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OPTIONS

# Energy Savings and Conservation

The present oil supply and demand situation has inspired two opposing views of the energy future: the strong belief that energy savings and conservation, induced by rocketing prices, will endure, and the fear that today's oil glut masks the threat to tomorrow's energy users. After an extensive statistical study, economist **Claire P. Doblin** is afraid that the common failure to understand energy savings and energy prices will lead to another energy crisis.

Cutbacks in energy consumption after the oil price shocks of the 1970s should not be counted as energy conservation "victories". Dr. Claire P. Doblin argues that "the greater part of these energy 'savings' in the OECD countries can be accounted for by the recession, the restructuring of the economy, unemployment, and falling personal incomes."

"And I am afraid," she continues, "we may be faced with a renewed, and possibly more acute, energy crisis in the mid-1980s. When (and if) the long-awaited economic recovery arrives with its rising energy demands, it will meet with our neglected development of alternative energy sources and true energy conservation through the introduction of energy-saving techniques."

There is no argument that there were cuts in energy use. While the trend from 1950 to 1970 was a straightforward annual increase in energy consumption, the 1970s were marked by fluctuating growth.

Cuts in energy consumption were greatest in the UK, followed by the FRG and the USA, and were least in Japan and France.

The 1981 figures for total primary energy consumption show that:

- the United States of America dropped back to just about its 1974 level;
- the Federal Republic of Germany returned to its 1977 level;
- France kept to its 1978 level;
- the United Kingdom dropped below its 1970 level;
- Japan held just above its 1978 level;
- and the twenty-three-country OECD (Organization for Economic Cooperation and Development) overall nearly returned to its 1977 level.

**Dr. Claire Doblin**

"This looks as if energy conservation has finally come to fruition," Dr. Doblin says. "To some extent it has. But besides the need to save gasoline that we saw in 1979 in the USA and in 1981 in Europe, there were also other factors at work to shape the development of energy consumption."

"Few of the cutbacks can be hailed as conservation through better fuel utilization. Major factors were the recession as well as a change in the mix of the GDP (Gross Domestic Product) – GNP (Gross National Product) in the USA. But not all of the structural changes curbing energy consumption in these countries contributed to a sound development fostering more energy-efficient societies."

## "Breaking the Energy Coefficient"

Energy consumption, total industrial production, and GDP indices moved along the same lines in the period of cheap and abundant oil from 1950 onwards. But since the 1970s, the statistics show unequal growth of real – adjusted for price fluctuations – GDP, total industrial production, and energy consumption. "In the OECD countries," states Dr. Doblin, "GDP has grown faster or fallen less than energy consumption ever since 1973. After the 1974–1975 recession, the upward movement of the index of total industrial production was faster than that of GNP in the USA; nearly as fast as that of GDP in Japan; but much slower than that of GDP and closer to that of total energy consumption in the FRG, France, and the UK."

The fact that since 1973 more GDP could be obtained with less energy – the "breaking of the energy coefficient" – is explained by Dr. Doblin as the result of "shifts in national economies favoring more services with light energy requirements, such as government and finance, and shifts within the industry sector towards less energy intensive industries, such as electronics."

There has been a substantial decrease in *total* energy input per *total* industrial output. It has been calculated, for example, that the 1981 output of American industry (mining and manufacturing) was produced with 39.5 percent less energy than would have been the case if 1973 rates of energy consumption had continued. A comparison made with 1970 = 100 based indices of total industrial production and energy demand for fuels and electricity by the industry sector shows that the gap between energy input and total industrial production tends to be even wider than total national energy consumption and total industrial output suggest. "However," argues Dr. Doblin, "this observation does not necessarily justify any conclusions about the existence or size of energy savings."

"For a valid appreciation of energy conservation in the industry sector, it is necessary to take one further step. One must examine the individual industries or industry groupings that lie behind the national average representing total industry. Such a comparison discloses that not all industries performed in the same manner and that there were considerable deviations from the average." Dr. Doblin found this true especially in the USA where the index of industrial production showed higher growth than GDP, while there were noticeable, but less acute, deviations from the national average in the FRG, France, and the UK.

In all four countries, the industries that did considerably better than the national average throughout the 1970s and into the early 1980s were mostly those with relatively modest energy input requirements, such as computers and other electrotechnical machinery. Almost all of the energy-intensive industries, such as basic metals and cement, are found among the "underperformers" – those falling below the national average.

An analysis of the manufacturing sector in the USA – about one quarter of the GNP – showed that roughly 80 percent of the purchased energy – fuels and electricity – was concentrated in only six industry groups: primary metals (iron and steel, aluminum, and others), petroleum refining, paper, stone and clay (cement), food processing, and chemicals. Five of these six industry groups fell below the national average growth of total industrial production in 1981. The exception is chemicals, but that grouping includes a variety of industries with differing energy requirements that cannot be isolated for meaningful statistical anal-

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ysis. It is also estimated that 25 percent of the manufacturing sector's energy demand in the USA is absorbed by only three industries: steel, aluminum, and cement. In the USA, the growth of these industries has lagged for years behind the national average, and Dr. Doblin claims that "this takes care of a good deal of so-called 'energy conservation'."

