Under-use of body energy and over-use of external energy

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Abstract
The world's affluent countries, such as the EU, are facing two severe problems with long-term consequences. One problem is the epidemic-like increase in adverse health effects, which are related to the increasing wealth, primarily appearing as obesity and its associated diseases. This is caused by overeating and under-use of the body energy, due to increased use of mechanized and energy consuming assistance for transport and other daily tasks. This connects to the other problem, namely these countries' excessive use of fossil fuels and other environmentally harmful forms of nature's external energy. This paper illuminates the options for integrated solutions to the two problems by making more use of body energy as a means to reduce the use of nature's external energy.

First is listed a human's body energy used for various tasks and occupations, showing that a person's use of external energy is and order of magnitude higher, which can be expressed by the scores of "energy slaves" each citizen utilizes. An extra health driven physical effort by humans seems to have negligible *direct* impact on energy consumption. The paper will, however, indicate examples of significant *indirect* savings of external energy, achieved by healthy extra human efforts. Also, the paper will suggest ways to integrate energy saving policies with health policies for organizing and designing cities and houses to be "healthy inconvenient", encouraging or pushing people to use their body in their daily doings. This is an enormous challenge to the conventional way of thinking among architects, engineers, planners, as well as individuals in general.

Introduction

> *Do not lose your inclination for walking: Every day I walk my way to the daily well-being and walk away from any disease; I have walked myself into my best thoughts, and I do not know any thought so hard, that you cannot walk away from it.*
> Soeren Kierkegaard, Danish philospher, ca. 1850
> (jsn translation)

Western Europe and other affluent parts of the world are facing two major problems. On the one hand, these countries are the dominating contributors to the global environmental problems, which are best illustrated by the high per capita CO_2-emission and other consequences of unsustainable over-use of nature's energy gifts. On the other hand, a health problem is developing with an epidemic-like speed in the form of obesity and the related diseases, caused by too much and wrong food intake, combined with too little use of the body's energy. These two problems could also be presented as two symptoms of one problem, the affluent wealth.

Many other negative impacts of economic wealth are increasing, while the gains are decreasing. The net marginal benefit of a growing Gross Domestic Product, GDP, is decreasing and some indications suggest it is already negative, meaning that people are getting worse off year by year. And so is the environment.

This paper suggests how society's policies and individual behaviour could possibly be adjusted to integrate increased healthy use of what is here termed *human body energy* with decreased use of what will here be called *nature's external energy*. Although there is a marked difference between the use of non-renewable energy like fossil fuels and the use of renewable energy like biomass and hydropower, the use of all of them have an adverse effect on nature.

Health versus Wealth

Survival, and hence health, has always played a central role in any development. This section outlines how the correlation has been between the development in material wealth and general health in regions like the Western Europe and Northern America towards their affluence. In ancient times, say 1000 years ago, in these regions average life expectancy was rather short, mainly due to various diseases and lack of treatment. But there are no reasons to believe that people were worn out from hard work, and in some way they might have lived a healthy and meaningful life when there were still plenty of forests, rivers and other nature around. It is interesting to observe, that their tasks for survival were dominated by activities like picking nuts and berries, fishing and hunting, activities we today are willing to pay for being allowed to do (Lidegaard 1972). Deforestation and other environmental degradation gradually called for harder work, promoted amongst others through the emerging protestant religion, to emphasise hard work as a virtue, a value in itself. This formed a basis for industrialized societies, but also lead to a couple of centuries with more hardship for most people than earlier in the form of longer and harder working hours, causing severe health problems.

GRANDPARENTS' HARD WORK

Even just a few generations back many people in the affluent countries like the EU, had their bodies gradually worn out and broken down due to hard physical work in farming, industry, construction, mining, transport and households. This is still the situation for many millions of people in developing countries. Today it is hard for Europeans to imagine the human power needed to bring the grain harvest in house, to forge the steel manually, to carry bricks up four floors, to walk 5 km to and from work every day, and to do the laundry manually, all of which was normal 50-100 years ago.

For the physically hard working people at that time there were usually no problems in burning off the food energy intake. On the contrary, the body needed fuel for the hard work, as illustrated by human energy required for various tasks and occupations, see Figure 1 and Table 1 below. In that situation fat pork meat was usually considered better food than lean pork, because it contained more energy. Alcohol too was part of workers diets, providing energy as well as relief of the pain from hard physical work. Although the fossil fuel powered steam engine formed a breakthrough in industrial production, the physical power output from labourers was still essential for increasing the production up through the 1900s.

MECHANICAL RELIEF OF HARD WORK

Gradually the physically most demanding tasks, such as carrying heavy loads, harvesting grain, hammering steel and sawing lumber were mechanized and powered, first by animal power, wind power and hydropower, and later by fossil fuels and electricity, leading to one of the industrialization's greatest achievements in terms of health, the relief of physically hard work. The main driving incentive behind this development, however, was probably mostly to increase labour productivity, that is, to make workers able to produce more per hour, while continuing working relatively hard physically, and now with more uniform and monotonous processes, determined by the speed and rhythm of the machines.

