ECOLOGY, ENERGY AND RESOURCES:

Some Problems of Indicator Formation.

by

Dag Poleszynski

Chair of Conflict and Peace Research,
University of Oslo
and
International Peace Research Institute, Oslo

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1. Introduction.

This paper is part of the larger World Indicators Program (WIP) and will discuss the relevance and problems of ecological indicators as one of the ten general value dimensions chosen as basic concerns for the program. Also, some ecological indicators will be shown as examples of the kind we would like to pursue in the future.

As discussed in MEASURING WORLD DEVELOPMENT by Johan Galtung et al,* the ten value dimensions are the following (with antonyms in parenthesis, as shown on page 31 in the mentioned paper):

1. Personal growth (alienation)
2. Diversity (uniformity)
3. Socio-economic growth (poverty)
4. Equality (inequality)
5. Social justice (social injustice)
6. Equity (exploitation)
7. Autonomy (penetration)
8. Solidarity (fragmentation)
9. Participation (marginalization)
10. Ecological balance (ecological imbalance)

These values are all related to a hierarchy of needs in which the most basic ones are seen as being the need for food, clothing, shelter, health and education, representing the material basis for personal growth. Furthermore, the ten value dimensions can be applied to both the intra- and inter-country level of analysis, a double approach which clearly must be applied also to the formation of ecological indicators in this paper.

As we will see later in this paper, one of the first problems one encounters when trying to develop indicators of ecology, is that they often can be seen as indicators of other dimensions as well, if the concept of "ecology" is interpreted broadly. In a particular case, we may not only be measuring, for instance, resource depletion, but also equity or exploitation. Being aware of this, however, will help us to develop indicators that combine our ecological concern with the concern for equity or equality and as such serve to strengthen our arguments for fundamental changes in world order.

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*WIP Paper No. 2, autumn 1974.

Another problem we will have to face in our work to develop good ecological indicators is the task of picking relevant measures from the enormous reservoir of observations that may be, and partly have been, made in this field. We will try to overcome this problem by picking a few indicators in each family of indicators, instead of trying to use any potential indicator we can think of. An important task, therefore, will be to delineate families (or clusters) of ecological indicators, thus laying great stress on our ability to classify and untangle parts from the large web of interrelated factors in our ecological material.

2. Why ecological indicators?

By 'ecology' we mean the study of the interrelationship between organisms and the environment. Implicit in WIP is the belief that these relationships are fragile and, if upset, may threaten the possibilities of maintaining conditions for life on earth. The fulfillment of the first nine variables on our value list, in other words, requires a certain degree of ecological balance, and possibly vice versa. However, since we do not know the extent of nor the sources of such balance or imbalance with any exactitude, we feel the need for establishing some numerical indicators which reflect the state of nature over time. We will use these indicators to reflect intra- and inter-country relationships in a 'good/bad' matrix, as shown below. Here we have also included a 'neutral' zone for the less clear cases, which probably will be many - if for no other reason due to lack of data.

FIGURE 1: Ecological impact

Inter-country \ Intra-country	Bad	Neutral	Good
Good	Peru?	Several TWS's	Many TWC's
Neutral	?	Norway? Canada?	?
Bad	Most rich countries	Sweden?	Switzerland?

The example indicated in this matrix should not be regarded as more than a loose supposition of what we might expect to find. Evidently, it will be easier to identify some of the more clear-cut cases than all the border-line ones, but that should not deter us from trying. In order to perform this task, we need some knowledge about how different technologies and lifestyles influence the environment locally, regionally and globally over time. In many cases, scientific disagreement will make this a difficult task, something which again calls for a certain selectivity and caution when drawing our final conclusions. To clarify our point, we will mention two examples of how scientific imprudence has influenced man either directly or indirectly

The first case in this connection is the now-famous thalidomide tradegy, which did not end until more than 6,000 deformed babies[1] had been born - one reason being that the sceptics of this medication could not prove with certainty that the effects were as serious as they had thought until the sample had become large enough that the link between thalidomide and malformations was absolutely certain. Our second example is also well known: It took about 3 decades for scientists to realize that the use of DDT would develop into a global pollution problem because of its non-degradable properties. Even if DDT has now been banned in several industrialized countries[2] it is still in widespread use especially in the tropics, where the pest problems are of great concern.

Concluding from the above paragraphs, we will assume the sceptics to be correct until proven otherwise in all cases where there is a scientific dispute over possible environmental hazards caused by any technology. This is exactly opposite of the present-day practice, which plays havoc with present and future generations.

From a theoretical point of view, our indicators should be able to differentiate between different levels of severity (high and low) and the size of the geographical area which is or will be afflicted with environmental degradation (at the local, regional and/or global level). The intake by mothers of thalidomide, for instance, would have a very high impact but only on those babies whose mothers used this medication. The use of DDT in North American agriculture, however, may not seem to have immediately affected Americans to a very large extent, but has over time definitely added to the list of global pollution problems.

By combining the high and low values of the environmental impact (or ecological impact) with the three levels of geographical extension, we could conceive of a large cubicle with 8 smaller boxes, or 8 different categories. Since a visual presentation would be somewhat confusing, we prefer to use the table as shown below

TABLE 1: Geographic extension of environmental impact.

Level	Box no.	Locally	Regionally	Globally	Possible examples
	(1)	Low	Low	Low	Organic farming methods
	(2)	High	Low	Low	Landscape littering
I	(3)	Low	High	Low	SO_2-pollution from high stacks
	(4)	High	High	Low	SO_2-pollution from low stacks
	(5)	Low	Low	High	IEA-country depleting oil outside of own territory
II	(6)	High	Low	High	-
	(7)	Low	High	High	-
	(8)	High	High	High	Nuclear atmospheric tests

In the Table above, we have divided the 8 combinations of different geographical environmental impacts in two; I representing the bottom of our cubicle (the vertical axis represents the high/low dimensions), where the environmental impacts are low on a global scale, and II where the global impacts are high. The geographical areas are seen as being non-cumulative in the sense that one country may cause environmental havoc in other countries or regions without seriously affecting its own ecology and vice versa. The examples presented may not be completely representative, but should indicate of some of the problems we are facing when talking about environmental impacts or ecological indicators. The table may not necessarily be full - some cells may be non-existent - but that does not preclude our general theoretical conceptions of the cubicle.