## Steel and Aluminum

She points particularly to "the slump in the steel industry responsible for the lion's share of the 'savings' in industrial energy consumption," and cites the following figures. Compared to the *total* industrial production, measured on a 1970 = 100 based index, the steel industry in 1981 was behind the national average by as many as

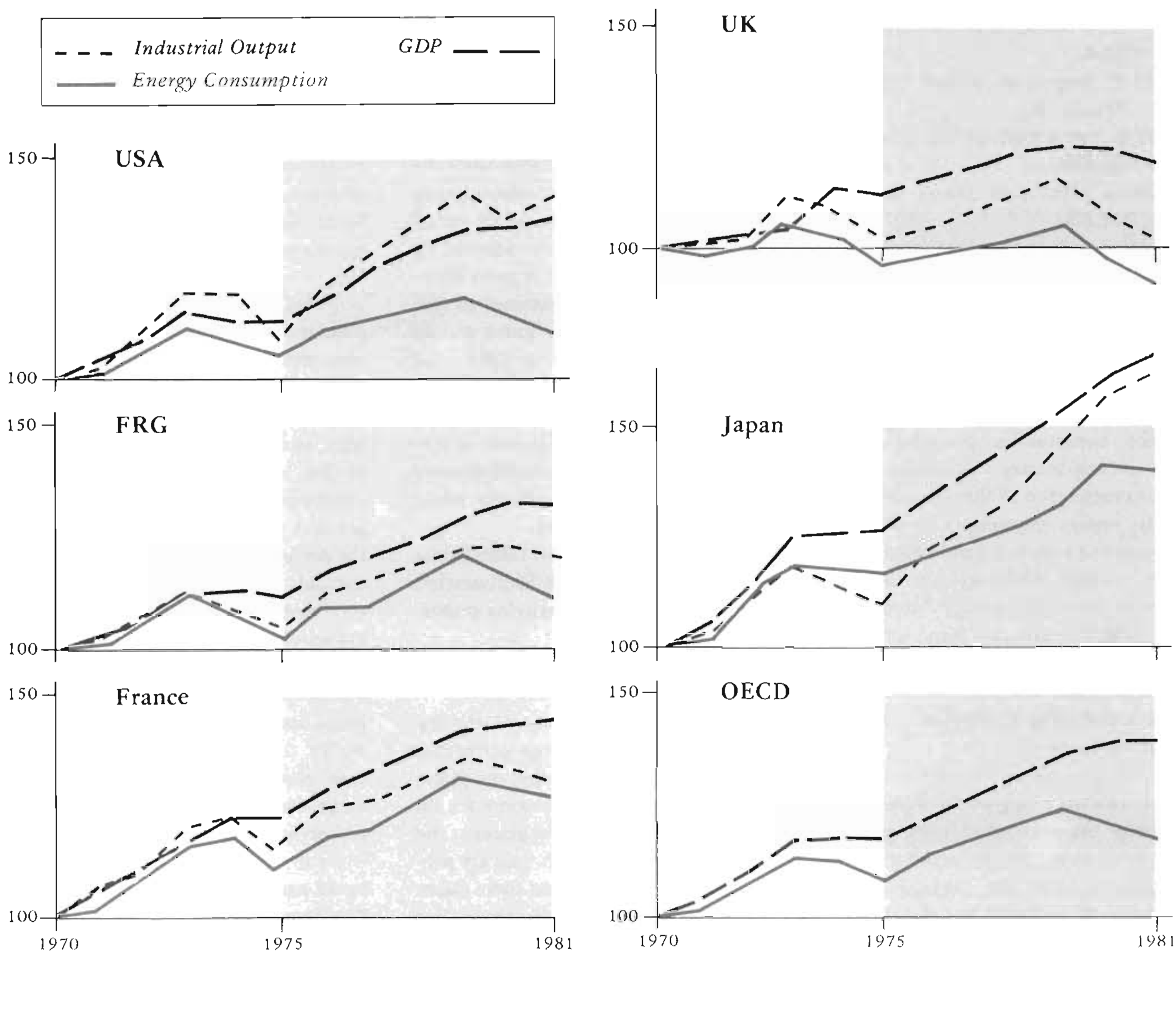
50.0 percentage points in the USA
24.0 percentage points in the FRG
39.3 percentage points in France
66.2 percentage points in the UK.