During the last half of the 1900s most of these remaining, physically modestly demanding processes, have in industrialized countries been replaced with mechanized and partly automated production systems, in farming, industry, service sectors and households. Tractors and other machineries have taken over a lot of the farmer's hard work, industrial production lines requires very few people at all, as compared to earlier, and in the households a wealth of machines now do most of the physically hard toil. Furthermore all sectors are bound together with an increasingly energy consuming motorized transport and electronic communication. The results are reflected in the change in numbers of jobs in various sectors as well as the time spent at home.

Today in Denmark, which by some is still considered a farmland, less than 4% of the labour force is employed in farming. Around 26% work in industry and other manufacturing, while the remaining 70% is in the dominating service sector (ILO, 2001), mostly pushing buttons, sitting down on a chair. When at home in the household, people spend on average more than two hours per day physically rather inactive with TV, pc, etc. The leisure time is, however, also where close to a quarter of people spend 1,5 hour every day with sport or other exercises (Bonke 2002).

HEALTH THREATS FROM BODY RELIEF

Having success in one area tends to make mankind continue and maybe overdo the thing. "If it is agreed that economic output is a good thing it follows by definition that there is not enough of it" was the way an authority like the US President's Council of Economic Advisors expressed this serious mistake in 1971 (President's Council of Economic Advisors 1971, p. 92). As suggested by the economist Herman Daly, the consequence would be that if rain is good for farmers, they cannot get too much of it! (Daly 1991, p. 99).

Similarly, in efforts to relieve people of excessive, unhealthy hard physical work, the inertia in societies have pushed towards the relief of *any* work or *any* physical use of body energy, so that most people today are sitting in a comfortable chair most of the day at work, at home and in transport systems. The physical effort is confined to pushing buttons to control the various energy-consuming machines. This obviously gives very little exercise, and to carry this physical relief development to the extreme, some push buttons have been advertised as requiring only a "touch as light as thistledown"!

Obviously, industrialization has provided the wealth, which now makes it possible to *cure* many health problems with medicine, surgery, and other treatments, as well as to *prevent* health problems from starvation, infections and hard work. But during the recent decades, the wealth has also *caused* severe health problems because people can now afford overeating, as well as overusing mechanical relief for transport and other physical tasks, and by market forces they are pushed to do so.

In 2004, the USA Minister of Health and Human Services, T. Thompson, declared that obesity now rivals smoking as the largest cause of premature death (Samuelson 2004, p. 49). In USA, obesity and its complications such as diabetes and heart diseases, contributes to premature death of about 400 000 annually, only a little less than the victims of smoking. "It is definitely one side effect of getting wealthier", Thompson stated, referring to the obesity problem in the USA. Samuelson, however, finished his article on this and other afflictions of affluence by calming down the reader by stating, that "None of this discredits the value of economic growth, …"(!).

HEALTH THREATS FROM OTHER OVERUSES

There are other overuses than the ones connected to overeating and using too much motorized body relief, for instance smoking and drinking alcohol. As indicated above, in USA an estimated 435 000 people die prematurely every year due to smoking. Although this "overuse" of tobacco is declining, the health consequences are delayed and will be around for decades. Similarly, 43 000 are the victims of overuse of alcohol (Samuelson 2004, p. 49).

Allergy is on the increase in most affluent countries, and typically now a quarter of the children suffers from one kind of allergy or another. There are probably many causes of this increase, such as synthetic chemicals in food and in people's environment. One explanation coming up recently is what is called the hygiene theory, saying that one of the causes of allergy is *too much* cleanliness (Wahn 2000). When the human body's own immune systems is bored, it weakens, or - for children – it does not develop properly. Today some homes are simply too clean, and instead of playing outside in the sandbox, garden, street, forest, etc. , children are seated most of their free time in front of the computer or TV in a very clean home, having their clothes washed every day. Children growing up in the countryside or with pets, are found to be much less likely to develop allergy. In older days a Danish saying went something like: "To stay healthy you have to eat seven pounds of dirt a year". A newer version of this, launched by immunologists, is "Give us this day our daily germs" (Rook and Standford 1999). In a way it sounds logically, that the body's immune system deteriorates with nothing to do, just like the muscles do, following the slogan "Use it or loose it". On this background it could seem surprising , that allergy experts are surprised about the hygiene theory. After having urged people to fight allergy through more cleanliness, they are now confused as to what to say to the public. The problem of disseminating this kind of message is that still some people could probably benefit from more cleanliness.

Quite a lot of energy is consumed to achieve this exaggerated cleanliness through washing clothes, drying clothes, bathing, etc. Some of this energy could be saved, just as less detergent should be produced and disseminated into the environment. Many detergents are also known to trigger allergies, so there are more benefits of using less of them. Furthermore, it is also suggested that allergy is directly related to obesity and lack of exercise (Wahn 2000), which attach allergy to the main theme of this paper.