To summarize, we feel that it is important to develop a set of environmental or ecological indicators for the following reasons: First, they may help us to understand the complexity of the subject and force us to clarify what we mean by environmental deterioration or ecological imbalance. Second, such indicators are important in determining the geographical dimensions involved and the time-scale we are dealing with. Third, we may improve the scientific basis for evaluating the seriousness of environmental offenses, both by producing our own indicators and by encouraging others to do the same. As we have seen, the problems involved are large, but, as earlier mentioned, we feel that the first steps should be taken in order to show unambiguously how we visualize a new world order.

3. Factors that influence 'eco-balance'.

By 'eco-balance' we mean a state of nature which not only is sustainable in the long run, but also one in which humanity will be able to achieve the nine values preceeding eco-balance as indicated on page 1. Such a state of nature would ensure that not only mankind could live in coexistance with its physical surroundings, but that all other naturally ocurring forms of life could exist in harmony with it. Eco-balance thus becomes a "minimum-factor" for human development, i.e. being necessary, but not sufficient for man to enjoy the "good life". The extent to which we experience ecological balance or imbalance (or environmental health or deterioration) is influenced by a number of factors having an impact on the environment, coupled with nature's ability to withstand such impacts. The environment's absorption capacity manifests itself in its bacterial flora, which breaks down animal and human organic wastes; in the ability of members of the eco-system to immunize themselves against man-made agents; by absorption in the nutrition chain; by chemical reactions and formations (like oxidation); by the sterilizing properties of pure water; by the antibodies' struggle against foreign elements; etc. Environmental impacts on nature can be created by nature itself or by human beings - i.e. either external or internal to human activities. The external and probably non-controllable factors are such things as volcano activity of the earth, variations in the sun's intensity levels, the impact made on the earth by meteorites or comets, etc. Of the internal factors we will mention the following:

Population: The quantity (number of people at present and in the future) and quality (people's health, cultural modes, ideology and lifestyle) of the world's population both have an impact on the environment. Population levels influence the climate, the technology in use, resources and energy use, and also the industrialization and pollution of the earth. Finally, external factors such as volcano eruptions may have a strong impact on settlement patterns and population density.

The climate is primarily influenced by external factors, but also by population levels, technologies, resource use, industrialization, and, of course, energy use and pollution of various kinds (from resource depletion, use of technology, energy use, etc.)

Pollution is influenced by all the mentioned factors. Technology use is determined by the population (especially the qualitative aspects), resource status, industrialization, pollution levels, the climate and external factors.

Industrialization, in terms of both its type and degree, is dependent on the available technologies, on the resource status, on pollution levels and the population.

Energy use is a key to understanding the type and extent of industrialization, population levels, industrialization, technology and resource use, and it stands in a dialectic relation to these factors. All the mentioned controllable factors have their environmental impacts, which when coupled with the absorption capacity of our environment, determines the degree of ecological balance. An index of eco-balance, therefore, would have to consider all the above factors to give us a "true" picture of the situation. However, since they all influence each other and all factors in no way could be included in our work, we will have to limit ourselves to a few "critical" indicators.

4. Threshold and eco-crisis.

When discussing environmental impact, it is important to realize that we are often talking about relative situations. A river may be polluted relative to how it was before, but clean relative to how it will be some time in the future if present development trends continue. (The Rhine may, for instance, in 10-15 years not only be a gigantic sewer, but a gigantic warm-water sewer because of all the planned nuclear power plants along its borders). But that does not mean that we have reached the pollution threshold above which no higher forms of life can exist, nor does it indicate that we experience an eco-crisis. In other words, pollution may be acceptable up to a certain level - an upper boundary being defined by nature and a lower one by people.

The most important issue we are concerned with is being able to identify relative changes in evironmental degradation which cause impacts on the environment that surpass a threshold, beyond which irreparable damage has been done, or where orms and values forbid further degradation. An eco-crisis we visualize as occuring when several such thresholds are surpassed and the total sum of environmental damage becomes so severe that man's very existance on earth becomes threatened. To examplify this, we could f.instance show (see later in this paper) that several regions in the industrialized world already have passed the acceptable threshold for average world energy use, since, if sustained by all or most countries in the world, such a level of energy use would push us into global eco-catastrophe. This would mean that man-made thermal energy production approached 1% of the solar energy influx-a level which probably (all other factors remaining constant) would result in a melt-down of the Polar ice-caps, the Greenland ice, etc. Such a meltdown would cause a rise in the sea-level of about 50-60 meters, leading to, among other things, the flooding of major parts of the best agricultural and residential areas in the world.[3)]

The above discussion should not be interpreted to mean that we are only concerned with the most visible consequences of industrialized man on the environment. We should also know that even small environmental impacts which may not be directly measurable or observable, may significantly reduce our possibilities for a "good life". Such considerations should make us suspicious when dealing with statistics which are intended to show us that f. inst. the consequences of an accident in a large nuclear plant are without concern or that low-level radiation from such plants can be overlooked because of its lacking significance. Fortunately, there are researchers who don't accept the establishment's laissez-faire attitude on seemingly innocent pollution problems (see Sternglass on the issue of low-level radiation[4]) and argue that we should consider seriously any man-made agent introduced into the environment. We are also of the opinion that one should never accept any theoretically harmful impact on the environment until it has undisputedly been proven to be harmless. In other words, it is they (the pollutors), not us (the pollutees), who must bear the burden of proof.

