ECO-ECONOMY

Challenges in education, research, and infrastructure[1]

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Abstract

Evidence of the detrimental effects of human activity on the environment, climate and human beings, has become increasingly evident to a growing number of alarmed individuals. It is now time to make a systematic assessment of this evidence in order to find a solution to the problem. In order to find this solution it will be necessary to revise the world economic system, since the present one is what has caused the problem. L. R. Braun has formulated some initial proposals concerning the matter in his new monograph **Eco-Economy, Building an Economy for the Earth**. The current abstract will furnish an overall description of Braun's monograph, along with other references; especially those that focus on the challenges presented by education, information and new ideas that could lead to a solution.

1. Introduction

For a long period of time we have been bombarded by information that has warned of a looming ecological, social or economic crisis. Individuals, who were aware of this, have given thought as to what appropriate action could be taken to ward off impending disaster. Even by the 1960s there were scientists who knew that harmful environmental change was occurring, as is demonstrated by the appearance of Rachel Carson's book **Silent Spring** [Carson62]. Shortly after this, in 1968, The Club of Rome was established and its first report [Meadows72] alerted the world. Various extra-governmental organizations were created, such as **World Watch**. These were charged with the monitoring of environmental change. Later on, the **Earth Policy Institute** was established in the USA and other countries, which preceded many governmental institutions in developed countries.

As a result of UN interest in the problem we had the first world congress in Rio de Janeiro in 1992. Recently, a successive congress concluded the work in Johannesburg (in 2002). These two world conferences have shown that the problems are complex, and that many governments, including leading world powers, are reluctant to implement agreements reached. For example, the refusal of the USA to implement recommendations made by the Kioto Conference is just one example of this problem. This reluctance may mean that people in authority are unaware of the serious nature of the environmental situation. As a result, it may mean that knowledge of climatic change, frequently confirmed by painful catastrophes, will remain unknown to them and they will not, therefore, be sufficiently aware of the problem and able to act accordingly. Unfortunately, this is also true of other influential

[1] Based on [Cempel03] with further amendments

spheres, including scientific circles, where a similar attitude may be found. Apparently, it was not their chance to acquaint with the whole system of unfavorable environment changes, coupled and interrelated each with other. It is, among other things, a goal of the present work, to reach a wide circle of people responsible for creating the future (such as educators, researchers and others responsible for guiding future trends).

2. Condition of the eco-system

What is the picture that emerges from the various reports and studies into the present global and economic situation? The answer to this can, in brief, be summarized in the form of three related threats:

- The human population explosion – the demographic bomb.
- The unthinking use of non-renewable resources – the energy and material bomb.
- Irresponsible human interference with the eco-system – the ecological bomb.

The threats combined, form a pattern that could easily lead to destruction of the human race. The pattern can be described by means of mathematical models [Forrester72]. This raises the question as to why we persist with such outmoded patterns of behavior. Most consider these patterns to be the effect of old-fashioned modes of behavior, or, state that:

- Unlimited and irresponsible human population growth is still possible.[2]
- The Ecosystem provides unlimited economic resources that are available for unrestrained exploitation.

This essay was prompted by the publication of the recent book by L. R. Braun, **Eco-Economy - Building an Economy for the Earth**, in which, apart from presenting the environmental problems, the author proposes a series of new eco-economic solutions. One of the goals of the publication is the holistic presentation of trends in environmental change, with an emphasis on the meaning of education, research, innovation and technology, since a solution to the problem must stem from these disciplines.

The present work presents a systematic approach to the problems noted and is based on the monograph mentioned above. However, other sources have also been consulted and their conclusions included too. In addition, the author presents the engineering and technical view, which has less concern with the pure “bio” problems.

Among the more erudite scientists one can often hear voices saying: "Why, of course we just do it; we optimize everything that can be optimized, such as materials and energy etc.… We also help our neighbours". The problem is that all action is related to an exceedingly complex system (i.e. the environment or eco-system) of which we are part, but we do not fully understanding the it. In short - the ecosystem includes a self-renewing multilevel balancing process in the flows of matter, energy, and information. Thus, the ecosystem comprises a network of non-linear connections, which bind its parts and regulate its existence. Our interference with any of its variables often results in appalling consequences. Our ignorance and/or carelessness lead to deregulation, destruction, and the ruining of these processes. Unilateral help given to the Third World provides a typical example of the effects of such ignorance. Statistics clearly show that if our help today saves one child from hunger in Africa,

[2] “Irrespective of commonly diffused axioms of religious, political, and economic nature, or temporary regional options, there is no enough space for all potential people on the Earth, similarly as all potential frogs can not find their place in a single puddle.” [Lenart02]

we condemn to death, by the same action, his four descendants 20 years later. This indicates how carefully considered our help must be, as it has long been known that there is a theory of systems (e.g.[Senge98]) which states that "**symptomatic treatment leads to worse effects than a lack of action would**". So the "*partial optimization*", as mentioned above, in scientists' discussions may have a similar effect, and merely ease the consciences of educators, researchers, engineers or those others around the world who care about such matters.