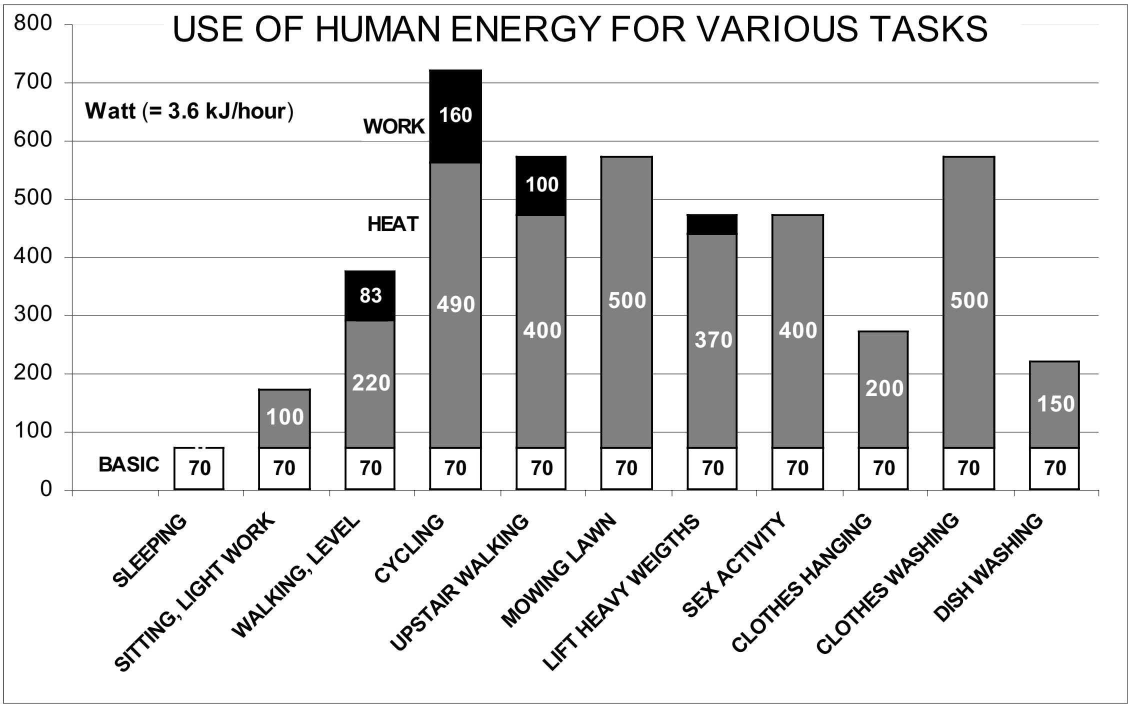

Figure 1. *Examples of consumption of human body energy for various tasks today. At the bottom is shown the "Basic" consumption used to maintain body function at rest, the resting metabolic rate. On top is shown for some tasks the physical "Work" performed by the human activity. The columns where work output is not shown, does not imply zero work, but simply that data to separate it from "Heat" are not available. The data shown cover a large variation and uncertainty. Based on (Hütte 1954, Åstrand 1994, Roymech 2003, Industrial Engineering, Ergonomics &Work Organization 2003, Levine et al 2005).*

Table 1. Examples of the extra body energy typically consumed during a workday in various occupations. Energy consumption used to maintain normal body function is around 70-80 W, or 7 000 kJ for a full 24 hours day, and not included here. Based on (Roymech 2003, Institute of Industrial Engineering and Ergonomics 2003).

OCCUPATION	EXAMPLES	EXTRA ENERGY CONSUMED AT JOB	
		(kJ / workday)	(W)
			(average over worktime)
Light Work, Sitting	Accountant	2 600	90
Normal Manual Work	Engineer	4 200	145
Moderate Manual Work	Bricklayer	6 500	225
Heavy Manual Work	Miner	12 500	435
Extreme Effort	Lumberjack	13 500	470

BETTER HEALTH WITH LESS WEALTH?

In countries like Denmark and Norway, where some consequences of Second World War was food rationing and lack of gasoline for motorised vehicles, many aspect of health seems to have been higher than ever before or after the war. People got sufficient nutrition, but not too much, and they were exercising by walking, cycling and doing all kinds of manual work. In Norway premature death rates caused by diabetes, which is one of the obesity related diseases, was around 30% lower during the 5 years of war than both before and after the war. Also heart diseases, which today are found obesity related, had a minimum during the war (Statistics Norway 1994).

Medical advancements in *curing* diseases have managed to increase life expectancy, but ignorance in preventing diseases have in recent decades counteracted this trend. For the first time in history, life expectancy of the up-growing generation in USA may be shorter than that of their parents, mainly due to obesity related diseases, as described above (Olshansky 2005). The *length* of a person's life certainly should not be used as the sole, or even most important, indicator of a healthy and good life. But it is worth having in mind, that the *quality* of a life struggling with obesity is not enviable either.