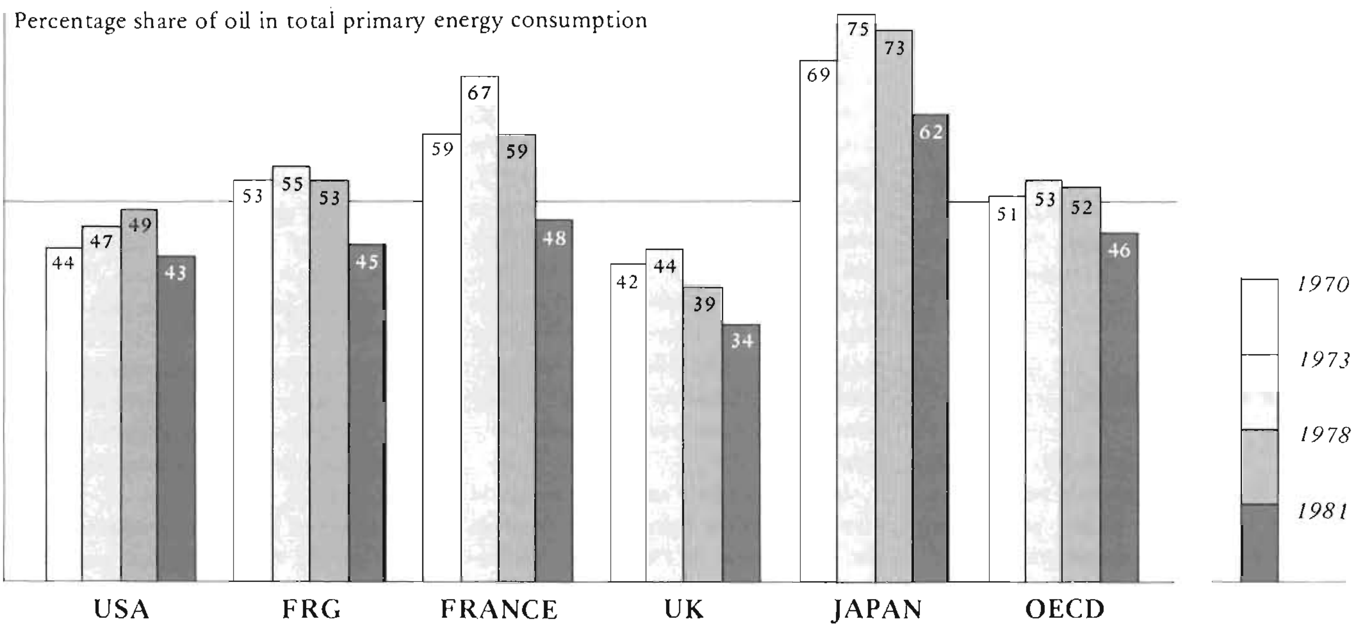
Crude steel production reached its high for the 1970s in the USA in 1973, with an increase of nearly 15 percent over the 1970 output. In 1974, French and German crude steel production peaked with 16 percent and 19 percent respectively. The German steel recovery in 1979 that had lifted total primary energy consumption through steel-related coal requirements was only short-lived.

In 1980 French and German crude steel production figures were back at the 1970 levels; in 1981, they fell further to 10 percent and 5 percent respectively below the 1970 levels. The UK, the country with the largest drop in energy consumption, hit another low in 1980 when crude steel production dropped to 41 percent of that of 1976. In 1981 UK output fell further to only 38 percent of the 1970 level.

In contrast to steel, aluminum is a younger, more growth-oriented industry. Output was rising through most of the 1970s, especially in the UK, where the industry was developed practically from scratch with the help of North Sea oil and gas. Aluminum also showed considerable growth in the FRG, but its rise was not as spectacular as that in the UK since it started from a broader base in 1970. In all four countries, 1981 output of primary aluminum was above that of 1970.

However, in the USA, where 75 percent of the four countries' combined primary aluminum was produced, the industry's growth was behind that of total national production, as measured on the 1970 = 100 based indices. The same was true in France.






In comparison with the 1981 national index of total industrial production, the primary aluminum industry was

- 17.2 percentage points below in the USA,
- 15.8 percentage points below in France, but
- 11.5 percentage points above in the FRG,
- 741.0 percentage points above in the UK.

"Obviously the lagging growth of US aluminum explains much of the USA's energy conservation," according to Dr. Doblin. "In all four countries, more conservation of energy in the industry sector may be in store with a number of energy-intensive industries – for instance, automobiles, petroleum refining, and coal mining – curtailing output as a consequence of the decrease in national energy consumption. With the automobile industry's and other industries' output declining for the first time in Japan, the energy "savings" in the OECD total also stand to make further gains.

