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The Importance of Holistic Approach in Energy Planning

Abstract

The challenges of energy management and planning are considered as technical and economic problems by the society including decision makers and engineers. This approach has proven to be insufficient globally. Therefore, in some European countries essential changes are afoot. In these procedures, they involve even several other disciplines (e.g. social sciences). Hungary is a conservative country in this regard. However, creating alternative energy strategies (Mathiesen, B. V. et al. [2009]; Kemp, M. [2010]; Munkácsy, B. [2011]) would be an important task to draw attention to, especially when it comes to the indefensibility of outdated methods. In this paper, some explanations and examples about the new approach will be shown and demonstrated.

Key words

Energetics; Holistic approaches; Non-technological principles; Well-being; Spatiality; Cross-sectoral interconnections

Introduction

Our time is the era of a global environmental crisis. The so-called developed civilisation has been proven to be underdeveloped from the point of view of its future. This problem can be described with considerable accuracy by the ecological footprint. According to this concept, the most significant problem is our extremely high carbon footprint which is connected to our fossil fuel based energy management (WACKERNAGEL, M. 2011). As the dominant economical paradigm, it does not take into account the environmental costs of this system; fossil fuel based technologies produce cheap energy with enormous environmental pressure. During the 20th century, our energy demand exceeded the potentials of fossil fuels; therefore, it seemed to be crucial to find alternative energy sources. The chosen nuclear energy has been also proven damaging in a very short time—considering not only the accidents but the whole life cycle of the technology. Taking it all round, our decisions on energy related topics will be made in the first decades of the 21st century which seems to be critical from the point of view of the next generations. It is high time to find sustainable solutions in this field and we must break away from the narrow-minded technological approach.

Results

The energy technology must be an integral part of the solution—for example as an instrument for improving efficiency—but it must not be the main issue in solving the energy problem. The holistic approach and changes in energy management require the involvement of other fields of engineering.

1. Technical aspects of energy planning – beyond the energy industry

Mining engineering, for example, has a traditional connection to energy management. In the future, due to the depletion of the stocks of fossil fuels and uranium ore (HUBBERT, M. K. 1956), this relationship will be more and more important. Collecting as much information as possible about the remaining stocks is indispensable for long term energy planning. In addition, the mining technology is also crucial, as it is an important factor of the most characteristic feature, called *Energy Returned on Energy Invested (EROEI)*. The problem we face now is that the overall *EROEI* figure is moving well down into single digits. It was around 100 in 1930, it had reached as low as 10 in some areas by 1990, while today that figure may approach 3 (MURPHY, D. J. *et al.* 2011).

There are two other areas which have a long and traditional connection to energetics, namely *chemistry* and *physics*. Both disciplines have several direct branches to engineering, such as chemical engineering, nuclear engineering or thermodynamics engineering and so on. In a sustainable energy system, both chemistry and physics will keep their crucial roles, as these areas are connected to energy storage technologies which will have fundamental role in the future, due to the spreading of intermittent energy sources. Chemistry is more connected to electricity storage, for example in batteries or hydrogen storage solutions in chemical bonds. The significance of physics might be more outstanding, as it will have a more general influence on electricity and heat storage and transportation. Moreover, it will play an important role in the development of renewable energy technologies—mainly ambient heat, solar and wind energy. Getting a deeper insight into these disciplines would help understand the real possibilities in sustainable energy management.