Proper use of the body's energy is central to many diseases, also others than the obesity related. It is found that also the mental well-being and performance depends on physical exercise (cf. quote by Kierkegaard in the Introduction). From a health point of view, it is really worth taking a closer look at the human body energy output.

Human Energy Output

The human body constitutes a small "Combined Heat and Power" plant, CHP, in the sense that the energy input in the form of food is through combustion converted into an output of energy, which can be split up into heat and power. Like in a CHP power plant, a certain basic amount of the fuel energy intake is used for internal maintenance, ending up also as heat. Actually, by far most of the work performed by humans will eventually end up as heat energy.

Both the heat and the power outputs from humans are needed in daily life, but we will here pay most attention to the power output, which means the work performed per time unit, as measured in watts (W) (= Joule/second) or in Joule (J), kilo Joule (kJ), or Mega Joule (MJ) per hour, per day, etc. The old energy units still used sometimes in connection with food intake, calories or kilocalories, are equal to 4.2 J and 4.2 kJ, respectively.

HUMAN POWER PERFORMANCE

When the physical work was still an important power input to the production in agriculture, construction, mining, and industry, careful studies were made to illuminate what was the optimal and the maximum work performance to expect from the labour force (Hütte 1954). In recent decades similar data are established, but now mainly to indicate how people can burn off the excessive food energy intake, not how much work they can perform (Åstrand 1994, Roymech 2003). For that purpose the efficiency in performing work is not important, and often the work output is not even assessed, as seen for some columns in Figure 1. When some real physical work is the purpose, a good estimate is, that 25% of the energy output can be in the form of work.

There are lots of variable parameters to clarify when estimating human's ability to provide power, such as for how long time should the work be sustained, etc. Figure 1 shows some typical values of energy output from an average person, when doing different tasks like walking, bicycling, etc.

TYPICAL ENERGY OUTPUT IN DIFFERENT OCCUPATIONS

People usually do not engage in the same task all day, and at least not continuously. Table 1 shows values for typical occupations with very different amounts of real physical work output.

Today the economies of the affluent countries considered in this paper, are dominated by work places in the service sector, often just sitting in a chair pushing some buttons. As seen from Figure 1 and Table 1, such office jobs requires very little physical work, - too little, seen from a health point of view. The more physically demanding occupations have also been relieved of the hardest bodywork and, furthermore, they are rare. Estimate of average human energy consumption for work must be based on the facts, mentioned above, that around 70% of people are working in the service sector. Although not all service jobs are in the "Light Work, Sitting" category of Table 1, few of them will probably exceed what is in termed "Normal Manual Work". Since very few people work in the categories of "Heavy Manual Work" and "Extreme Effort", we assume an average European today consume at work 150 W or 4 300 kJ during an eight hours workday.

ENERGY SLAVES

One way to illustrate industrialized societies' use of nature's external energy is by calculating roughly how many people would be needed to provide the physical work used in society. This is termed "energy slaves", and the results of the calculations obviously depend on how hard the "slaves" are anticipated to work. In the following are given two examples of "energy slaves" calculation, just to get some comparison between *human's* own ability to perform work, and the amount of *external* energy used in today's industrialized societies, which for EU annually is around 160 000 MJ per person. True, not all of this external energy is used to provide work, since a lot of it goes for heating. In this rough estimate, however, we convert it all to work, assuming for instance that the "energy slaves" are used to run heat pumps to provide the heat too.

First we assume like Slesser and King (2002, p.59) that the "energy slaves" are *hard working*, each providing on average 70 Watt during work time. Let us further assume that they are struggling for 10 hours a day, 365 days a year. This effort corresponds roughly to continuously walking, see Figure 1, and since the human work is performed by the body with an efficiency around 25%, the human energy consumption during work hours will be around 300 Watt, as also seen in Figure 1 for walking. These "energy slaves' " performance during work hour corresponds to that of an occupation between a bricklayer and a miner, as shown in Table 1, but they are assumed to work longer time, and thus provide annually 900 MJ of work output. To provide the same amount of work by a power plant, typically with 30% efficiency, would require 3 000 MJ of external primary energy input. From this follows that the external energy consumption corresponds to each European having 160 000 / 3 000, or roughly *50 "hard-working energy slaves"* at work.

If, on the other hand, we assume the slaves are physically working more *relaxed* as the average European do today during working hours, they consume around 150 Watt of body energy as suggested above. For work with low physical activity, the work efficiency is normally much lower than the 25% (Hütte 1954), rather like 10%, which we will assume in this example. Work output would then be only 15 W during work hours. With 37 working hours per week for 46 weeks a year, the annual work output for such a "relaxed slave" would be around 90 GJ or only one tenth of what the hard-working "energy slave" could offer. Consequently, with slaves assumed to work only at our own *physical* performance at work, each European would need not 50 but *500 "relaxed energy slaves"*.

Obviously these calculations cannot be referred to real slaves, which themselves would require food and other energy services, and thus forming a vicious circle of energy demand. Early in the 1800s, Americans had on average around one such human slave per household (Taylor 2001). In EU today, more than 100 *"hard-working energy slaves"* are needed *per household*, but they are "fed" mainly by nature's limited stock of fossil fuels.