## The Lessening of the Oil Dependency

At the beginning of the decade, the growing share of oil in total primary energy consumption reflected the long-running trend of the displacement of coal by oil (and gas) and the strongly growing demand for gasoline. After the short-lived drop of total energy consumption in 1974–1975 caused by the recession, oil demand, the oil dependency, and total energy consumption in the USA continued to grow through 1978 – for as long as nearly half a decade after the first oil price explosion. A gradual loosening of the USA oil dependency started in 1979 with the dramatic fall in gasoline consumption and recession-caused cuts in the use of other petroleum products, notably by the industry sector. In the three European countries the lessening of the oil dependency occurred much sooner than in the USA, coming right after the first oil price hikes. This was despite the fact that gasoline demand was as quick to resume growth at pre-energy-crisis rates as in the USA, since oil in households and industry could be replaced by natural gas.

The oil dependency has fallen below the 1970 level in all OECD countries, as shown in the accompanying graphs.

## Fuel Switches

Dr. Doblin's analysis shows that the various energy commodities' prices rose at different rates. Generally, the prices of gasoline, electricity, and household gas rose much less than the prices of the mineral fuels from which they are processed. Within the mineral fuels themselves, price rises were also uneven. For instance, in the USA and the UK, coal prices rose far less than prices of petroleum products used by industry, while in the FRG and France prices of coal and petroleum products used by industry rose at about the same rate. In the USA the price of natural gas used by industry rose even more than the price of petroleum products. This also occurred in the French industrial sector, whereas in the UK, because of their North Sea fields, the price of natural gas increased less than that of any other fuel.

"This uneven price growth does explain the changes in fuel preferences to some extent," she notes. Electricity and natural gas replaced oil in the industry sectors of the three European countries, as it did in the household sectors of the Europeans and the USA. The relatively cheaper prices of household gas and electricity, particularly during the period between the oil price shocks, not only made them substitutes for oil and coal, but greatly increased total household energy demand. This explains to some extent why, especially during the intershock period, the Europeans had a higher growth in household energy consumption than the USA, even though population was at near stagnation level in the FRG and the UK and grew only by 6 percent in France, while in the USA population increased by 12 percent between 1970 and 1981. The result of this uneven growth of energy demand can be seen below:

1981 Energy Consumption

| | |
|---|---|
| *Industry sector* | |
| USA | 10% below 1970 |
| FRG | 7% below 1970 |
| France | 10% above 1970 |
| UK | 26% below 1970 |
| *Household sector* | |
| USA | 8% above 1970 |
| FRG | 8% above 1970 |
| France | 29% above 1970 |
| UK | 8% above 1970 |

The absence of savings and the amazing growth of the household sector's demand for energy as compared with industry in the FRG, France, and the UK reflects the changes toward energy-intensive households that occurred over the last decade: preferences for modern apartments; splitting of households into smaller units; progressive motorization and electrification of appliances and heating. Some of these structural changes had already run their course in the USA.

A particular incentive for fuel switches in the French household sector was the intensive electrification campaign run in 1975, while in the UK there was abundant and relatively cheap natural gas to displace oil and coal demand.

"From the beginning to the end of the 1970s, sales of household electricity almost doubled in the FRG and trebled in France," Dr. Doblin found. "Relatively slow-rising prices certainly helped."

The situation in USA households was somewhat different, since they started the decade with a more advanced base than the Europeans. There "the more slowly rising prices of household gas induced homeowners to switch from oil to gas, until 1979 when household gas itself also became subject to horrendous price rises, and the switch from oil to gas caused householders pain." But Dr. Doblin states, "it does seem that the USA household sector *did* come up with actual savings in total final energy consumption."

## Road Transport

"Despite the fact that consumers were conscious of the energy crisis, there was no conservation in the inter-shock period when gasoline demand resumed annual growth at pre-crisis rates," Dr. Doblin points out. "Now gasoline demand has fallen, curbed by price rises that coincide with adverse business conditions and soaring unemployment."

In the years between the oil price explosions, the *current* prices of gasoline at the pump, tax included, rose less than that of any other energy commodity. In terms of *inflation-adjusted* prices, they tended to stagnate or even decline slightly.

Gasoline demand in 1981 in the USA – the main factor in total primary oil consumption – had slid below the level of 1973 and 1975, but it was still above the 1970 level. In the three European countries, cuts in gasoline consumption took longer to emerge. Drops occurred in 1981 in the FRG and in the UK, but French gasoline purchases were still showing a slight increase. Stagnation in gasoline demand may have occurred in all four countries during the first half of 1982 but the complete statistics are not yet available.

Some explanation for the relatively slow rise of gasoline prices before 1979 may be due to the fact that gasoline taxes were also slow to rise as, for example, in the USA, where the Federal tax on gasoline did not increase at all between 1970 and 1978 (staying at 4.0 cents per gallon or 1.06 cents per liter) and State taxes increased only very little (from 1.85 cents to 2.06 cents per liter); thus the tax bite on gasoline eroded from 31 percent in 1970 to 19 percent in 1978, calculated on a *current* price per liter, tax included, as 9.50 cents in 1970 and 16.52 cents in 1978.