So, after due deliberation, I made attempts to find answers for myself (and to help others do the same) by regarding the nature of the problem, and finding what could be done to find the best solution in the domains of research, education and technical innovation.

3. The need of converting to renewable energies

Our civilization exists in the form we understand thanks to non-renewable energy sources – particularly those of coal and oil. If theses resources were to come to an end, our civilization would cease to exist in its present form. There are optimistic and pessimistic estimations of mineral resources. According to the pessimistic argument power **shut-downs** will begin in great towns after 2012 [Hanson01]. A similar scenario is shown in Figure 1 drawn from the recent Meadows' report [Meadows92]. The figure presents the fundamental nature of the problem - growing population connected with available petroleum mining giving decreasing per capita energy value, even assuming a high death-rate (a collapse). Growing environmental pollution and reduced availability of other resources complete the image. We can only argue whether this comes in 2012 or a little later, as is suggested by another comprehensive Figure 2 [Lenart02].

Considering the fact that the combustion of petroleum or gas poisons the environment (an ecological bomb), the only solution is to be found in "pure" renewable energy, according to the diagram of Figure 3. The entire average use of these resources at present reaches 6 percent in Europe, while in Sweden it is 30 percent and in Poland 2.5 percent (with 7.5 percent forecasted by 2010 [Strategia01]). On the other hand, it is heartening to learn that in Denmark and northern Germany, wind power meets up to 20 percent of energy demands [Cordis02]. It is clear that there is much to do with regard to this problem, i.e. in the spheres of education, research, designing, building industry, production, and traffic; starting from small water- and wind-power plants to be located at least instead of former water-mills and windmills[3].

[3] The power of the most advanced air generators with an airscrew diameter exceeding 50 meters currently reaches 4MW

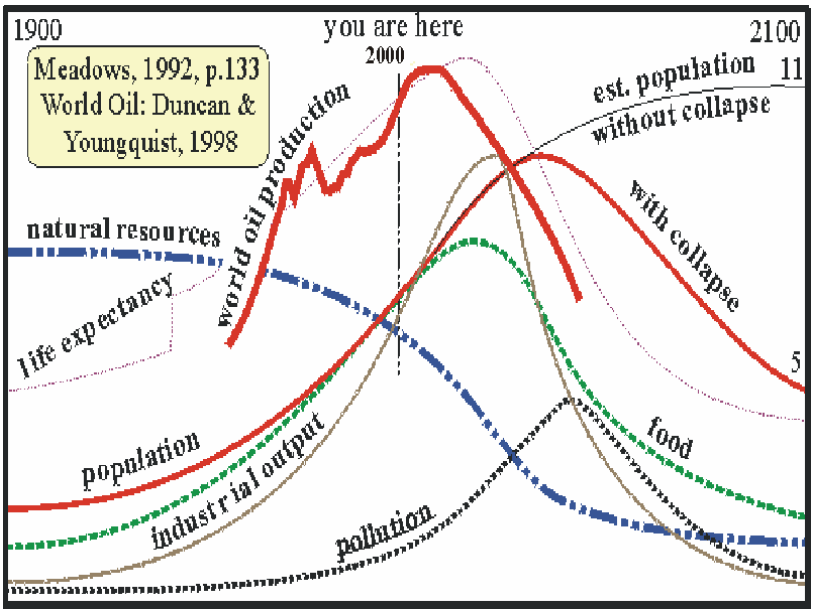


Fig. 1. Petroleum production and its forecast against forecasted demographic and pollution data [Meadows92].

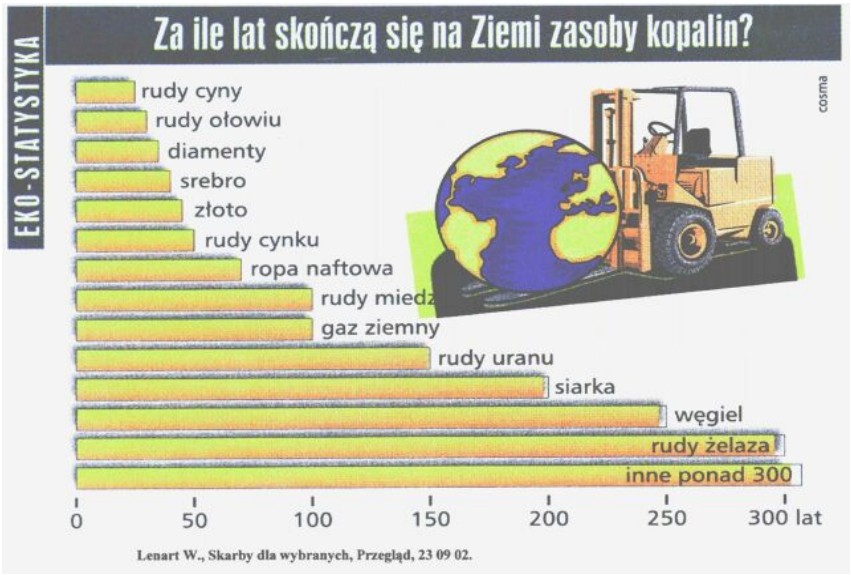


Fig. 2. Resources of minerals, raw materials, and energy, according to other source materials [Lenart02]

Another resource of renewable power is geothermic energy. Generally it is possible to use this for heating purposes (heat pumps) for large areas of the country. It may be used even for electric power generation when used with special heat exchangers in conjunction with the application of low-boiling liquids. Suitable production engineering processes are already available in Poland. The appropriate investment and financial incentives would give rise to a larger number of users and force those in the spheres of research, innovation, and technology to take note of this solution.