We will also reject the "cost-benefit analysis" approach, partly because eco-balance is an absolute good and cannot be traded against, and also because of the difficulties involved in quantifying environmental costs and supposedly gained benefits. However, we will not deny that certain man-made activities which do have environmental impacts must be performed in order to maintain human life on earth- agriculture, forestry, fishing- but the question is not, for instance, whether we want the fish in the river or electric power. We can find ways to make the electricity we need and to conserve our fish resources, but in many cases we simply can do with less electricity.[5] What we would be looking for, in other words, are ways in which we can minimize or reduce environmental impacts while still achieving the goals of human development. Since human development is not compatible with increasing global pollution, resource depletion, inequitable distribution or eco-crisis, it should be of universal interest to find out how environmental degradation can be avoided.

5. Units of analysis for measuring eco-balance.

The variables with which we choose to measure eco-balance can be applied to six levels or units of analysis. These are the following:

I. One country

Analyzing one country at a time, we could compare socio-economic groups, the urban vs. the rural population, different age groups, sexes or occupational groups, all with respect to their use of resources and the part of their incomes devoted to covering fundamental needs.

II. Set of countries.

We can look at different countries and compare them in terms of energy and resource use, pollution levels, etc., but we could also add the division of each country into different groups as discussed under level I before making our comparisons.

III. Structure of countries

Some interesting dyads could be analyzed, for instance, the U.S. - Latin America, Japan-Asia, EEC-Africa, etc. Here we would be interested in resource exploitation, pollution transfers, or other issues related to fundamental needs.

IV. Set and structure of non-countries.

Of special interest here would be looking at the environmental impact of transnational corporations (TNC's) and in particular the oil/energy companies. It would be relevant to find out how much of the different resources in different countries is controlled by the TNC's, and we could classify TNC's according to products or branches of industry which had varying environmental impacts. Finally, we could try to arrive at a blacklist of TNC's which were unacceptable from an environmental and needs perspective.

V. The world as one country.

We here could divide the world in for instance quintiles according to wealth (the 20% richest, second richest 20%, etc.) to see what part of world resource use, pollution and environmentallly offensive technology the represent.

VI. Putting I - V together.

This would be the task of trying to see a whole range of different measurements in one glance, something which, needless to say, would represent a very difficult exercise, and at the present stage it is even difficult to come to grips with it conceptually.

In this paper we shall concentrate on level II in our examples of eco-indicators, but also touch upon some of the other categories. Unit VI, however, is seen as being more a future possibility than as practicable at the present stage. Out first goal would be to start filling in our matrix presented on page 2 of this paper; some indications of clear-cut cases we should get at the end of this paper.

5. Classes and families of eco-indicators.

Above we have discussed several factors which have an impact on the environment and therefore determine the degree of eco-balance. Some of these factors wil be analyzed further in order to pick relevant measurements and combine these into classes and families of indicators that together tell us something about equity or exploitation, equality or inequality, etc.

A family of ecological indicators is a collection of data or measurements that show different aspects of a more general factor which has some kind of impact on the environment.

There are different types of resources, the most important being energy. Other resources can be classified into metals, non-metallic minerals, organic materials, water, air and soil (land). Energy is most important because by employing it, we can utilize and/or "create" other types of resources like metals and other minerals (the extraction of which demands energy inputs), water (which can be pumped up from the ground or desalinated by using energy), or agricultural land (forest clearing, removal of rocks, plowing, etc.).

Resources also have different properties. They can be renewable or non-renewable, geographically dispersed or concentrated, limited or(for all practical purposes) unlimited, simple or complex to exploit, essential or non-essential for human survival, culturally or non-culturally defined. Oil, for instance, is a non-renewable geographically concentrated, limited resource which is relatively complex to exploit, essential for "modern" transportation, agriculture, industry, etc., but it is essential for human survival only because it has been thus defined in the Western culture. By this we mean that it is Western Man who created the dependence on oil, both in private transportation (the automobile), in agriculture (pesticides, fertilizers) and industry. Some of the roots to this development can be traced to his individualistic attitude, his desire not to perform manual labor and the urge to dominate other peoples and nations. To perform these activities, oil has been an ideal resource - but we will stress that oil is not the only source of energy with which we may cover fundamental needs. Solar energy, even if played down by the industrialized countries, has been the basis for human survival for millennia. This energy source is renewable, dispersed, for all practical purposes unlimited, simple in use (it grows our food), totally essential for human survival, and cannot be ignored by any culture.

A family of indicators which would tell us something important about world energy use would include statistics and numbers on all levels of analysis as indicated on page 9. Some of these indicators could show for instance: Total reserves to resources, the capacity and potential of renewable and non-renewable resources, export and import patterns, consumption, depletion ratios, thermal impact per capita and land unit, pollution from use (SO_2, CO/CO_2, NO_x, dust), net energy considerations, etc. Such a family of indicators should give use a good impression of the importance of energy in the total picture. Since the magnitude and manner in which energy is used is vital to our understanding of world order, both in a power and an environmental perspective, such indicators also would give us a good idea of who (agent, country, class) is causing eco-imbalance where (geographical area). However, it does not tell us why (for profits, malice, carelessness, indifference or ignorance) energy use is too high or too low in a particular country or class, but we do not claim that ecological indicators can explain causality.

7. Examples of indicators to be made.

Before showing a more complete list of indicators of energy use and misuse, we would like to discuss some approaches to indicator formation which we feel should be undertaken at a later stage, either by ourselves or by others.