In the European countries gasoline is taxed more heavily, which partly explains why it is so much more expensive than in the USA. Between 1970 and 1978 gasoline taxes were rising, not by 7 percent as in the USA, but by 13 percent in the FRG, 14 percent in the UK and 17 percent in France. Since current gasoline prices increased far more than that, the tax bite eroded as in the USA, albeit at a higher level between 1970 and 1978: from 72 percent to 61 percent in the FRG, 73 percent to 44 percent in the UK, and 74 percent to 56 percent in France.

Dr. Doblin foresees "a continued lowered gasoline consumption in the USA and the three European countries for the short term. This should help to further reduce total petroleum and total energy consumption in the four countries, as will the development of more fuel-efficient automobiles."

## Outlook

Dr. Doblin is not optimistic when asked about the future. "Total primary energy consumption, particularly oil and gas, is slated to remain at low levels – as long as industrial output is depressed and unemployment remains high.'

"What is frightening is that lowered energy consumption and slightly dwindling oil prices are being taken as a signal that the energy crisis is over."

Her pessimism stems from the fact that "a short-term oil glut and lack of investment funds in depression-ridden economies has stopped the admittedly costly development of nonconventional energy resources, including synfuels, tar sands, shale oils, etc. Efforts to improve technological efficiency (with some exceptions) are delayed for much the same reasons, since they now look economically unattractive."

"When – if – the long-hoped-for recovery comes about, regardless of a new onslaught of current and inflation-adjusted energy prices, consumption is due to rise again," Dr. Doblin explains. "This new demand for energy, coupled with our neglected development of alternative energy sources and supplies and the neglected development of true energy conservation, may lead to a renewed, and possibly more acute, energy crisis, with obvious negative implications for the world's economy."

**Roberta Yared**

Claire Doblin's statistical compilations are available in Doblin, *The Growth of Energy Consumption and Prices in the USA, FRG, France, and the UK, 1950 to 1980*, RR-82-18, US$10.00, available from IIASA. This work was undertaken as part of the IIASA Energy Program's global analysis. Dr. Doblin worked with the Research and Analysis Branch of the US Department of State and the Economic and Social Affairs Department of the United Nations before joining IIASA in 1975.

# Describing the Human Economy

Taking current economic theory to task for neglecting the realities of human life, IIASA Guest Scholar **Maria Augusztinovics** outlines a descriptive framework that incorporates important nonmarket economic activities.

Economics has always been fascinated with the market: rightly so, since the market is the most amazing product of human economic activity. It has made the economy the master with man its defenseless servant; it has come to exercise a power beyond and above human will. It helped create the modern nation, and it is now in the process of creating a supranational system of forces above and beyond national will.

However, economic activity has not been completely absorbed by the market – at least not yet. The existence of nonmarket economic activity is an established fact in developed capitalist and socialist economies as well as in the Third World. It is also a fact ignored by all major schools of economic theory.

What is perhaps worse is that nonmarket economic activity is also neglected, with some inconsistent compromises, in the empirical evidence available, such as the System of National Accounts. Some of the consequences are well known and much discussed. Let us speak of just two examples of great significance.

The first is the production of goods and services within households, with all its economic and social implications. As John Kenneth Galbraith has noted: "The common reality is that the modern household involves a simple but highly important division of labor ... the servant-wife is available, democratically, to almost the entire present male population. Were the workers so employed subject to pecuniary compensation, they would be by far the largest single category in the labor force."

The second example is the subsistence sector in developing countries. For instance, it is highly important for a country to be classified as "least developed" by the United Nations since this category is entitled to preferential treatment in various matters, such as the distribution of official development aid. The major criterion for such an identification is an upper limit of per capita GDP (Gross Domestic Product – Gross National Product in the USA). Recently, however, a UN study pointed out that this criterion cannot be applied in cases where the economy is highly monetized since this "accounts for a higher nominal per capita GDP than in countries which have large subsistence sectors insofar as in these countries income generated in the subsistence sector is not fully reflected in monetary GDP."

It is important to note that nonmarket activity should not be confused with what is usually called the "second" or "black" or "underground" economy, which *is* market activity, only tax evading and therefore (and sometimes also for other reasons) illegal. The nonmarket economic activity discussed here is performed within socioeconomic units, not between units. On the other hand, the market is more than just the place where things are exchanged. Throughout this article the term "market economy" is used in its broad sense, to include the monetary and financial superstructure, and income redistribution through national and local budgets (what Kenneth Boulding calls the "grant economy"): everything that goes with the modern market which created modern money.

## Enlarging the Scope of Economics

Economic literature of the past five to ten years seems to be so aware of and so concerned with the unsatisfactory performance of economic theory that it could justly be called "crisis literature". One can even get the discouraging impression that economists spend more time thinking about other economists than about the economy. The profession appears to be divided along as many lines as it has ever been, but an encouraging trend is becoming evident: a common, almost general wish to let in some fresh air, to enlarge the scope of economic theory.