The two extreme "energy slaves" examples above illuminate the uncertainties in such calculations. But they also demonstrate, that the possible extra physical work we can provide with healthy use of our human body could not *directly* replace any significant part of our present use of nature's external energy resources, for instance by a stationary bicycle producing electricity. As we will see, however, there are many situations where the extra physical body exercise, which people in the affluent countries of EU, etc. need to do for the sake of their own health, *indirectly* can result in significant energy savings if we take benefit of these body activities to change behaviour and organisation.

EXTRA HUMAN POWER FROM HEALTHY BODY USE

For a better health, it is not necessary to work physically like the hard working "energy slaves" described above. Such hard work is probably on the "wrong"side of optimum on the health versus exercise curve, meaning that it would be a threat to the health, just like physical work was to our grandparent's generation. There is a general agreement among experts, that from a health point of view it is not a matter of shifting from the category termed "inactive", to very heavy physical exercise. The greatest progress in health is observed when changing from "inactive" to "moderately active".

Actually, recent studies suggest that obesity might be prevented by just sitting a couple of hours less per day and instead stand or walk around (Ravussin 2005, Levine et al. 2005). This could consume as much as 1500 kJ extra human energy per day, and in controlling weight the research points towards the importance of people's daily posture and movement, that is how much people are sitting, standing, walking, and talking, as compared to purposeful exercise. These ways to burn human energy is termed NEAT, which stands for non-exercise activity thermogenesis. Further steps upwards in activity do improve the general health, but only up to a certain point.

In a Danish health campaign, authorities have recommended people to take half an hour of walk every day, which according to Figure 1 corresponds to burning around 500 kJ per day. Finding this too modest, we will here illustrate two levels of healthy extra exercise, which could then be utilized to save external energy consumption.

1) Modest extra exercise

The target is here 1 000 kJ/day. It can from lists like Figure 1 be converted into various combinations of tasks, such as 0,5 hour of bicycling per day or one hour of walking per day or 15 minutes on stairs plus 0,5 hour of walking, etc. As indicated above, if the reference level of activity is "Sitting" most of the day, this target might be reached by just moving a little more around during the day. Hanging clothes for around 1,5 hour every week consumes around 1 000 kJ during the week, and might be combined with other household chores and gardening to give the proper natural exercise per day. According to the "energy slave" calculation the direct energy contribution from this modest human exercise amounts to only around 0.2% of the external energy consumption, but as we will see, the real impact can be significant.

2) High extra exercise
Here the aim is to burn 3 000 kJ/day. Such target could for instance be reached through 1,5 hour on bicycle, *or* 3 hours of walking, which seems a lot, but integrated into daily routine it could be acceptable. Actually many people already do walk during most of the working time, and they might not need more. The *direct* energy contribution to the external energy consumption is only around 0.6%.

Obviously, sport, dancing, and play are exercise options, which, for good reasons are often recommended, and one rare example of combining play with savings in nature's external energy use is shown in Figure 2. In this paper, however, such sport and play, as well as the use of exercise machines, are in general left out, because focus is here on the possibility of integrating the exercise into everyday life, as a kind of *Natural Exercise,* making use of the body energy, and as a side benefit save significant amounts of external energy. Some examples will in the following illustrate that option.

Healthy Energy Saving Options

As demonstrated above, with a typical human power output of only a couple of percent of the external energy use, the possible power contribution from humans does seem negligible. Even if people changed daily behaviour towards more healthy *extra* use of their body, their work output could *directly* cut less than one percent of the external energy consumption. Three factors should be kept in mind, however:

- The extra human power input is a source of *free work*, assuming the work is done primarily for the sake of better health.
- Present consumption of nature's external energy could according to several studies be cut to one third through better technology.
- Most important of all, it should not be considered as a direct replacement, where for instance the electric power is generated by a human powered tread mill, but as a completely different and often much more elegant approach to solve the task. The latter can best be illustrated by using a bicycle for transport instead of a car, as elaborated below.

Figure 2 *African children play with a merry-go-round, which uses their energy to pump water. Children in affluent countries need such exercise even more (World Challenge 2005).*

Consequently, it usually does not make sense to compare *directly* the external energy use today with what a human body can provide under healthy conditions. In the following are indicated examples with only rough illustrative quantification, from areas where human body energy can make significant contribution to energy savings. The reason behind these large options could be that we have in recent decades spend an disproportionate amount of external energy on eliminating the little remaining use of human physical energy.

TRANSPORT

A look at Figure 1 demonstrates that transporting oneself is a rich source of opportunities for replacing motorized cars, trains, escalators, elevators, etc. with healthy exercises.

Bicycling to Work

Take the *modest extra exercise* mentioned above of 1 000 kJ/day, it corresponds to 0,5 hour of cycling or 10 km. Compared to driving the 10 km alone by car, this would save around 1 litre of petrol or 35 MJ/day. Using this option to commute to work, this would annually save 35*220 = 7700 MJ ≅ 8 GJ of primary external energy out of a total per capita energy consumption of 160 GJ, or 5%. Obviously the savings from going by bicycle instead of *public transport* is somewhat less, but still significant.