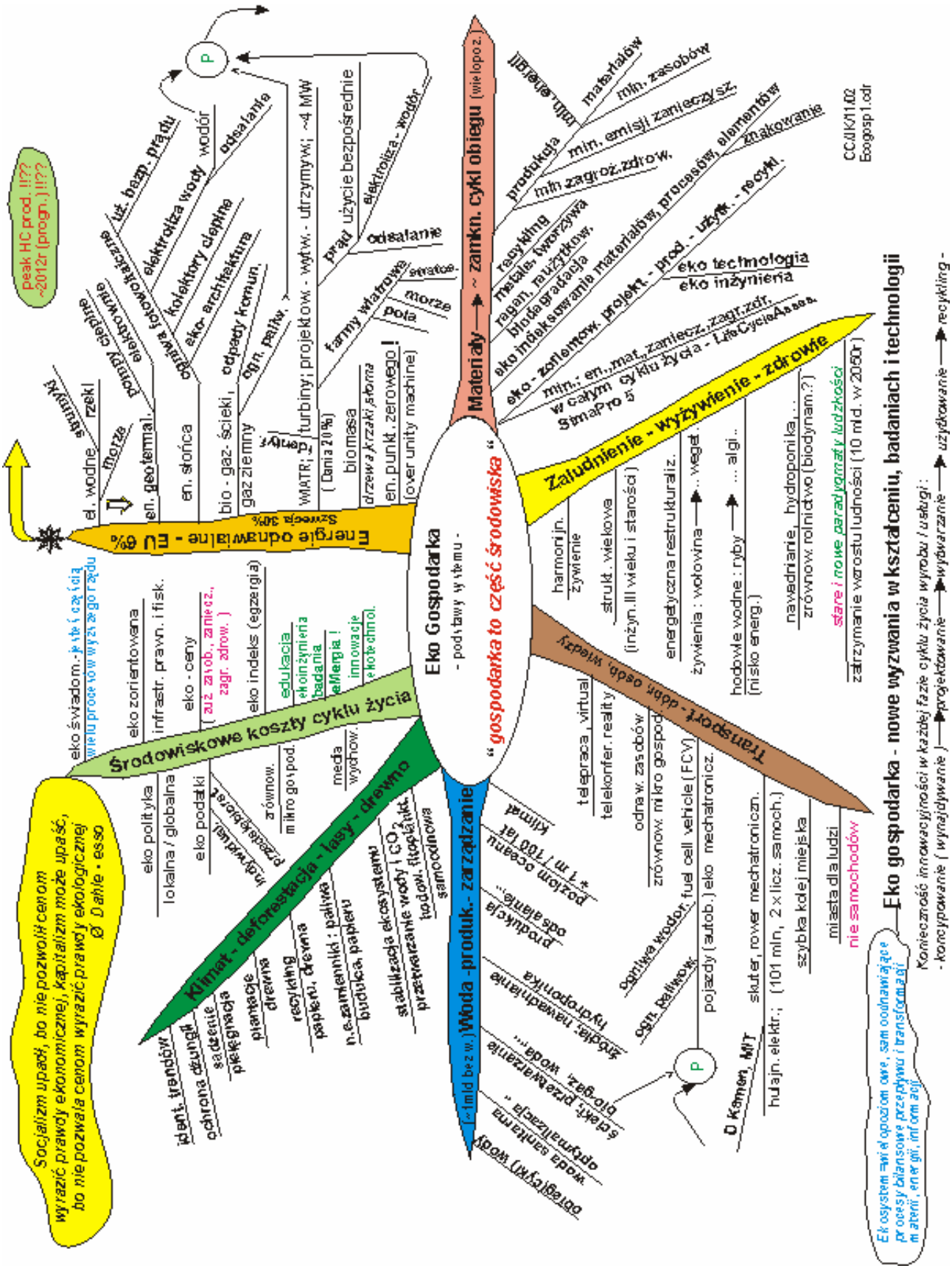


Fig. 3. Diagram of ideas related to future eco-management and its implications in the sphere of education, research, innovations, infrastructure, and technology

Much more important power resources are delivered by the Sun: $27 \cdot 10^9$ MW of solar energy falls on the lands/Earth. In this case there are many feasible forms of harnessing the energy. Some of them are shown in the diagram of ideas (Fig. 3.). They include architectural solutions such as direct use for heating and/or cooling rooms and indirect use facilities, which employ collectors, batteries and/or solar cells. This provides for the possibility of direct power generation or hydrogen production to be utilized in hydrogen cells, which can, in turn, power vehicles or other equipment.