In some cases this is just a matter of making room for something that should always have been there: for example, including money in economic theory, or the interaction between distribution and efficiency. In many cases it is about rediscovering matters that were once dealt with in the classical tradition but have been forgotten or neglected, such as the distribution of income, wealth, and power in society: that is, returning to the classical political economy from the contemporary would-be "value-free" economics. Some economists speak explicitly of political economy, but we also find "institutional economics", "instrumental economics", "interpretative theory", "social economics", "economic sociology", and even "integrated social science". The trend seems to be clear, although a name has yet to be found.

There are, however, also attempts to bring in something that has never been there, to enlarge the scope of economics as such, not just the scope of this or that theory. In most cases these attempts point in the same direction: to social issues beyond the political superstructure, to the human aspects of economy.

Within this stream there is even a world turned upside down: there have been serious attempts to explain love and hate in terms of marginal utility. Naturally, most of the work is the other way round; for example, explaining consumer behavior in terms of human psychology is certainly a much more promising idea. Nevertheless, one need not go as far as psychology to look for territories that at present lie beyond the bounds of conventional economics and that will have to be incorporated into the main body of a future, more meaningful economic theory.

Some economic thinking and formal model building has started to include the economic aspects of human life.

Dr. Maria Augusztinovics

The term "human capital" had already gained some respect in better times, when society was educating more and more young people to higher levels. Recently, with the increasing number of elderly people and with permanent inflation, the social security system has become the first area where the historically unprecedented interdependence between the human life-cycle and the financial superstructure can no longer be ignored.

Indeed, there are now so many promising beginnings that one is inclined to wonder: has the time come for a new synthesis? The correct answer would probably be, "no, not yet." Before this is possible, at least two fields of outstanding significance would have to be covered systematically. One is the nonmarket economy such as the household, the own-account production and consumption on farms, the subsistence sector in developing countries. The other is the human life-path: more precisely, its economic implications, including the need for child care, education, health services, and so on. Today even the broadest economic theory in the conventional sense assumes that human labor appears from nowhere, and human consumption disappears to nowhere. These two ends will have to be conceptually connected through the human life-path, which is itself the source and the purpose of the human economy.

These two fields are interrelated in many ways. Obviously, people do live in some kind of socioeconomic unit — a family household or a tribal village, for instance — that has traditionally been the setting for economic activity, production and consumption as well. No matter how much of this activity entered the interunit division of labor through the market, much of it remained within the basic unit. Nonmarket economic activity (in other words, intraunit economic activity) is mostly, although not exclusively, connected with the needs of human life. Most of the "family tasks" devoted, for example, to the care of children, the sick, and the elderly, have no connection with the market.

This interrelation is one of the reasons why the economic aspects of the human life-path have to be incorporated into economics. A further reason is the fact that with increasing life expectancy, the human being is more and more becoming the longest lasting economic asset — and surely one of the most expensive. In 1703, 0.6 percent of the population of New York City were sixty years old or more; today this figure is around or well above 20 percent in most industrialized countries. A human lifespan of seventy to eighty years or even more is becoming a major factor in long-term economic dynamics. [A new IIASA project will investigate the socioeconomic aspects of ageing populations.]

Performance provided and consumption absorbed are not distributed in a parallel manner along the human life-path. If we include nonmarket performance, the distinction between "active" and "nonactive" ages will not be as rigid as it seems to be now, but it still remains true that in the first and last periods of life a person absorbs more of the labor (goods and services) provided by other members of society than he himself provides. In between these times of life, he has to provide more than he consumes.

What are the ratios between these periods of life, the ratios between performance and consumption within each period, the corresponding figures for various classes and other social groups? How will they change, and how should they change for society to be able to maintain balanced survival and progress when life expectancy increases and the age distribution of the population is in permanent transformation?

These are not "soft" psychological or moral or emotional problems; they are "hard" economic questions. It is impossible to answer them without extending economic theory into the economic aspects of human life. Of course, we shall have to be careful. While economics will have to consider the cumulated lifetime consumption and performance of human beings, it will have to make it absolutely clear that this is not in itself a basis for social values or moral judgments. Neither a high nor a low performance-to-consumption ratio in itself makes a person more respectable or valuable to society.

It is also clear that these and similar questions cannot be answered by picking a few phenomena and constructing "human life economy" models: the nonmarket economy cannot be understood without considering its interaction with the market. Everything goes together, and before their interrelationship can be understood they have to be described. This brings us to the problem of methodology.

## On Methodology

Nowadays, it is fashionable to attack economic models — the small, theoretical ones for being small and abstract; the large, numerical ones for being large and empirical; and both types for being irrelevant. Some kind of antiquantitative mysticism is even becoming a sign of fashionable scholarly thinking.