Materials science, which also has a clear relationship with the above mentioned branches of knowledge, can provide information about the embodied energy of different products, for example that of buildings. There are great variations of construction materials all with different levels of embodied energy, but it is a fact that this kind of energy usage can be massively significant. Sixty studies of different buildings have been performed (BRIBIÁN, I. Z. *et al.* 2011) and found that the proportion of the embodied energy (in materials used and life cycle assessed) varied between 9% and 46% of the overall energy used over the building's lifetime when dealing with low energy consumption buildings, and between 2% and 38% in conventional buildings. These wide ranges in results are due to the variety of buildings, materials, the lifetime considered, and the geographic and climatic conditions. It is important to notice that in extreme cases the embodied energy can be almost the same amount as all the other energy usages throughout the lifetime. According to BRIBIÁN, I. Z. *et al.* (2011), as a general figure for the embodied energy of an average building area there may be used 1,600 kWh/m^2. This value is almost the same as the average yearly per capita electricity consumption of households in 2010 in the *EU27* (EEA, 2012). In other words, the embodied energy content of a 100 m^2 flat uses the same amount of energy as the per capita household electricity consumption during 100 years. The embodied energy of a car is estimated to be around 70–75,000 kWh per car (PARIKH, Y. *et al.* 1995; MACKAY, J. C. D. 2009)—which is comparable to ~45 years of energy consumption of an average *EU* citizen. Sadly, buildings and cars are just two out of our thousands of equipment and devices. Therefore, it is crucial to recognise the importance of resource efficiency from the energy consumption's point of view *(Figure 1)*.

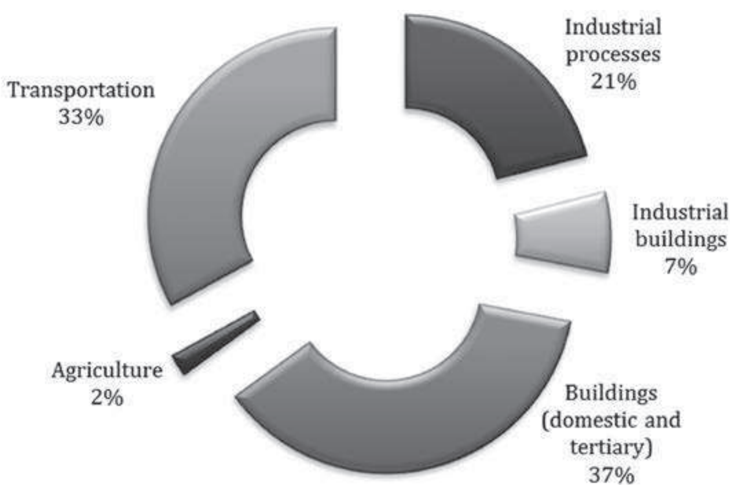

Figure 1 – Share of total energy consumption of the European Union

Source: EUROPEAN UNION 2010; Edited by BOKOR, L. (2013)

The role of *Architectural Science* is going to be more and more appreciated from the point of view of energy, as operating energy of our buildings cover approximately 44% of the whole energy consumption of the *EU* (EU, 2010). This fact can be seen in the background of the adoption of *Energy Performance of Buildings Directive* in 2010. This document requires member states to ensure that all new buildings built will have become a so-called 'nearly zero-energy building' by 2021. This rapid action would be important because suboptimal solutions in the building sector have resulted in unnecessary energy consumption over the decades.

Agricultural and forest engineering are also essential partners of the state-of-the-art energy management. These days, the biomass produced by these sectors—both as residues and direct energy plants—are considered to be one of its main resources. These are especially suitable for the energy system as they can be converted into several forms of energy and fuels can be stored easily. It means that it is controllable. It can be adjusted to meet the demand, taken as a whole. It can solve the intermittency problems, like those associated with wind and solar energy. Therefore, it will be more and more important in the future. At the same time, we need to learn more about its potentials in order to operate our recent system and plan our future energy ones.

Waste management is also tightly connected to energy issues. For instance, organic waste can be converted into biogas and can be utilised in heat and electricity production as well as in transportation. Therefore, it is more and more important to evaluate the potentials of this resource and use as much biodegradable waste as we can. From agricultural waste, 60–300 kWh power and 100–400 kWh heat can be produced per ton—depending on the type of source and technology. There are also existing technologies for household solid waste utilisation based on the separation of organic components. Its ratio can be 30–60% depending on the type of the living environment and season. Therefore, the diversion of these components from the landfill sites could easily double their lifetimes. This process has a connection to agriculture or even to forestry, as the by-product of anaerobic digestion, the sludge, generally after a composting phase, can be used as fertiliser.