Solar energy is also a source of life on Earth, particularly as it enables plants to provide natural photosynthesis laboratories. It is an enormous resource of renewable energy, called in general a biomass. Particular value may be assigned to trees, bushes, straw, and materials derived there from. The exchange/renewal cycle of the biomass may even be short - from several months for straw - to up to more than ten years for trees. Hence, the biomass-to-power conversion is very profitable, even when employed in direct combustion, being more environmentally friendly than coal or petroleum employed in the same manner. In our local conditions biomass is one of the most important resources of renewable energy, formerly only inadequately used [Lewandowski02,r15].

According to Figure 2 resources of natural gas will last longer than those of petroleum. Moreover, a similar kind of gas may be produced from farm, or even communal, waste water (as a biogas) [Mikielewicz99]. As usual, the energy may be obtained by combustion, although more and more frequently the gas should be supplied to fuel cells enabling direct generation of electric power in stationary or even portable generators. A tremendous breakthrough in recent months was a 5W electro-generator, of a size of a book, supplied with methyl alcohol, developed by an American laboratory JPL (NASA) [JPL02]. A similar promising advance of a similar nature is a prototype product made by Genesis, an American company [Genesis02], using water as a source of heat and electric energy. A brief technological description allows us imagine that water is excited by resonance and decomposed into oxygen and hydrogen that may be then used for combustion or as a source of electric power in a fuel cell. Vailant [Vailant03] proposes a similar multifunctional operation by gas generators of heat and/or electric power.

Wind energy is the next most feasible resource in our climate. The most important wind energy is available over the sea and at the seashore, i.e. in North Poland. However, going away from this region we may mention windmills used in the past. At present, wind turbines towers exceed a height of 50 meters and the capacity of a single generator reaches 4MW. In addition to these, multi-wind generators of recent design may operate effectively at a low wind velocity >2.5 m/s [Lewandowski02,s83]. This means that, in practice, such generators could be placed anywhere in Poland. Hence, a wind farm including several wind generators installed in an area where wind-mills were formerly located, may generate a power of about 10MW that might be delivered to the power grid or, alternatively, hydrogen might be produced (designed for further utilization in plants similar to present motorcar LPG installations[4]). The wind energy solution calls for innovation and fresh ideas in education, engineering and new technologies. Identification of resources distribution, through to the design of new generators, their production, planning, construction and designing of wind farms (taking into account noise reduction), and ending at their operation etc.

[4] It should be noted that the first fuel cell driven motorcars (FCV) will be used in the streets of California this year (The year should be specified).

The most important resource of renewable energy available to us at this latitude is that of biomass (trees, bushes, straw and their waste products), which can be converted into heat, bio-fuel or electricity. In Poland this approach is made more especially desirable because 1.7 million hectares of arable land are crop-free. Perhaps, apart from agro-tourism, agro-energetics would be worth discussing and launching [Wojciechowska02]. One could easily imagine power stations making use of all the above mentioned possibilities (co-generation), starting with water races, biomass, and bio-gas, and finishing at wind power - with a view to ensuring more efficient power- carrying agents and improving the readiness and reliability of the power supply system.

There is another one important power source, that of zero-point energy, which presents a challenge for alternative physicists and researchers [Puthoff93]. Experimental demonstrations of the Casimir effect [Milonni94] reduced criticism levelled against such scientists but, as is clear from yearly conference results of the Institute of New Energy (INE), in the USA [INE02] and others, EPZ[5] technology for mass application is still unavailable.

In spite of the problems outlined above, there is hope for humanity to avoid the danger of exhausting petroleum-derived energy sources if we seriously consider the threats and undertake systematic action to resolve the problem, starting from **education and research** and ending with changes in local and global policy and economics. This would mean adopting the notion that **economics is a part of the environment**, which contrary to previous thought. Otherwise, the metaphor of O. Dahle - the ESSO Vice-president - might prove true, forecasting the decline of capitalism by preventing prices from reflecting the cost of ecological truth (cf. Fig. 3).

4. Turnover of materials in eco-economics

The demonstrative diagram of Figure 3 shows another threat, consisting of the lack of structural raw materials, particularly the rare ones. Taking into account that many polymer plastic materials are derived from petroleum, the problem of the lack of materials becomes more serious. Also, it should be mentioned that the production of many materials demands considerable consumption of energy. First of all, ore mining and processing: these are needed to obtain materials and semi-finished products, even before they are converted into final products. Energy is expended at all stages during such processes. Part of the energy is released into the environment in the form of heat, dust emission, production waste etc. This, in turn, leads to risk to the environment[6], human health and life. Therefore, a simulation of nature should result in almost closed multi-level circulation of matter and energy in the **life cycle** of our products. Thus, the prime concern in obtaining and using materials should be: can they be regenerated, recycled and/or used again. Even if it is impossible to recycle, an ideal final use of a product would involve it being used to generate heat or energy in some way (through bio degradation or bio gas, for example)

Thus, our environment-oriented designing must include plans for the entire cycle of the product life - from the obtaining of raw material, through its cycles of material production, its processing, possible multiple reutilization, regeneration, and recycling. Moreover, the circulation within the whole life cycle must be subjected to multi-criteria optimization with a regard to minimal energy output, minimal threat to the environment while obtaining the raw

[5] The energy included in the space of 1 cm^3 is estimated by J. Wheeler to the amount of 10^{94}g, i.e. about 10^{118}J.