It is high time to draw the lines between the concept of a model, the economic content or assumptions of particular models, and the role of mathematical tools. No science can exist without models, formalized or not, simply because reality cannot be perceived in its entirety. (Those who speak against models think in terms of models themselves, only they do not bother to specify their assumptions.) The actual content of a model is another matter. If some models are unrealistic or irrelevant, it is not because they are models but because their particular assumptions are unrealistic and their theory concerns itself with irrelevant questions.

Finally, mathematics, as we all know, is a bad master but a good servant. To subordinate the subject matter to the mathematical form, to introduce impossible assumptions in order to be able to use available techniques or to reach an elegant solution: that is really an unforgivable sin in economics. As long as one does not commit this sin, the formal presentation of a model contributes to clarity, enforces intellectual discipline, and helps to specify the underlying assumptions. This is useful even if it turns out that there is no solution to the particular mathematical problem, or rather that it cannot be handled with the mathematical tools presently available. If the problem is relevant and the formulation is precise, mathematics will have to – and will be able to – develop appropriate tools sooner or later.

The crucial problem of economic methodology is not in model building, but elsewhere. The most important thing to do would be to separate assumptions clearly from the observed or observable facts – and this is often ignored. Obviously, no theory can exist without assumptions for the same reason that science cannot exist without models. But science and theory are not identical. Science also has to deal with facts, to observe them, to describe them, to analyze them – and only then comes the theory, based on assumptions, to explain the whys and wherefores. Assumptions should be distinguished from observations.

These ideas are not widely recognized in economics. On the contrary, an interest in the facts of economic reality is often regarded as narrow-mindedness, both in academic life and in economic policy making. This attitude says that only simpletons busy themselves with "accounting models". Modest attempts to enforce elementary consistency in plan computations have been called "plan book-keeping", an insult rather than a compliment. The chief economist of the OECD, Sylvia Ostry, has been criticized for "always digging deeper into the details and the broader implications of economic policy." (Her response: "... I am increasingly skeptical about the ability of the parapoliticians to make effective decisions.")

The point to be made here is that to distinguish between assumptions and observations we need a framework to describe facts, and this framework must be not only consistent but also comprehensive. (I should gladly say "total" if this word did not carry overtones to which most economists are hostile.)

The most implicit, and usually the most crucial, assumptions concern not what the theory or the model is about, but what it is not about. Obviously, no theory or model can be about everything, but it should always be made absolutely clear what is neglected. We cannot ask for a list of all the matters not considered at the beginning of every paper: the list would be longer than the paper itself. What we need is a comprehensive descriptive framework as a commonly accepted background.

If such a framework could be generally adopted, and if following it were a moral and scientific obligation as strong, for instance, as proving a theorem in mathematics, then I believe economics as a science would greatly benefit – might we say it would graduate?

## The Human Economy

Such a descriptive framework cannot easily be prescribed. Its development would take time and interdisciplinary effort; by definition it would never be finalized since the economy is ever-changing, and changes would have to be reflected in any framework that is to describe economic facts. A few basic requirements for comprehensiveness can be pointed out, however.

- A comprehensive descriptive framework should cover the economy as a whole, including the nonmarket and "human life" economy. It should account for production and consumption, exchange and income transfer, money and finance.
- Such a framework should be able to account for duality in the human economy: the interaction between man and nature on the one hand (the physical aspect) and between man and man on the other hand (the social aspect).
- The framework should place economic activities in time. It should accommodate both stocks and flows, "statics" and "dynamics".
- Finally, a comprehensive descriptive framework should describe the economy as a system, to show the interaction and interdependence between the various sets of agents and events.

A few basic notions (components) of such a framework can also be pointed out. The term duality as used here refers back to the classical tradition of political economy as having both a technological (man/nature) and a social (man/man) aspect. This basic duality leads to various "sub-dualities", and is reflected in diverse ways in economic theory and practice. One such duality that needs to be taken into account in a comprehensive descriptive framework is the asset–equity duality. The essence of this is that any economic object is not either an asset or an equity but is simultaneously both from different points of view. The asset aspect tells us what economic objects are: their physical form if they are tangible assets such as fixed capital (buildings, machines, etc.) or inventories (raw materials, unfinished goods, etc.); their legal and income-providing characteristics if they are financial assets such as deposits, bonds, shares, etc. The equity aspect gives a different breakdown of the total value of all assets: it tells us about the source of that value in terms of property or claiming rights. Part or all of the total value may be unconditionally owned by a given economic unit: this part is termed property. Another part may be lent by outside creditors under various conditions: these are financial liabilities. The basic equation of duality is that the total value of assets is equal to the total sum of equities.