The significance of this bicycle case is mainly due to the fact that if you decide to switch from car to bicycling, you would not pull along the one ton of steel and other materials built into the car, but only a few kg. Also, you will sometimes, but certainly not always, have to accept longer travel time. But when taking into account all the time spent on earning to buy and maintain a car, the time spent on going by car typically makes less than 20 km per hour or the same as by bicycle (Illich 1974, p.19, Nørgård and Christensen 1982, p.106).

Walking to Public Transport

Using public transport saves energy as compared to individual car driving, but it is *less convenient* due to the fact, that most people will have to walk or cycle some minutes to and from the bus stop or train station. From a health point of view, this is exactly an *advantage* of public transport. A Danish campaign to get people to walk more for health reason, put posters in busses suggesting people to push the stop button one stop earlier than normal and walk the rest of the way.

Stairs versus Elevators and Escalators

When shopping or going by trains people are often tempted or even forced to go by escalators or elevators, being deprived of one of the healthiest daily exercises, walking upstairs, see Figure 1, and here for free. For raising less than three floors elevators could be locked with a key, still leaving the elevator option to handicapped people. In the longer run this might reduce the number of handicapped, by forcing healthy people to exercise. Stairs are found in many office buildings, but they are often not easy to access and unattractive, considered only as an emergency option. If upgraded the stairs could be a welcome change for the daily sitting routine.

ELECTRIC APPLIANCES

Pedalling power can, as seen from Figure 1, provide 160 W, which is sufficient to keep an efficient TV-set and a few CFL-lamps running as long as the cycling last. Such a system could be better than the total waste of body energy when using a stationary exercise bicycle, and would furthermore confine the temptation to watch TV (which in most cases is also an advertising tool for over-use of energy, etc.). But this is hardly the best way to save external energy by using bodily energy.

Food Storage

Typically around 12% of European electricity consumption is used to keeps food cold or even frozen, in individual homes as well as in shops, storages, etc. The smaller the storage capacity, the higher its energy consumption per unit of storage volume, due to geometric circumstances. This could imply large energy savings from changing to a pattern of using the larger units, like in the stores, and having fewer small household units. While this is hard to imagine for refrigerators, it could be an option for freezers, where a few household could share one chest freezer. Another option is to place the freezer (or refrigerator) in a colder room, maybe even at a different floor or halfway outdoors. Both these option were exploited in the first so-called "Passive House's" build in Germany in 1991 (Feist and Ebel 1996). All this will require more physical activity by the users, but can save one to two hundreds kWh annually per household.

Furthermore, if you don't have special need for frozen food storage, you can rely on the freezer in the food store, and take the extra walks to the store as a welcome exercise. Compared to Northern Europe, where industrialized frozen food is very common, people in Southern Europe enjoy more the frequent purchase of fresh vegetables, fish and meat from the local market as well as the chatting associated with this shopping. Such habits can save a lot of the energy otherwise used for freezers and refrigerators.

Drying Clothes on a Line

Hanging the clothes on a string outdoors (or in open shed or a naturally ventilated non-heated room) instead of using a gas heated or electric clothes dryer is a striking example of how to save energy and get healthy exercise, if such space is available. Today people often seem unaware that clothes can very well dry outdoor in frosty weather. The exercise when hanging clothes up resembles the gymnastics which people go in for in lack of sufficient exercise in the daily routines. The only external energy consumption required for this drying on a string is the free solar and wind energy.

An electric clothes dryer typically uses around 3 kWh per load, and used for every laundry, which is typically 5 times a week, it would over the year consume 750 kWh. This can all be saved in two healthy ways, partly by curbing the excessive cleanliness by doing less washing, and partly by drying manually on a string.

Washing the Dishes

It has been claimed that a careful use of a dishwashing machine consumes less energy than doing the dishes manually. The confusing point in these analyses is that a careful dishwashing is compared to a careless manual dishwashing using running hot water during the process. Experiments have shown that with a careful manual dishwashing using bowls of hot water, the primary energy consumption will amount to only around 25% of what the electric dishwashing requires, if the hot water for the manual dish washing is provided by a gas or oil boiler, and even only 10% if hot water is provided by combined heat and power production (Nørgård and Guldbrandsen 1994). To sum up, there is plenty of external energy to be saved by using a little body exercise energy, only 250 kJ for 0,5 hour manual dish washing. It is actually one of tasks recommended for the sake of health.

INDIRECT ENERGY SAVINGS FROM BETTER DIETS.