At the very core of WIP lies the idea of basic needs, i.e. that everybody on earth has the right to cover the fundamental needs for food, water (and, of course, air), clothing, health care, human contact, education and work. Since a large part of the world population (between 1/3 and 1/2 of humanity) does not get these basic needs satisfied, we should aim for the satisfaction of those needs for all before we start fulfilling higher-order needs for a few, not to speak of the luxury consumption pattern (which pollutes the earth and depletes its resources) of the very few. This may be seen as a social justice argument, but it also is important from an ecological point of view, which would come in as a moderating factor in describing which physical goods that could be consumed by all of humanity. Physical consumption is limited by the carrying capacity[12]. Evidently, we cannot all cross continents in SSTs. Neither can we all go to the moon in space ships, brush our teeth with electric toothbrushes eat 80 kilos of meat per year. One fruitful way of pursuing these issues, therefore, might be to estimate the environmental impact of successive higher consumption levels for the whole of humanity, in order to find the consumption pattern which would surpass the ecological threshold. Clearly, humanity must stay below this level.

This approach excludes the threshold as visualized by for instance Ivan Illich,[6] who believes that the limits to energy use will not in the end be ecological in nature, but social. In this paper, the social limitations on energy use will be kept aside, although not forgotten. For people who are concerned with ecological questions, however, it is important to realize that they don't have any monopoly on the idea of limits to growth and that social scientists also must be brought in to bear on the problem of defining upper limits to our resource and energy use.

Another approach would be to make a list of products that we know are environmentally unacceptable on a large or totally superfluous from a needs-perspective and relate the production of these goods to the production of necessities. This could be done in any unit of analysis, but we would prefer to start at the country level, for instance in terms of percentage of GNP devoted to such production. On a global scale, we would contrast the magnitude of waste production with facts like these: In the present world, some 500 million people all over the world are permanently hungry - at least 40% of these are children.[7] According to some estimates, it would cost only $20 per year to provide 600 additional calories and 20 grams of protein to each child every day, or $4 billion to secure 200 million childrens' nutrional health. As a matter of fact, this is not more than approximately 4-5% of a "normal" U.S. defense budget per year, the funding of which represents a continuous threat to world ecology and sanity.

To be a littlemore specific, some of the environmentally and socially less desirable products we would like to look closer at, would be the following:

Military equipment (guns, fighter- and bomberplanes, battle ships, submarines, missiles, grenades, ABC weapons, etc.), SSTs, nuclear energy technology, electric toothbrushes/meatknives/ nailfiles, nonreturnable cans/bottles/jars, vaginal sprays, deodorants, plastic wrappings on food/wasteful packaging, aerosol spray-bottles in general, throw-away items (paper plates, plastic dishes, etc.), candy and lollypops, fashion fads, superrefined carbohydrates (sugar and flour), vitamin-enriched polished rice, plastic shopping bags, artificial food meat tenderizers, body building protein tablets, Deluxe Rallye GTO Extra equipment for the car, herbicides,pesticides,fungicides, LNG tankers, Ultra Large Crude Carriers, etc.

This list is by no means complete, and it is put together fairly at random. But it contains a number of products which are polluting and/or depleting resources vital to man. The next step, therefore, would be to classify items on the list according to their magnitude and environmental significance (depletion/pollution effects), and then start on the top, blacklisting. We also could start on the "bottom", that is start by trying to find out how much of a country's total GNP is used for essentials and non-polluting, non-environmentally unsound products, services, etc. and let the rest be an estimate of how much of the economy represents wasteful production. Both tasks, however, are major undertakings which at this point in time are beyond our capabilities.

8. A basic need: Food.

During the last years' discussion about the possibilities of feeding an ever-expanding world population, it has become more and more evident that the food problem cannot be solved only by increasing the total supply, but that a redistribution of present consumption patterns also must take place.

It also should be clear that achieving a substantial increase in world food production by using "modern" methods would require large inputs in terms of machinery, fertilizers, water, means to control pests, besides clearing of vast new areas of farmland, etc., all demanding massive energy-inputs. It is far from clear, however, that such a program would be environmentally (or socially) acceptable - it seems probable that we would experience such large ecological consequences that our program would soon limit itself. A more rational way of reassuring everyone an adequate diet would be to restrain population growth at the same time as we found a more equitable manner to distribute and utilize present world food production. Restraining global population growth, however, is not likely to come about without first redressing the severe imbalance in consumption of food and material products between different groups. Therefore, the redistribution of food would not only help to alleviate the food problem, but would also alleviate the problems of unrestrained population growth. At the same time, it would solve many of the evident negative effects of overconsumption of food in the rich countries (coronary heart diseases, diabetes, obesity, dental decay, etc.).

In this paper it is not only our task to discuss ecological issues but also to suggest useful indicators. Related to the above discussion on food, we suggest to use figures as shown in the table below and apply them on a per country basis:

Table 2: Carrying capacity related to food habits. (numbers in billion)

Consumption of flour and fodder per capita and time-period (FAO estimates):		Sustainable population: A*	B**
1) Developing countries, present level.......	200 kg	6.68	12.5
2) --"-- --"-- FAO goal yr. 2000...	250 "	5.28	10.0
3) Western Europe 1960-61, Japan 1973-74.....	320 "	4.12	7.8
4) --"-- --"-- 1967-69....................	450 "	2.93	5.6
5) U.S.A. 196061..........................	800 "	1.65	3:1
6) -"- 1967-69............................	940 "	1.4	2.7

*With 1970 grain and fodder production of 1320 million tons.
**With an estimated production in 2000-2020 of 2500 mtons.

Judging from the figures presented in this table it is apparent that world food habits in no way can follow North American or European standards of today. In such a case, rations would only reach a small part of world population, and the rest would die within a matter of weeks. In 1970 world population was about 3.7 billion, today it is above 4 billion. By 2000, all estimates point to a total population of at least 5.5 - 6.5. billion, which means that we by then should aim for a nutritional standard on a world-wide basis not more extravagant than what was found in Europe 10-15 years ago. Should the expected production figures prove too optimistic, we should prepare ourselves for diets equivalating what FAO considers realistic for developing countries by the year 2000. And to avoid local famines, each country would have to make sure that the food recources became shared equitably by all community members. This will be no easy task, and it will take a lot more than ecological indicators to make the average U.S. citizen cut his meat consumption from the present level of about 80 kilos a year to, say, 30-40 kilos.

