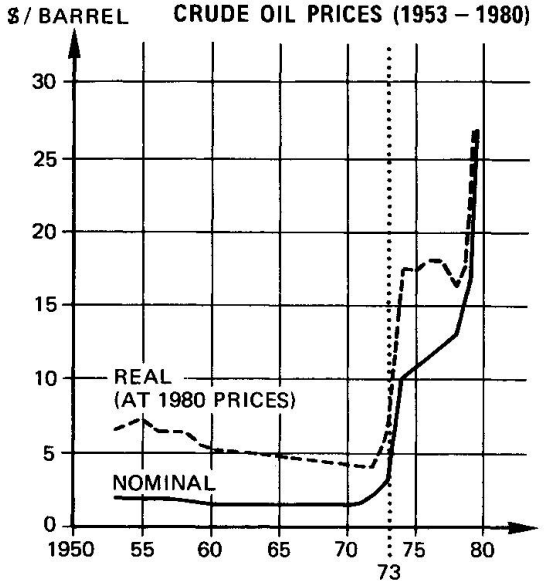

FIGURE 3

A minimum prerequisite in this respect is that energy prices are deregulated and that there should not be tax exemptions made for energy.

If there are - and there are indeed - imperfections within this mechanism, the efforts should be aimed at supplementing and not supplanting the market mechanism. On a first level, information and motivation should be improved in the education sector from primary schools up to universities, in the public sector for the man on the street and also in the industrial sector, from labourer to top manager. This information should demonstrate the widespread relevance of energy flow in our society and civilisation and give hints how to avoid unnecessary dependence on costly energy in the present and the future.

However, the response of the consumers to better information is still voluntary and government's energy policy may have to become more positive. The rationale for government intervention are cases where

(1) private markets do not work (or do not work well);
(2) private markets can not work; and
(3) private markets should not work (Ref. 8, p. 2)

For instance, environmental and ecological side effects of the use of energy cannot be taken into account by the market mechanism. In order to limit these effects to an acceptable level, the environmental costs could be internalised. The market mechanism could then work as before. As this internalization is very complicated and often controversial, the other alternative is, to set explicit standards for insulation or speed limits for cars, etc., which must not be violated. Even in this latter case, governments should only prescribe standards but not give instructions how they have to be obtained. This task can be fulfilled

by the market.

Another deficiency of the market mechanism may be the already-mentioned conflict between tenants and landlords. Building codes with mandatory minimum thermal efficiency standards may then be reasonable. Unfortunately, their efficiency is limited to the fact that they can only be applied in the context of the construction of new buildings. For existing buildings, the occasion of renovation has to be awaited.

5. THE FOUR STEPS TO ENERGY CONSERVATION

These considerations of the question of how to strengthen the energy conservation efforts indicate that an efficient energy conservation policy should

- rely primarily on the price mechanism
- provide the necessary information for all kind of private or industrial, direct or indirect energy consumers
- and - if necessary - supplement the voluntary efforts of consumers by certain governmental measures.

If these guidelines are accepted, the energy conservation policy that can be recommended consists of four successive steps (a synopsis is given in Figure 4):

The four Steps to Energy Conservation — Figure 4

Step	Necessary Conditions	Who is concerned ?
1. Avoiding obvious waste of energy	• Avoidance of stupidity • Awareness • Information	• Individual consumer • Government
2. Rational use of energy	• Effective energy price signals • Proper calculations • Rational behaviour and energy management	• Investors • Building contractors ↑ (Engineers, Architects, Economists)
3. Forced savings (by legislation)	• Mandatory measures • Inhibitions	• Governments • Politicians
4. Self restraint	• Readiness to renounce on comfort and convenience • Insight, change of life style • Moralistic austerity appeals	• Individual consumer ↑ (Opinion leaders, Philosophers, Politicians)

- The first step is: avoiding obvious waste of energy. Everybody is able and encouraged to do this. There are plenty of examples for this case e.g., not to heat or to cool empty rooms or buildings, to reduce the almost tropical and unhealthy temperature levels of offices and private rooms, not to regulate the room temperature by opening windows but by turning off the radiator, not to let machines, appliances or cars operate which are not really used, etc.