[6] Interruption of multi-level self-renewable matter and energy circulation in the ecosystem.

material, minimal energy consumption during the manufacturing process, and minimal threat for human health. This may be achieved by the application of special designing procedures called the **Life Cycle Assessment** (LCA), based on some European and international standards (ISO14040 and later). Special computer software is already available that enables the multi-option environmental assessment for the life cycle of a product or service unit (e.g. [SimaPro5]). Nevertheless, for this purpose, the data for each manufactured material or applied technology must be available in order to determine the effects of on the environment (impact assessment). It means that materials, goods, and technological processes must be subject to appropriate eco-cataloguing. This task is one of the important challenges in the field of studies, technology and education, and is similar to the undertaking that designs the life cycle of other products and services - from conception to reutilization, which takes into account the entire cost - i.e. the costs arising in the production plant, to the community, and to the environment (c.f. Fig. 4). Only such an approach can enable us to design a system that will enable the multi-level circulation of materials, the maintenance of minimal cost and an imitation of the natural circulation of the ecosystem.

5. Population - alimentation - health

The main reason for the shortage of energy and raw materials is the uncontrolled growth of the human population. According to some estimates, the human population will number 10 billion by 2050. However, according to a UN assessment, this figure will be reached by 2100. Irrespective of the difference between the two estimates, the main long-term goal of governments, the UN, and many co-operating organizations is to halt this avalanche of growth. This is difficult, as the main problem lies with those countries where the daily maintenance cost per capita amounts to US$ 1.00, or even less, and where more than half the population is illiterate [Population02].

Changing the life and energy use pattern cannot be changed overnight, and the growing population of the Earth must be fed. According to Braun [Braun01] the erosion of soils and grasslands is happening not only in Africa and Kazakhstan, but also in the USA. Therefore, it is crucial to increase the area of arable area by irrigation, the application of new technologies (such as hydroponics etc.). Of particular, importance is the matter of well-balanced farming and low energy consumption integrated with the production of renewable energy (water, sun, wind, biomass, biogas).

This is not only way ensuring appropriate results. If we calculate the energy necessary for manufacturing food in units of primary sun-derived energy and accounting energetic cost of its gradual transformation, we obtain a so-called **emergy,** introduced by Odum [Odum96]. Using this method, it becomes clear that producing high-grade animal meat requires much more emergy than is required than for any cereal, fish, algae or micro-algae. So, an energetic catalogue of farming products and food is indispensable. All our methods of food manufacturing and alimentation must be thoroughly restructured. Leaving the contemporary “industrial diet” in order to feed a bigger population, one should, preferably, adopt a vegetarian mode of alimentation, with fish, or even better, micro-algae. This is nearly connected with individual, well balanced feeding, according to the blood group, proposed by d’Adamo, that might be one of beneficial solutions in the social scale [d’Adamo01].

On a global scale the age structure of people will be subject to changes, as the number of elder people of the age past 60 is expected to increase, exceeding 35 percent of the population in Europe of 2050 [Population02]. This is connected to a complete redefinition of employment, that, together with the growing significance of automation and computers is

giving rise to the big social problem of unemployment that needs to be resolved. Irrespective of the above, medical treatment and engineering will find answers to many questions and problems related to "mass" occurrence of the "third age", and will assist the lives of handicapped people by "robotization" and the provision of a special infrastructure. This is another challenge for education, research, and innovation sectors of the whole economy.

6. Transportation of people, goods, and knowledge

Life in the towns will need to be completely restructured. A modern town today is wholly subordinated to the motorcar and a significant part of petroleum use is designed just for this purpose, particularly in the USA. This has to change. Mass communication must be introduced to the towns, including rapid railways at more important distances (over longer distances), eco-buses etc. On the other hand, it seems that the only solution at near distances (for local travel) is a high-tech bicycle. It could be named a mechatronic bicycle that, on the one hand, would be very beneficial to health as a meansof combating the growing obesity of our community, while; on the other hand, it should include many facilities for assisting the journey. These would include an intelligent drive to make use of electric power generated, for example, by fuel cells. It is important to note that, today, the number of bicycles is twice as large as that of motorcars. The first two-wheeled walkway mechatronic vehicles of traveling distance reaching 30 kilometers are proposed as standard equipment for the police [Kamen01]. The first fuel cell driven motorcars (FCV) are already used in the streets of California, while in Europe the first buses with such drives are in operation [Cordis03]. In the future the need for the long-distance transportation of people should decrease as a result of the developing possibilities in tele-working and tele-conferences, this is thanks to improvements in "virtual reality". Tele-working may also help halt the further enlargement of urban agglomerations and reduce the need for long-distance transportation of people.