From the above we can visualize a number of indicators on food which together would represent a family giving us a rather good idea of how world food resources are shared and used and what would be the effects of different diets on a world-wide basis. Some of these are: Per capita consumption of grain and fodder, meat, fish and fishflour for each country; import and exports of food per capita; each country's occupation of land areas in other countries by net imports of fodds and non-foods (tea, tobacco, jute, cotton, etc.); energy inputs in domestic food production, per capita consumption of non-foods requiring agricultural land; consumption of luxury foods (sugar, cacao, etc.); agricultural area taken out of production to airports, roads, cities, etc.; topsoil erosion; food losses under storage, processing and transportation; water resources and requirements for different kinds of food production; use of organic/inorganic fertilizers in food production; etc.

Such figures would be useful in suggesting how the hungry people in this world could cover their needs for food; for instance by ending world trade with tea, coffee, cocoa, cotton and jute and converting the liberated land areas to basic food production [8] (primarily grains & legumes). We also would get a clearer pixture of the significance of changes in global land use and the way in which rich and poor people cover their protein and caloric needs (the former mainly through domestic animals and extensive food processing, the latter mainly from unprocessed vegetarian foods).

9. Some indicators of energy use

In the following we shall look a little closer at some indicators of energy use on a per-country basis (level II). As is the case for other factors having an impact on the environment, indicators of energy use are numerous, so we shall not pretend that we in any way can present them all. But for a start, we have made three Tables as shown in Appendix 1, 2 and 3.

In Table 4, we have looked at some figures for crude petroleum reserves, production and consumption and calculated some ratios we feel represent members of a familiy of energy-indicators. We have chosen some oil producing exporting countries, some industrialized non-oil producing, some rich producing and importing countries and some poor non-producing importing countries, totally 14 countries. The figures are from 1972 and may therefore not be fully representative of the present situation (Norwegian oil reserves are, for instance, much higher now than quoted in our Table).

the reserves-to-consumption ratios do not correspond very well to the reserves-to-production ratios, meaning that countries either consume more than they produce or produce more than they consume. The relationship between the reserves-to-consumption ratios and the reserves-to-production ratios we have called "dependency ratio". A ratio near zero (below 1) means that a country is a net importer of petroleum, i.e. exploits other countries' reserves, a ratio of 1 that the production equals home consumption, and a ratio above 1 that the country is sharing its resources with other countries. From an equity point of view, an oil-rich country should be willing to share its resources with others, but should not import other countries' petroleum to save its own reserves from exhaustion, as is the case with f.inst. the U.S.A. From an ecological point of view, it also is important that the reserves are large enough to last for several generations, say at least 100 years, so that future generations are given a chance to decide what the remaining resources shall be used for. As we see from our Table, only one country satisfies our demand for the duration of reserves: Algeria, which at the 1972 production level would have reserves lasting 116 years, but if only interior consumption should be covered*, they would last for more than 1.400 years. In this Table

*at the 1972 level

we also could have included per capita consumption of petroleum to get an even better impression of how the world production is shared among us. Such a figure would be an indicator of inter-country equality (inequality).

Since per capita energy use is not reflected in the "Dependency ratio" as calculated in Table 4., we have made some additional calculations in Table 5 (Appendix 2), where each country's share of world population and crude petroleum use are included. The relationship between a country's share of world population and its use of oil has been labelled the "Excess ratio", which can be used to moderate our "Dependency ratio". By dividing the latter ratio by the former, we get an "Equity ratio", which incorporates both total reserves, production and consumption and also per capita figures. As we see, the "Equity ratio" gives the result that countries like Algeria and Angola show up even more generous than reflected in our "Dependency ratio", while the U.S. and USSR show up as less desirable examples.

In Table 6 we have looked at total energy consumption (only commercial energy) in 14 countries and related this to the population and land area. The per capita energy use (in kilos of coal equivalents) could here be seen as an indicator of equality, a measure which we could relate to the world average. In this table we also have looked at the energy use per square kilometer, giving a social indicator combined with the eco-perspective. After having subtracted the renewable energy sources (hydro, etc.) we have calculated the thermal load per sq. kilometer in kilos of coal equivalents. Evidently, the higher the fraction of total energy supplies that come from hydro-power and other renewable energy sources, the better, all other factors kept constant. We notice that Norway is the only country where water-power represents more than 15% of the total and that the world average is as low as 2.1%. Our figure for thermal load shows that our worst case, the Netherlands, has an energy production per land unit 30-40 times the world average. Japan comes as a good number 2 and Denmark number 3, while a rich country like Australia has a very insignificant thermal impact. As expected, we also find extremely low values in the case of Bolivia and Ghana, where energy consumption per capita is 20-30 times lower than that of most industrialized nations. Our figures on energy use reflect our concern that humanity might use more energy on a global or regional scale than the environment can absorb without serious damage. To get an illustration of what some of the limits which will have to be imposed on global energy use would mean in practice, we shall make some calculations: Each year the world's surface receives 1.1×10^{12} GWh solar energy [9] equivalating approximately 137.5×10^{12} tons of coal equivalents [10] burned. Conversely, solar radiation hitting the world's land surface would be about 41.25×10^{12} tce, since the world's ocean areas cover approximately 70% of the total surface. Dividing this figure by the total land area of 135,783,000 km^2, we find the solar energy to equivalate 303,800,260 kilos of coal equivalents per square kilometer. As we know, recent research indicates that thermal impact by man only would have to be 1% of the solar influx to cause a major eco-catastrophy, excluding other effects (CO_2, NOx, etc.). If we choose a safety factor of 10, we would say that a country should be allowed to produce as much as 303,800 kce/km^2 without unduly influencing the global heat balance. From an ecological point of view, we would assume that all countries could, if they wanted to, reach this limit. Looking back at Table 6, we see that several countries already have surpassed this limit: the Netherlands by factor of more than 6, Japan by a factor of almost 3, Denmark by more than 2, and France by almost 1.3.