On the other hand, we need to recognise that incineration (which is one of the most widespread procedures in the field of waste management and which is known as an energy production technology) ultimately means a huge loss from the point of view of energy. By this way, we lose all of the embodied energy of the materials. The concept of incineration is against the basic rule of waste minimisation and resource efficiency (*Directive 2008/98/EC* on waste [Waste Framework Directive]), as the operation of incineration plants requires a huge amount of waste material—that is converted into air pollution and slag. In this context, it is surprising that several European countries (e.g. *Sweden*, *Denmark*, the *Netherlands* and the *United Kingdom*) already have an overcapacity in this field. Nonetheless, constructions of new facilities are in progress (JOFRA, S. M. 2013).

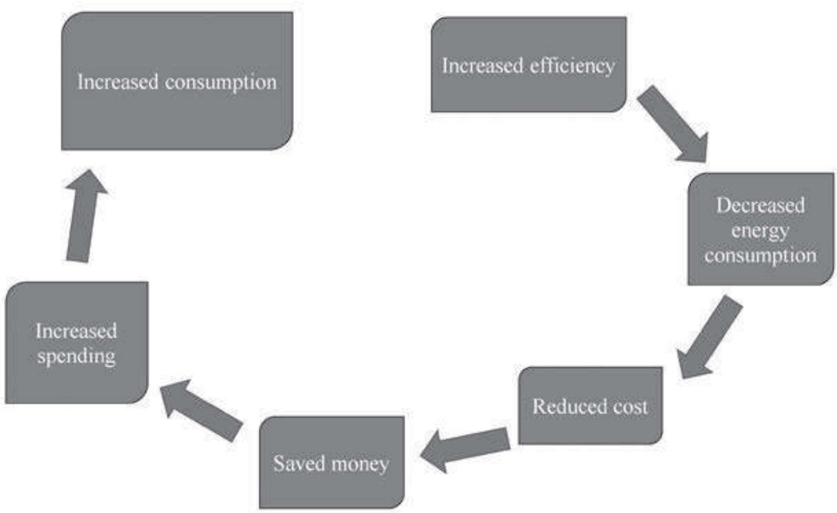

Figure 2 – Concept of rebound effect

Edited by MUNKÁCSY, B. (2013)

Water management is responsible for surveying and utilising the world's vast hydroelectricity potential. This area is particularly important, because the building and operation of hydropower stations—mostly the large facilities—can cause huge environmental burdens and social challenges. However, it can solve several problems of energy management. The most important advantage of this area is that it can contribute to the integration of other renewable energy applications, as the hydro energy can be controlled and stored easily. Due to these properties, hydroelectric power stations will be important elements of our future energy system *(Figure 2)*.

2. Non-technological factors of energy planning

There are several non-technological principles which already have serious impacts on energy planning. The most contradictory of them is *economic science*, as it has a detrimental effect on sustainability of the whole global system through:

a) belief in exponential economic growth (BOULDING, K. E. 1966);

b) the unresolved problem of external costs of environmental pollution; and

c) incorrect evaluation of natural resources (SCHUMACHER, E. F. 1973).

The above mentioned distortions result in a relatively low price of nuclear and fossil fuel based energies, which means a competitive disadvantage for renewable based energy and measures of efficiency. These discrepancies were recognised in the 1960–1970s; nonetheless, the economical mainstream has ignored them until today.

The other fundamental principle, which is already involved in energy planning, is *jurisprudence*. The legal regulation should have an important role in the energy transition, but decision making processes established on the aforesaid have distorted figures of economic calculations. This explains that legal regulation also appears as a drawback effect—see adversities of the *California Air Resources Board's Zero Emission Vehicle Mandate* in the 1990s (DIJK, M. *et al.* 2013) or the impossible battle against the increase of greenhouse gas emissions.

However, there are other unavoidable, *non-technological aspects* of energy management, as well; most of them being connected to the fact that energy services have been used by human beings. Their importance in energy planning is less recognised these days, but specialised studies have been dealing with their importance since the middle of the 19th century. According to *William Stanley Jevons* (1865), if there is an increase in efficiency in the use of a resource, its price can reduce leading to an increase of its consumption. Under certain circumstances, this phenomenon can actually increase the overall resource usage as opposed to reducing it. The *EU* financed and has just published a research on this *rebound effect* (MAXWELL, D. *et al.* 2011) *(Figure 3)*, concluding that the value of direct rebound effects for household energy efficiency is estimated in the range of 10–30% for developed countries. In commercial road transport, this value can be 30–80%, which highlights the importance of the human factor.