Transporting people may be considered a separate field of activity, but a much more important problem arises with the transportation of goods that must be moved from one country to another. This makes for needles extra consumption of energy, wear of materials, roads, etc. Providing appropriate political and fiscal regulations, only the transfer of "**know how**" would be sufficient for local manufacturing of all necessary goods in micro- or macro-regions, ensuring, at the same time, suitable indexes of **balanced development** that would be easier to be introduced on a local rather than global scale.

7. Water - production and management

Here two trends may be observed. On one hand ocean water levels are increasing (in the last century the world's oceans rose by 1 meter). On the other hand, the level of underground water in many locations of the globe has gone down, causing the enlargement of steppe areas in whole regions (e.g. in Africa, Kazakhstan, at the Baikal area). Both phenomena result from human activity [Braun01] and the quarrels over water may lead to international conflict, as, for example, that between Lebanon and Israel[7]. More than one billion people live without running water, whilst, at the same time, Europeans and Americans bathe in water, consuming even 200 liters a day per capita. Here water is wasted, particularly in sanitary purposes. Therefore, for example, the idea of dealing with fecal matter without the using water is considered evermore seriously. Appropriate knowledge of water circulation, management of

[7] One colleague from Hayfa (Israel), when asked the reason for war in the region answered: "Too many people, too little water!"

waste water (which would enable the processing and reusing of water), management of energy (biogas) and raw materials are still in at an early stage. With good technology, water, biogas, and many raw materials may be recovered [Mikielewicz99]. Apart from such an approach, new sources and intakes of water must be found or even seawater desalinated in order to make good any deficits in water. Water resources should be carefully managed to avoid the lowering of underground water or, still better, to restore optimal climate and environment condition.

8. Climate - deforestation

The reasons for climate change are not very clear. We do not know whether the increasing size of ozone hole over the poles is a part of a long-term cycle, or whether it results from our activity [Jischa93]. What we do know, almost certainly, is that the increased of CO_2 concentration in the atmosphere is caused by the combustion of carbon-derived substance (HC), such as wood, coal and gas. People and animals also have an effect on this matter. Also there is the decreasing photosynthesis intensity on a global scale, caused by clearing jungles in Africa, Asia, and South America [Jischa93,s142]. In these regions the forests are being destroyed with total disregard for any consequences, and converted into fields and pastures, or serve as resources of fuel, building-timber, or raw material for paper production. In Europe the wood and forest management is well balanced, although there are some local shortages of wood, particularly for paper production. Nevertheless, in the Third World wood is considered as a fuel, building material and source of money through its exportation. Hence, some new, faster, methods of wood growing are necessary for these purposes until new low-energy wood substitutes are found instead. The restoration of forest areas that are lost at present, would restoration the CO_2 photosynthesis.

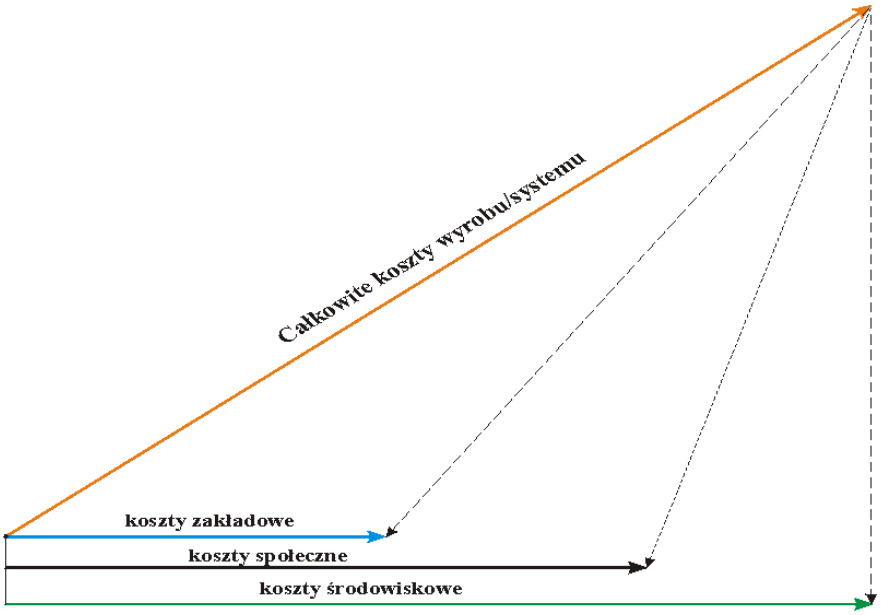
The growing concentration of atmospheric CO_2 is a matter of great concern as it may be a direct reason for the greenhouse effect, glacier melting and other climatic changes. A certain optimism may be felt after examining the cultivation and activities of phytoplankton, which occupies the upper layers of the seas and oceans,. It appears that a full cycle of carbon absorption by phytoplankton lasts about one week [Falkowski02], while full absorption capacity of a forest may be achieved after 20 years. Moreover, phytoplankton may be cultivated and fertilized; its growth and number may be artificially increased. However, the long lasting effects of such an activity becomes unknown and is an object of present research.