If we combine the limitations imposed by our thermal load factor and the demand for equality, it seems from this point of view that the world per capita energy use already is too high. However, allowing for varations in climate and natural endowment of resources, it would not be unreasonable to allow for variations in per capita energy use between countries, for instance in a 1:5 relationship based on total energy use. It would make sense to put an absolute limit on the thermal energy use to 300,000 kce/km^2, but to allow the total to become considerably higher (five times suggested here) for countries with high population densities. In the case of the Netherlands, this would mean that total energy use would have to be limited only by 1/6, but thermal energy use by 5/6. The difference, 4/6 or 2/3 of the total, could conceivably be replaced with solar energy in the form of direct radiation, wind power, tidal energy, wave power or other renewable forms of energy.

When making the final calculations of per capita energy use, we would have to include all non-commercial forms of energy, except human labor (cow dung, wood, peat, etc.) and non-land based energy use (the energy used by the Norwegian commercial fleet is for instance not included in the figure for the total or per capita energy use).

The above discussion should not be looked upon as a final proposal of world energy use among nations, but rather as some of the considerations we must take when discussing the level of energy use each country should aim for. Our point would be not only to prevent eco-catastrophy, but also to restore equity. In the latter perspective it might be interesting to look at some other levels of analysis to get a better grasp of present inequalities. Calculating from WORLD ENERGY SUPPLIES 1969-72,[11)] we can divide the world into several groups of countries (level III as discussed on p. 9) in the following table:

TABLE 3: Energy and population in groups of countries, 1972 estimates.

Group of countries	Energy use Mill. tce	share	Population Millions	share
"Developed" capitalist	4,604	62.1%	741	19.8%
East European	1,668	22.5%	354	9.5%
"Developing"	657	8.9%	1,815	48.6%
Centrally planned Asian	481	6.5%	824	22.1%
	7,410	100%	3,734	100%

As we can see from this table, the developing world with more than 70% of the world's population only consumes about 15% of total energy, while the developed market economies and the East European countries with together less than 30% of the population use close to 85% of all commercial energy.

If we could divide the world into quintiles according to wealth (level V analysis), the inequalities would be even more striking, because variations in energy use are large within each country. For sake of comparison, we would like to mention that Weaver and Jones[12] have made this exercise for the 1964 population and found that in terms of incomes, the poorest group only gets 2.9% of world incomes, the next 20% gets 3.5%, the middle quintile 4.7%, the next richest group 22.5% and the richest 20% gets 66.4%. Even if these figures may not be entirely correct, they should indicate what we may expect in terms of energy use between different socio-economic groups.

10. The "ideal" energy system.

In trying to redress the severe imbalance in energy use between different countries, we should not forget our basic values. An energy system which impedes the fulfilment of any of our ten value dimensions, is not an ideal system. Needless to say, such ideal systems are hard to come by, and modern forms of energy generation seem increasingly to be in conflict with these ten values. As we briefly have discussed, all giant energy projects have some kind of impact on the environment. This applies not only to the traditional use of non-renewable resources such as coal or petroleum, but also to large-scale hydro-electric projects or eventual future giant solar "parks". Large-scale projects also have a tendency to become alienating (preventing personal growth) and to dominate the total energy system (causing uniformity and increased vulnaribility). Also, they require experts with specialized education (causing inequality), thus preventing the "grass-roots" to take part in planning and development of the energy project (marginalization). Such a schism between experts and "the people" often leads to fragmentation (preventing solidarity) and has a tendency to lead to relative poverty in large groups of the community. A society with centralized energy systems tends to enforce centralization throughout the community in its industrial structure, its service & school system, etc. Thus the society tends to become more and more centralized and bureaucratically controlled in a dialectic process between energy use and the different sectors of the community. The more centralized, the more a society becomes susceptible to foreign and internal dominance (exploitation), as small communities cannot on their own keep up the quest for increasing sophistication of technology.

Our "ideal" energy system would be the antithesis to the above. It would have the following characteristics:

1) It would be based on a great variety of small, relatively simple centrals run by renewable energy resources, including for instance human labor, animal labor, wind, direct solar radiation, wave and

hydro-power, tides, organic waste for methane production, and perhaps the use of geothermal (where non-polluting except heat) sources requring relatively simple methods to use.

2) The system would be essentially non-polluting, and there would be no wastes (organic material from methane production would be used for fertilizer, f.inst.).

3) The system would have to fulfill several social requirements, such as: the need to fit small economic cycles, decentralization, low level of complexity (easy to understand), good storage capability, flexible utilization and local ownership and control, etc.

4) The system should be able to absorb changes in demand laid upon it by seasonal differences, changes in the population structure, etc.

Such a system would also have to be coupled with other parts of society in a consistent and dialectic manner. This we have tried to show in Appendix 4, where the two counterparts of social development have been contrasted. Our preference is the one to the right, called "low-energy, counter-strategies to TNC's",

It is important to realize that we cannot choose parts of both strategies to be applied in a country's development, since the choice of each sub-category implies certain responses for other categories. Some of these relationships are intuitively obvious; if a country wants to have large-scale production of goods, individual car ownership and big cities, it will need to use a lot of energy produced in large central power stations. If, on the other hand, the goal is to cover basic needs for the population through small-scale production and great diversity, relatively small energy-inputs are required. Less obvious is what "ideological label" we should put on such a low-energy society (communist, cooperative, populist, socialist, etc.) and also how population policies and foreign policies should be shaped. But if we want to be responsible for our actions, the choices should become more visible. Hopefully, an extension of the present paper should be able to further clarify the relationship between ecology, energy and resources. What is needed then, are more exact indicators combining ecology with the rest of our 10-items value list.