The obesity is obviously also due to too high intake of food energy, and a reduction in that will generally lead to less food production and distribution and thereby indirectly save energy. For a country like The Netherlands, external energy consumption associated with food and beverage intake makes up around 9% of all external energy consumption in the country, or on average per capita 17 000 MJ per year (Biesiot and Moll 1995, p. 42). A lower consumption of food and processed beverages in general, as well as a more healthy composed diets with for instance less meat and dairy products, and the use of less frozen food and greenhouse grown vegetables, could result in significant savings of external energy use for fertilizer, machineries, greenhouse heating, processing, frozen storage, etc.

Organic farming is interesting in this context, because the provision of such ecological produce has the double benefit of 1) saving external energy input for chemical fertilizers, pesticides, etc. and 2) typically requiring more human body energy for weeding, etc.

Obviously the use of body energy instead of external energy can often also imply substantial savings of energy and other resources, as well as money, on the *investment side*, by not having to invest in a car, a clothes dryer, a dish washing machine, a freezer, etc.

TIME CONSUMPTION ASPECTS

Typically, using human energy output to do a task immediately seems to take longer time than when using external energy. This should, however be seen in the light of:

1. The time saved on exercise machines or jogging to stay fit should be subtracted from the extra time doing the task.
2. The better well-being when using the body for walking, cycling, gardening, etc., makes sometimes the extra time spent more pleasant.
3. The working time saved for affording to buy and maintain a car, a clothes drier, etc. should be subtracted from the extra time doing the task.
4. In some cases like cycling in the city traffic, it actually does not take more time to reach the target than going by car, including parking.
5. If the economy is reorganized towards providing better health and more happiness, instead of just more GDP, there will be plenty of time for "do it yourself" tasks,

maybe less labour productive, but more productive in providing health and satisfaction.

Aiming for Inconvenience?

How then should we integrate the solutions to the two problems of too little use of our body energy and too much use of nature's energy gifts? In many cases the way we should organize and design our man made environment of infrastructures, cities, homes, working places, machines, etc. will appear like a U-turn from the conventional path. In the future all this should be guided more by a long-term well-being and less by short-term convenience. Or provocatively expressed, it should be guided *by some short-term inconveniences*, wherever this can achieve some better health and savings of external energy or other of nature's precious blessings.

A few examples will illustrate both the options and the breach with conventional thinking of engineers, architects, planners as well as individuals in general. So far, they have all opted for immediate *maximum* comfort instead of *optimum* comfort. In order to get sufficient healthy exercise integrated into daily life as natural exercise, it is relevant to *avoid or remove some of the temptations* to use external energy. Just like it is unwise to have heavy food, tobacco, and alcohol in front of your eyes all the time, if you want to cut down on using these intakes.

Such self-imposed inconveniencies and work is, of course, not unknown. For the sake of training in sport some people spend many hours a week doing hard work, which is certainly not convenient for the time, and even "wasted" from an energy saving point of view, but done in the hope of being rewarded later on. Similarly with the time spent in fitness centres, which is not even giving the play fun of a sport. So, it should not be impossible to imagine small changes in your everyday life, which could secure your health up through life, and typically appear more immediately meaningful and satisfactory than many activities at job.

The general aim in designing future infrastructure and organization can be expressed stepwise:

1. Stop encouraging as little physical activities as possible.
2. Make healthy, natural physical activities possible.
3. Encouraging natural physical activities integrated in energy savings.
4. Pushing people towards more natural physical activities.

NEW GOALS FOR ARCHITECTURE

How do we design the not too convenient home or work place? It sounds almost like a joke, but we will greatly regret it, if we do not ensure some healthy and attractive stairs by building two or more floors dwellings. Make sure that proper facilities for clothes drying on a line are available outdoor or/and under open shed facilities, is just one illustrative example.

CHALLENGE IN CITY PLANNING

Besides the obvious effort to make walking and cycling more attractive in the cities, it should to a higher extend make the use of car less attractive. The Austrian traffic planner Herman Knoflacher has proposed the idea that in order to discourage people from choosing car driving instead of public transport, car parking lots should somehow be placed at similar distances from homes or other destinations as the distance to nearest train station or bus stop (Knoflacher 2003). This would in any case ensure a certain walk every day.

At train stations and other public places at different levels, ordinary stairs should always be easier available than escalators or elevators, not the other way around as it is today.

INDIVIDUAL RESPONSIBILITY

"You should not follow the line of least resistance" is an old saying, discouraging people from being lazy. But it gets a new value now, where you should try to arrange for some "resistances" or "inconveniences" in the way you organise your home. And it is always easier to resist temptations to use technologies, such as a freezer, a TV set, a computer etc. if placed a little distance away. It is especially easier to not take the car, if placed some distance from your home – or if you leave it at the dealer and save the purchase! You can also look at the problem the other way around, that you should not spend too much effort in making the home most comfortable.

GOVERNMENT RESPONSIBILITY

It can be argued that it is people's own problem and their own fault, if they suffer from obesity and related diseases, since they can just stop over-eating and do some exercise. But the problems are not just those people's own problems, because in the EU societies, health care and social welfare programmes will have to take hand on the people, when they are ill, disabled or otherwise in trouble. Furthermore, we are not all equally suited to resist the thousands of temptations we are facing in our daily lives. For a citizen it seems fair to ask Government for assistance and to expect help for getting out of bad habits, especially when these bad habits are promoted by the government's own policy.