9. Politics - environment costs

Most of the solutions for a new eco-economy outlined here, relating both to the areas of engineering and biotechnology, cannot work without systematic changes in our outlook and a wide-ranging common acceptation of the need for change. First of all, the managing paradigm should be changed in the political scale This change should state that the economy and we, together, are a part of the ecosystem. Such an idea might be called an eco-conscience, if generally implanted in everybody. Legal and fiscal structures of the state should be changed and made friendly to the new managing blueprint. This concerns the eco-policy, on a world scale with states and self-governments managing their own regions. Individual taxes must not penalise men of initiative, as often occurs at present: the emigration of people from Sweden over ten years ago who left for financial reasons would be a good example of this. The question as to what extent is this possible in a well informed community is confirmed by a recent initiative of the Mitsushita Electric Industrial Co. Ltd, which consisted of the sale of functions and services instead of products. As a result companies are offered, for example,

supplies of suitable lighting instead of light bulbs. This enables a better organizing of material management with respect to environment needs [Sustainability02].

Taxes should rather be charged according to any negative consequences of our activity, e.g. for exhausting natural resources or environmental pollution. Similar means should be applied to other institutional operators on the economic scene, with special attention paid to management at the regional stage in a manner well coordinated with the ecosphere. However, this goal might be reached upon the changing of our understanding of economic activity, considering not only the book expenses usually rather easy to seize in the enterprise. Our long-term thinking of economic activity cost must include any social costs within a region[8], particularly environmental costs derived from a considerably bigger area and larger time-scale. An approximation of this necessary change in thinking and activity is shown in Figure 4, which presents a projection of the total costs for a product on a profitability axis, according to adopted way of their view.



Hierarchiczny i holistyczny sposób widzenia kosztów aktywności gospodarczej

Total costs of a product/system

Institutional costs

Social costs

Environmental costs

Hierarchic and holistic view of the costs of economic activity

Fig. 4. Three different points of view on the costs of economic activity

Implementation of the proposals mentioned above is not only a question of goodwill: in many cases we simply do not know how to proceed. There are some proposals of eco-indexing, for example, depending upon the amount of energy consumed[9], as per Szargut's suggestion

[8] Dismissal of superfluous workers of an enterprise reduces present costs but the region bears losses paying out unemployment benefits, apart from mental charge of the families, affecting further labour productivity and creativeness.

[9] Exergy, put briefly, is the energy able to effect work.