11. Conclusion

It is quite clear that the ideas presented in this paper cannot be summarized in a few sentences in an adequate fashion. Therefore, we shall limit ourselves to say that this paper has attempted to discuss some ideas related to the formation of ecological indicators. The work will no doubt continue.

Notes:

1) The figure was given by Statens Institutt for Folkehelse in Oslo, where we were informed that thalidomide, which is sedative, was recommended to pregnant women in Germany and sold without prescription from 1957 to 1961.

2) In the US, DDT was banned in 1971, with the result that the levels of DDT being found in human tissue and in animals have gone down. A report by the Environmental Protection Agency showed that residues in human fat have declined from nearly 8 parts per million (PPM) in 1971 to 5.9 PPM in 1973, based on a sample of more than 1,000 persons. International Herald Tribune, August 12. 1975.

3) See for instance James T. Peterson: Energy and the Weather, Environment, vol. 15, nr. 8, October 1973. A more comprehensive review of the climatic effects of energy production is given in Study of Man's Impact on Climate (SMIC), Inadvertent Climate Modification, MIT Press, Cambridge, Mass. 1971.

4) Ernst J. Sternglass: Low-level Radiation. Ballantine Books, N.Y. 1972.

5) In spite of diligent attempts from the electricity producers to convince us of the inevitability of an all-electric future, facts tell us that what people need, is not primarily electricity, but energy in the form of heat: If British end-use by physical type is classified, one finds that about 55% is low-temperature heat, 15% mechanical work, about 25% high-temperature heat, and only 5% requires special forms of energy such as electricity. (Conf. opening remarks by Amory B. Lovins, Energy Panel, at the Conference on Growth and Technology in Ottawa, 4.-5. February 1975, sponsored by The Ministry of Science and Technology and The International Society for Technology Assessment.)

6) Ivan Illich: Energy and Equity. Ideas in Progress, Calder & Boyars, London, 1974.

7) In a document prepared for the U.N. World Food Conference, E/Conf. 65/4, The World Food Problem - proposals for national and international action, Rome, 5.-16. November 1974, it says that "On the most conservative estimate there are well over 460 million of such people ("who are permanently hungry and whose capacity for living a normal life cannot be realized") in the world today and their number is increasing. At least 40% of them are children (p.1), However, another document prepared for the W.F.C., "Värdslivsmedelskonferansen 1974 ", Utenrikes/Jordbruks/Handels-departementet, Stockholm 1974, states that "Med en mindre snäv definition på undernäring skulle man troligen få en fördubbling av antallet undernärda till ca. 800 miljonar.. Det amerikanske jordbruksdepartementet beräknade redan så tidlig som 1960 att 1900 miljoner då bodde i länder med otillräcklig näringstillförsel för en mycket stor del av befolkningen". (p. 10).

8) This would not be enough to end World hunger and might even aggravate the problems in the short run. But in the long run, it is obvious that luxury non-food agricultural production must yield for the benefit of basic food-production.

9) According to Survey of energy resources 1974, World Energy Conference, N.Y., 1974 (see the chapter on solar energy, p. 233-236).

10) The conversion factor being 1,000 kWh = 0.125 coal equivalents (metric tons).

11) United Nations: World Energy Supplies, 1969-1972, Statistical Papers, Series J, No. 17, N.Y., 1974.

12) See Gunnar Adler-Karlsson's Harrying and Carrying Capacity. Royal Ministry for Foreign Affairs; A Swedish Contribution to the U.N. World Population Conference. Stockholm, 1974.

APPENDIX I.

Table : Crude petroleum - 1972

	Reserves[1] mill.tons	Production,[1] mill.tons	Consumption[2] mill.tons	Reserves-to-consumption	Reserves-to-production[1]	Dependency ratio R-C/R-P
Algeria	5977.-	51.6	4.2	1423	116	12.2[3]
Angola	171.1	7.0	0.9	190	24	7.9
Australia	197.2	15.4	25.7	7.7	13	0.5
Bolivia	25.-	1.46	0.72	34.7	17	2
Brazil	106.53	8.158	31.3	3.4	13	0.2
Canada	1075.-	69.41	88.4	12.2	15	0.8
Denmark	34.75	0.18	19.98	1.7	193	0.01
France	9.21	1.484	109.6	0.1	6.2	0.01
Ghana	0.1	-o-	0.74	0.1	∞	-o-
India	130.16	7.374	19.8	6.6	18	0.4
Japan	3.57	0.708	192.5	0.02	5	-o-
Norway	228.3	N	7.1	32.2	N	N
USA	5569.-	436.15	769.8	7	13	0.5[4]
USSR	8138.-	394.-	306.7	26.5	21	1.3
Total world	91525.-	2493,-	2477.2	37	37	1

Figures taken from:

1) from Survey of energy resources 1974, (p. 108-110), World Energy Conference, New York, 1974.

2) from World Energy Supplies 1969-72, United Nations, Statistical papers, Series J, no. 17, N.Y. 1974.

3) A "Dependency ratio" of 12.2 means that Algeria's production of crude is 12.2 times larger than her own consumption. The ratio also indicates that Algeria's petroleum reserves are depleted 12 times faster than warranted by the country's interior consumption.

4) A ratio of 0.5 means that the US must import half of her total consumption of crude oil or that he reserves last twice as long as they would have lasted without any imports.

The ratios are rounded off to the nearest figure when necessary.

APPENDIX 2.