  This very primitive stage can be achieved without loss of comfort. No basic change of behaviour and no investments are required. It needs only some information, awareness and concern about the energy situation. Although the contribution of this step cannot be quantified, it is obvious that considerable progress in this respect is possible. This step is, by the way, the most advantageous one, because no or only an insignificant effort induces a considerable result.

- The second step is based on the concept of rational use of energy. This is the major field of activity of professional engineers, architects and economists. Although, the decisions are taken by investors and building contractors they have to be informed and advised by specialists. Loss of comfort or convenience is not required at this stage either, however it needs substantial effort either of an intellectual nature and/or in terms of capital investment. This step is the art of finding the optimum relationship between energy input and the obtained result, as was pointed out by Figure 1.

  This approach shows that energy can, to a certain extent, be replaced by capital and know how. Today's tendency is evident: As energy costs increase drastically, it will prove, quite often, that the technical solutions of the past ten to twenty years can no longer be the solutions of today or tomorrow. Our buildings should no longer be conceived as a pure matter of statics and aesthetics but must also take account of energy requirements. They should not, as a critic pointed out recently, remain energy anihilation machines. A real revolution in building construction and architecture is needed. This revolution is not based on some nebulous and vague socio-revolutionary idea but on the hard fact that energy is no longer abundant and cheap.

  This step can be considered as the most promising one. Its potential is enormous and the improved energy efficiency is not the result of less comfort, or government regulations, but the result of rational behaviour within free-market conditions. The better it works the less are the chances that government has to step in or that energy prices will rise faster then they have already.

- The third step of accelerating the process of energy conservation is forced savings. As already pointed out market mechanisms are sometimes not as perfect as desirable. Consumers may sometimes not be as well informed as proposed in step one, and will possibly not behave as rationally as the pure "homo oeconomicus" of step two would suggest. In these cases, a supplementing of the market forces by mandatory measures by governments may have to be taken into consideration. In the transportation sector, for example, it may be reasonable to introduce speed limits instead of leaving the decision on the maximum speed up to the individual driver. Price signals obviously do not work well in this case.

  Another example of imperfect market mechanism is the already mentioned sector of rented houses, where the interest of the landlord lies in low construction costs, whereas the tenant is interested in low total costs, including the

costs of energy for heating and warm water. Mandatory insulation standards may in this case be an acceptable and efficient solution.

An even more extreme measure in the category of forced savings would be an absolute inhibition of certain forms of energy use. People could by such measures be forced to restrain from purely luxury energy consumption like heating of private swimming pools or outdoor heating.

It is obvious that these measures should be only a last resort for governments. There prevails the danger that these measures are arbitrary, that they create inefficient bureaucratic paper work and it is almost certain that they would not be popular to the public. Although mandatory measures may sometimes be psychologically helpful and acceptable, their range is limited. In normal situations their effect should not be overestimated. Experience shows that, by and large, the market mechanism provides better results than a multitude of government interventions (Ref. 10, p. 11). One should, therefore, always compare the possible deficiencies of the market mechanism with the possible deficiencies of mandatory measures.

The fourth degree of energy conservation could be called self restraint, in contrast to step three which was called forced saving. Like the first step (avoiding obvious waste of energy) it appeals to the energy consumer's free will. However, at this stage, the possibility of renouncing on comfort is no longer excluded. Renouncing on pleasant room temperatures (heating and air-conditioning), walking instead of driving, manual work instead of using all kinds of appliances in kitchen, house and garden are also considered as possible alternatives to energy consumption. Another indirect way of reducing energy consumption would also be to consume less energy-intensive products and services. Clearly questions of our life style, of personal behaviour as well as fundamental questions of our civilisation are involved. Is personal and collective happiness any longer positively correlated with the amount of consumed goods, the flow of services and, hence, energy consumption? Can we afford an energy consumption level which is nearly twenty times higher than the one in developing countries? These are important and justified questions indeed. However, the answer cannot be given by engineers and economists. It has, if ever these ideas are to be convincing, to be the result of a change in the public attitude, which in itself could be the result of the efforts of all the philosophical, ethical, moral and political authorities to reduce energy consumption, not only by increasing efficiency but also by diminishing the consumption demand in broad terms. It would, of course, be one of the most effective steps to energy conservation if people would decide to consume less.

Although one cannot be too optimistic with respect to the possibility of voluntary energy savings, one has to bear in mind that a wise self restraint is much more easily to be accepted than a situation in which a forced restriction turns out to be the only possibility.

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