Fighting overuse of food/beverages and motorized power can turn out to be a hard struggle for a government, if at the same time committed to growth in GDP. Experiences have shown the difficulties in mitigating other over-uses of consumer goods like tobacco and alcohol. The related industries are fighting back, and expensive campaigns must be launched to counteract their advertisement, etc. And on top of this, the government in many countries will loose a comfortable income from taxing these goods. When it comes to limit the use of food/beverage and motor powered technologies, the fights could be not just against specific industries, but more or less *against the general industrial development*. It could certainly hamper the overall tax revenue of the governments. All this makes it tempting for governments not to engage in such *preventing measures*, and rather aim for *cures* in the form of new medicines, more surgery, special exercise technologies, special transport system for overweight people, etc. Such cures are simply more expensive, and hence more attractive in societies aiming primarily for higher GDP, that is more consumption and production.

The double negative effect of aiming solely for growth in GDP and work, namely the threat this aim poses to people health and well-being and the threat it imposes on the natural environment places, however, a big responsibility on government's economic policies, and the dilemma might be an eye opener for European governments to redirect their goal, as suggested below in the conclusion.

Conclusions

Health problems with obesity and other diseases call for more use of human's body energy, and it seems reasonably to consider using this "free" energy to save some of nature's external energy, and thus mitigate the environmental problems. However, Europeans each consume at least fifty times more of nature's energy gifts than what they can possibly provide with their own body, even if working hard. At a first glance, this seems to indicate, that the extra exercise needed for health reasons can do little to ease the external energy use.

Nevertheless, the way people can use their body energy for solving tasks is more elegant than the way external energy is used at the consumer. Thus by integrating the "free" human energy output into the daily routines in a proper way, it can save a substantial amount of nature's external energy. Examples show how human energy contribution can in several cases save many times more external energy, typically by adapting a different approach to the tasks to be done.

To harvest the benefits for both health and environment of such integrating solutions, a dramatic change is required in planning and design of the man made infrastructures, cities, buildings and other technologies. From being guided solely by *maximizing short-term* comfort the design should be aimed at *optimising long-term* comfort and well-being, by finding the proper balance where people are encouraged and pushed to get sufficient exercise in the daily life. At today's level this will often imply *less daily conveniences* and hence a breach with most conventional aims of engineers, architects, designers, planners as well as with most people's own perception about how the want to organize their daily lives. Obviously, due attentions should be given to options for disabled to still get around.

The measures to turn healthy exercise into savings of the external energy constitute a double preventive measure, namely preventing diseases and preventing environmental problems. This should be a blessing for a real economist and economically correctly guided politician. Consumption of food, motorized transport, energy and a wealth of other items can be reduced, leaving both people and the environment better off. Nevertheless, in a society where an ever-growing consumption and production is the sole aim, prevention is *not* better than cure. This is the basic obstacle to pursuing this *double preventive* policy, just as it is the obstacle to energy savings in general.

A sensible development in economy would be to aim for a good and rewarding life with the least use of the external natural energy gifts. This points towards solving unemployment through sharing the work by gradually cutting working time. If people cannot get much exercise in their daily jobs, see Figure 1, the extra leisure time can be used for sport, play and dancing, or for using it for walking, cycling, gardening, cooking, and doing other things, in a way which from a time consuming point of view is not very productive, but otherwise very rewarding.

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Energy expenditure refers to the amount of energy a person uses in the form of calories. Caloric intake must be balanced with energy expenditure.Â To understand energy expenditure, you must understand how your body produces energy. To provide fuel for movement and daily functions, your body makes energy in the form of heat. The energy found in food is measured in kilocalories, or calories as we commonly refer to them. Technically speaking, a kilocalorie is the amount of heat required to raise the temperature of one kilogram of water by one degree Celsius. The total number of calories you burn for energy each day is your total daily energy expenditure. Our bodies use glucose all the time because certain tissues, notably the brain and red blood cells, cannot survive without it. Blood glucose levels must be maintained all the time, even during starvation. In that case, amino acids from muscle protein breakdown serves as a source of carbons for gluconeogenesis, which take place in the liver. Fat, mobilized from adipose, is the major source of energy. After a typical mixed meal, carbohydrates are the preferred fuel while most of the fat is stored in adipose. Four hours later, fat starts being mobilized from adipose. From using kites for wind power to converting waste to energy, these energy startups could be coming to a street near you very soon.Â They have managed to develop a device that can collect kinetic energy from vehicles on roads as they drive over it. It's almost akin to an energy harvesting speed bump. "CONSTRUCTIS is leading the kinetic energy revolution with a zero carbon emission roadway power system. Our Roadway Energy X (REX) platform is a rumble strip box buried in the roadway that harvests over 1,100 watts of electricity for every 2 axle car pass, enough to power 3 family homes with just 4 lanes of busy traffic installed." - Constructis.