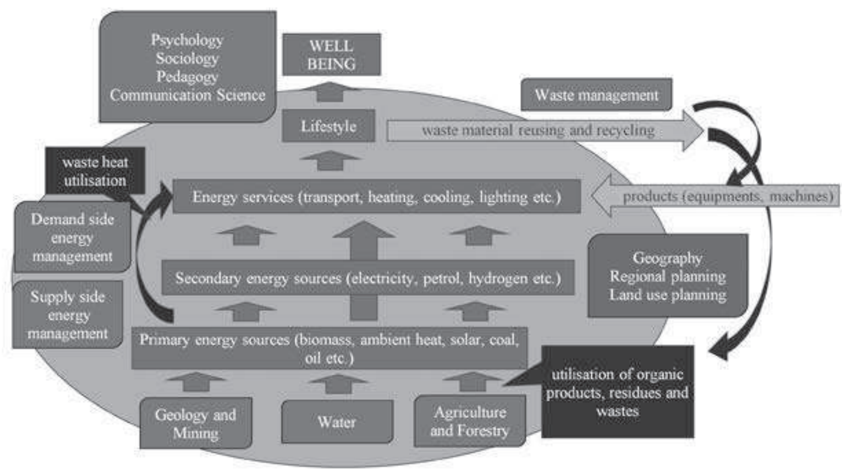

Figure 3 – Holistic approach of energy planning and management

Edited by MUNKÁCSY, B. (2013)

Beyond this whole concept, there is a fact that our ideas about "well-being" determine our lifestyle. However, our lifestyle is defined by the *amount and types of energy services* that are used by the society, or a community, or even a single consumer. Through the different energy services, this system is connected to the energy chain and, therefore, it has an effect on the consumption of energy sources and the environmental burden of our energy system (NORGAARD, J. 1998). Because of the above mentioned relationship, this issue is an interesting area of the *environmental sociology* that emerged in the early 1970s. There is also a special area of study, called *energy social science*, which deals with the social and behavioural aspects of energy use (LUTZENHISER, L. 1993). The *pedagogy* and its allied discipline, *psychology*, should have a tight connection to energy issues, as well. The formal education has a particular role, as staying half a day in schools, younger generations get important inputs at these institutions. Schools (and the families) should compensate the negative effects of the massive media campaigns of the consumer society which is a serious challenge these days. In order to meet this provocation, there are new areas in both fields, such as the *environmental or global education* and *ecological psychology*.

According to the previous paragraph, communication has a crucial role in the development of the environmental crisis. On the other hand, media and communication sciences have a responsibility and they should have a leading role in answering the questions raised.

3. The role of geography in energy planning

The changing role of geography should be remarkable, as it is a complex (social and natural science) discipline itself. This discipline will be more and more important, as the decentralisation of the energy system goes on. *Spatiality* is a crucial factor in sustainable energy production, due to the fact that renewable energy sources are dispersed in space. New methods of geography, as geographical information systems (GIS) are essential in the calculation of potentials, may be those either wind, solar or biomass technical energy potentials (MUNKÁCSY, B. – KOVÁCS, G. – TÓTH, J. 2007). International comparisons of capacities or production data can provide sufficient basis on estimations of socio-economical potentials (MUNKÁCSY, B. 2011) and contribute to create progressive national or regional energy strategies and plans.

Engineers generally have special knowledge in a narrow field, while geographers are more open and see a wider picture. Therefore, they can recognise the potential relationships (discussed in the first part of this paper) among the different sectors of environmental management in a given area. Thus, electric engineers cannot deal with architecture; agronomists do not deal with forestry. However, revealing the connections among these fields, sometimes, would be substantial within a geographical area, as energy and material flows do not consider the borders of different fields of knowledge. Recognising the possibilities in these kinds of connections might yield good results in energy and resource management, as well.