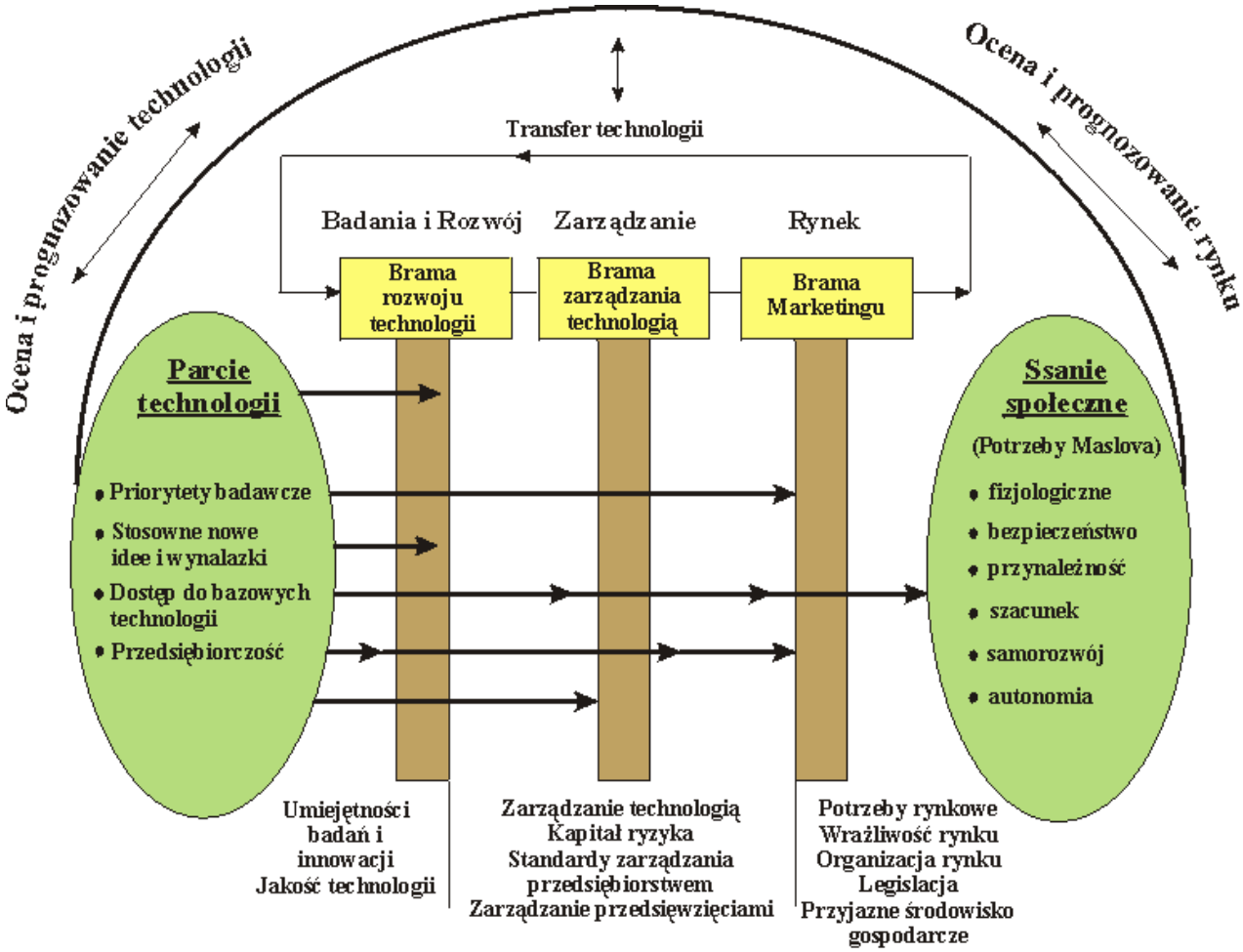
[Szargut01], or according to the consumption of emergy, as shown by Odum [Odum96]. In some cases the beginnings of ecological taxation based on Western patterns have already been implemented nevertheless, they refer more to standard guidelines, doses, and concentrations of substances than to market self-coupled regulations [Johansson97]. In general, in order to decide what is better at the local or global scale in a determined (any particular) case, some studies aimed at assessing ecological indices and piloting implementations of new computation methods are necessary.

10. Eco-education, eco-innovation and technology

All human activity, particularly that which is innovative, includes three components: thinking comes first, secondly there is the discussion process finally there is the stage of team effort in research and implementation. Considering the problem in terms of knowledge transformation, one could distinguish internalization, externalization, and implementation of the knowledge, provided, of course, that the knowledge itself is available. Thus, eco-economy must be assisted by broadly considered education, studies and technological innovation. The education must be considered very widely, including not only schools but also multi medial approach. According to Braun [Braun01] the attitude to family planning in Mexico changed as a result of TV serials. In a the same way, eco-economy will give rise to many new professions and fields of as per the diagram of ideas presented in Figure 3, (also discussed by Braun). People should be prepared for such professions, and should be familiar with a new data base: that of eco-knowledge, eco-engineering along with new skills that include a wide-ranging understanding of the phenomena and their consequences, in both the short and long term.

This cannot happen spontaneously, particularly because of the innovations and new eco-technologies required. The number of obstacles to be surmounted whilst introducing new ideas into the market is shown in Figure 5, and is derived from American literature [Sage95]: the country where everything, apparently, works so efficiently. Well, how does it go in Poland, our country? How many more obstacles are to be overcome in Poland?

Considerable help might come from the fact that computer technology is slowly converting us into a civilization of knowledge. As a result we be able to make use of knowledge at any time and in any location [Cempel02]. Research achievements in nanotechnology [Cempel99], biotechnology and bioengineering will have an increasing effect on such matters. We should, therefore, be prepared for this and properly prepare our graduates and, at the same time, organize a permanent change to our education in order to make a harmonious and synergetic use of the undergoing changes.



Rys. Konceptualna ilustracja transferu technologii i idei przez trzy bramy rozwoju systemu gospodarczego

Fig. 5. Three obstacles to be overcome while introducing new ideas, goods, and technologies in the market [Sage95,p65]

11. Summary

Energy is the basis of all human activity. Therefore, any significant reduction in energy available to any single inhabitant Earth might mean the beginning of the end of civilization as we know it. This must not be allowed to happen. It is now the time for switching from the old ways to a new pattern of managing the Earth in an environmentally friendly way; including locally generated optimized renewable energies and multi-level material loops. It is time to change transport, management of water, woods and green areas and to introduce a self-renovating capability for the whole system.

It is also time to note that many new solutions of eco-management (heat, electric power) may be produced in local areas in away that would change the whole infrastructure of heat and power transfer. New branches of industry and new professions would be called for, therefore our education system, research activities, new technologies and design procedures should undergo changes as appropriate. Returning to the medical metaphor, we should act in accordance with the injunction "**primum non nocere**" (first do no harm) in relation to the whole ecosphere: we, the people and our economy, are part of a system which comprises

many sophisticated processes; these must be not disturbed with impunity as have little understanding of them.