Table 5: Equity ratio of crude petroleum.

	a) part of World Population	b) Part of World crude Petroleum consumption	c) Excess ratio	d) Equity ratio
Algeria	0.14%	0.17%	0.43	28.4
Angola	0.15%	0.04%	0.27	29.3
Australia	0.34%	1.04%	3.06	0.2
Bolivia	0.14%	0.03%	0.21	9.52
Brazil	2.62%	1.26%	0.48	0.4
Canada	0.58%	3.57%	6.16	0.1
Denmark	0.13%	0.81%	6.23	0.002
France	1.37%	4.42%	3.23	0.003
Ghana	0.24%	0.03%	0.13	-
India	14.91%	0.8%	0.05	8
Japan	2.83%	7.77%	2.75	0
Norway	0.1%	0.29%	2.9	N
USA	5.52%	32.17%	5.83	0.09
USSR	6.55%	12.38%	1.89	0.7
Total world:	100%	100%	1	1

a) Calculated on basis of 1972 estimates by Statistisk Arbok 1974.

b) 1972 estimates by World energy supplies 1969-72

c) Excess rato = $\frac{b}{a}$

d) Equity ratio = $\frac{\text{Dependency ratio}}{\text{Excess ratio}}$

As we may see, these figures correct for the unjustifiedly large per capita consumption of the industrialized world and brings, for instance, the USSR below 1 (the "ideal ratio").

APPENDIX 3.

Table 6: *Energy consumption and impact - 1972

	1) Total energy Consumption in mill. metr. tons coal equiv.	1) Per capita energy use kce	2) Land area in km2	Total energy consumption per km2 in kce	3)Hydro etc. as % of total energy	Thermal load per km2 in kce
Algeria	8.132	533	2,381,741	3,414	0.5%	3,400
Angola	1.194	205	1,246,700	958	6.7%	894
Australia	73.885	5,701	7,686,848	9.6	1.9%	9.4
Bolivia	1.092	210	1,098,581	0.99	8.1%	0.9
Brazil	52.544	532	8,511,965	6,173	10.8%	5,506
Canada	235.011	10,757	9,976,139	23,557	9.5%	21,319
Denmark	27.794	5,567	43,069	645,336	0.01%	638,883
France	214.934	4,153	547,026	329,913	2.8%	381,278
Ghana	1.380	152	238,537	5.7	29.9%	4.1
India	104.818	186	3,280,483	31,953	3.3%	30,899
Japan	344.552	3,251	372,154	925,832	3.2%	896,205
Netherlands	76.133	5,711	40,844	1,863,990	-0-	1,863,990
Norway	18.244	4,639	324,219	56,271	46.3%	30,218
Sweden	46.614	5,739	449,964	103,595	14.4%	88,677
USA	2,426.075	11,617	9,363,123	259,110	1.4%	255,482
USSR	1,179.560	4,767	22,402,200	52,653	1.3%	51,979
Total World:	7,565.926	1,984	135,783,000	55,720	2,1%	54,529

*Only commercial energy

1) United Nations: WORLD ENERGY SUPPLIES 1969-72. Statistical Papers, series j, No. 17, ST/STAT/SER.J/17 New York, 1974.

2) United Nations: UN Statistical Yearbook 1972.

3) Calculated from 1).

APPENDIX 4.

The two counterparts of societal development (main emphasis)

Unit of analysis	Energy-intensive, TNC rationality	Low-energy, counter-strategies to TNC
Main societal goals	Achieving a higher material consumption level for all	Covering basic material needs; then max personal growth and happiness for all
Economic policies	Max growth, waste to save time acceptable, full marketing freedom	Work towards non-growth, reduction of waste and convenience use, no advertising (local display of goods)
Agricultural policies	"Rational", competitive production, energy intensive methods ("Green revolution"), market mechanism determines production	Max self-sufficiency, labor-intensive methods, "organic" farming nutritional needs determine production
Industrial policies	Structural rationalizations encouraged, large units, max automation, specialization quantity above quality	Preference to small units, quality production, automation only if compatible w. human goals, great diversity
Transportation policies	Individual car ownership, highways, large transportation needs, huge airports, mass tourism, SST	Collective means of transportation, bicycle lanes/pedestrian paths, low need for transportation, selective cultural exchange
Trade policies	Max exchange of goods and services, priority to Western world, but raw materials from poor countries with "competitive advantages"	Trade only to cover fundamental needs, exchange on equal terms and at equal processing level, diversified trade partners
Research and educational priorities	Prestigeous research laboratories, highly paid specialists, theoretical education to produce specialists	Research at all levels - for and by the masses, practical education, general orientation
District policies	District centers, school centers, concentrated services, encouragement of city growth	ispersed population dispersed service facilities (schools, hospitals, post office), small cities or towns

Energy policies	Large projects, specia-lized energy production, max growth in use, low price for industrial use, high-level technology promoted (fission/fusion)	Small units, varied sources, non-growth graduated prices for increasing use, low-level technology encouraged (hydro, wind, wood, animal and human power, etc.
Foreign policies and defense	Aid to reactonary regi-mes, stimulation of IBRD and regional banks, mili-tary threat or interfe-rence to foster capita-lism, heavily equipped derense, alliance mem-bership	Aid to liberation struggles, non-inter-ference, local defen-se (guerilla)/ people defense inte-grated in daily life (psychologically/ economically self defense only), non-alliance
Population policies	Population control not necessary in rich count-ries, growth good for business, technical and energy-demanding birth-control methods, foreign labor welcome when needed, non-citizenship for for-eigners	ZPG most important in rich countries, populatitin control through social means, economic equality instead of sanctions to reduce growth - free abortion for all production adapted to population, but full rights for immi-grants

Characteristic of the scheme: units of analysis are mutually depen-dent of each other and inconsistent if taken from different "poles". The "pure" types, however, are not known to exist today, but it is assumed that most Western countries are close to the version "Energy-intensive, TNC rationality". China is the closest we know of to the other extreme. Russia seems to promote a State version of the former.