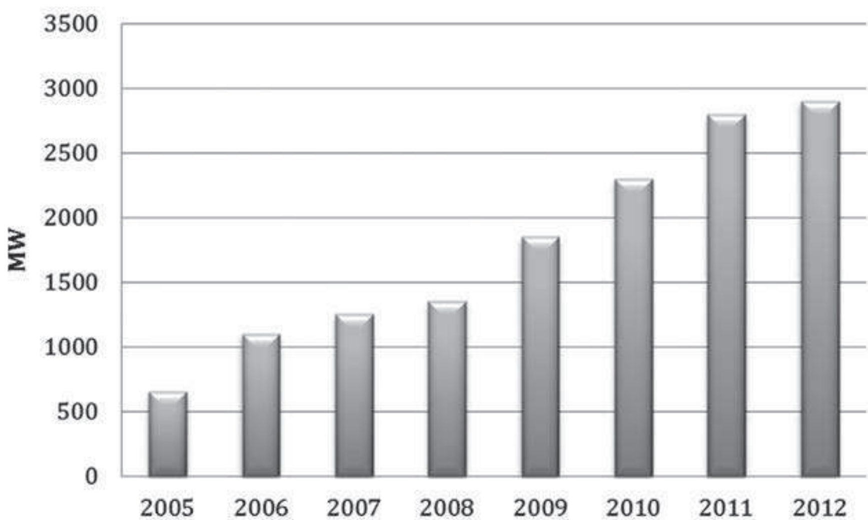

Figure 4 – Energetic capacity of biogas plants in Germany (2005–2012)
SOURCE: ERNST, R. et al. (2012); Edited by BOKOR, L. (2013)

For example, in *Germany* 2,200 MWp of biogas capacity was built between 2005 and 2012 *(Figure 4)*; 60% of them on bio-waste basis (ERNST, R. *et al.* 2012). It means not only a state-of-the-art waste processing activity, but also a highly efficient heat and power cogeneration, which is close to the consumers. Considering these developments in Germany, it is difficult to explain the necessity of a new nuclear power plant in *Hungary* which would produce electricity with a very low efficiency, while producing several types of radioactive waste and huge amount of waste heat.

Astronomical geography should also have an important role in energy related projects, namely in new building activities, as passive house planning and generally *passive solar energy applications* are based on the *Sun's* orbit. According to FARKAS, I. (2010), heating energy consumption can be reduced by 15–20% with direct passive solar systems, and by 25–35% with indirect applications under Hungarian climate conditions. Planning new streets and plots, and creating new quarters in our settlements are very complex tasks, in which—account taken of the above—planners should consider this astronomical geography's aspect, as well.

Meteorology is one of the closest associating disciplines to geography. Without this scientific subject, it would be impossible to calculate potentials or install applications in the fields of harnessing of wind, solar and, moreover, hydro energy. Meteorology can also provide short time forecasts in order to enable power system operators to create the daily schedule of electricity production.

The energy efficient consumption is also connected to geography, for example "eco-routing". With intelligent navigation systems, we can save significant quantity of fuel. Experiments show that up to 33% of fuel savings can be achieved only by advanced route planning (DHAOU, B. I. 2011).

4. Conclusions

On the verge of the global environmental crisis, it is an urgent challenge to reshape our dramatically polluting energy sector worldwide. First of all, we need to remould our approach both to supply and demand sides of energy planning, in a way of giving up the narrow-minded technological and distorted economic attitude. The holistic approach needs to be the basis of the new energy planning procedures. There are three important tasks facing the experts and decision makers:

a) involving those disciplines which deal with the human factor of energy (sociology, pedagogy, psychology, communication science);
b) involving geography which can recognise and point out the possibilities in cross-sectoral interconnections in a given geographical area;
c) connecting the different engineering disciplines to each other.

After having solved the above indicated deficiencies, it would be possible to decrease the energy demand of the society and economy. Counting on "sufficiency" and moderate consumption are indispensable in order to set up a sustainable energy system, as the recent energy use could not be covered by renewable energy sources in a sustainable way (MacKay, D. J. C. 2009; Munkácsy, B. 2011).

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