A flow is an event or transaction that simultaneously affects two stocks – a stock being the value of the existing amount of a given economic object at a given instant of time. For most economists the term flow will instinctively convey the notion of transition: a flow of products, incomes, or funds is coming from somewhere and going to somewhere else; one stock is decreased and another is increased. The physicist or mathematician will immediately think in terms of a transition matrix: some particle flows – transits – from one state to another. The accountant, however, is familiar with transactions that increase both assets and equities simultaneously while nothing gets decreased, or that reduce both at the same time while nothing increases.

There is nothing mysterious about this. Dual-increase flows, in which both asset and equity increase, represent nothing other than the notion of economic growth. If the increase of one asset necessarily required the decrease of another, the total value of assets would never grow and the economy could never expand. Dual-decrease flows represent, for instance, loss and damage due to fire, flood, or negligence (if a house burns down, both asset and equity perish). Thus dual-increase and dual-decrease flows are not mere book-keeping technicalities but facts of life. Without them the dynamic process of economic growth cannot be properly described, since transitions alone can only alter the structure of a system; they cannot make it expand or contract.

Double-entry book-keeping, invented in the Middle Ages by practical-minded Italian merchants, provides an ingenious means of dealing with dual-increase and dual-decrease flows, as well as transitory flows, in a single unified framework. The device is as follows: the relation of assets and equities to increase and decrease is reversed. Thus only two different kinds of entries are needed to describe four types of flows and their impacts on stocks: a debit entry represents an increase in the case of an asset and a decrease in the case of an equity; a credit entry represents a decrease in the case of an asset and an increase in the case of an equity. It can be represented as follows:

| | Stock to be given: *Credit* | *Debit* |
|---|---|---|
| Transitory flow (assets) | asset ↓ | asset ↑ |
| Transitory flow (equities) | equity ↑ | equity ↓ |
| Dual-increase | asset ↑ | equity ↑ |
| Dual-decrease | asset ↓ | equity ↓ |

The arrow pointing upward represents an increase, and the arrow pointing downward represents a decrease. We can make use of the basic equation in book-keeping — that opening stocks plus incoming flows minus outgoing flows equals closing stocks. We can use a few other clever devices of book-keeping, but we can abandon the tiresome procedure of keeping separate records for each stock and having to account twice for each flow if we adopt the more convenient flow matrix notation.

These are all existing, well-known techniques, although they have not yet found their way into economic theory. (A self-respecting economic theorist would seldom go anywhere near double-entry book-keeping.) The new task is to incorporate the "human-life economy" into this framework. For this purpose the most plausible way would probably be to define human assets as the value of cumulated lifetime consumption by human beings alive, and human equities as the value of cumulated lifetime labor performed by human beings alive.

Thus far we have made no assumptions. We have derived some key concepts from the reality of everyday economic life, and selected a convenient frame for recording observable facts. But the indirect, endless circular interdependences of the "human economy" we are interested in cannot be directly observed and therefore cannot be recorded in a strictly descriptive framework. They can only be established if we make certain assumptions. At this point our framework ceases to be strictly descriptive and tends to become a model. By keeping mainly with the facts and applying as few, and as plausible, assumptions as possible, we can go on to develop an analytical tool or model, as distinct from a theoretical or a predictive (forecasting) model. This crudely outlined framework and a simple but powerful analytical technique of symmetric handling of input coefficients and output coefficients make it possible to define the matrices whose entries represent the total (direct plus indirect) effects of each variable on every other variable. These matrices contribute to our understanding of the indirect, circular interdependences within the real, human economy, providing a basis, one hopes, for further explorations.

Further elaboration of Dr. Augusztinovics's thinking and her descriptive model can be found in her paper *Describing the Human Economy*, available from IIASA. Head of Department at the National Planning Office of Hungary, she has been Vice-Chairman of the Committee for Development Planning of the United Nations since 1978.

# Evolving Theories of Water Pollution Control

**Bruce Beck** argues that, as in many other fields today, water pollution control should take advantage of new approaches as well as new technologies. He offers his view of what water quality management policy might become.

Water pollution control is such a practical, humble subject that one would not expect to find it unduly burdened with theory – nor is it. But if there has actually been a theory of water pollution control, it might have been caricatured (for the purposes of argument here) as a one-dimensional, static, and linear theory: one-dimensional in the sense that one type of pollution problem has been tackled at a time; static in the sense that, given today's average equilibrium level of water quality, the question has been what future average equilibrium quality could be achieved by spending a certain amount of money; and linear in the sense that wastes may receive preliminary treatment and then primary treatment, followed by secondary and tertiary treatments.

If this theory has matched and satisfied practical requirements up to the present, what of the future? Can one even speculate about a new theory – for example, a multidimensional, dynamic, nonlinear theory? One could so speculate simply by examining the succession and dynamics of change in the problems, economics, and technologies of managing water quality over the past two decades and by making extrapolations of these changes into the next two decades.

## Accelerating Problem Succession

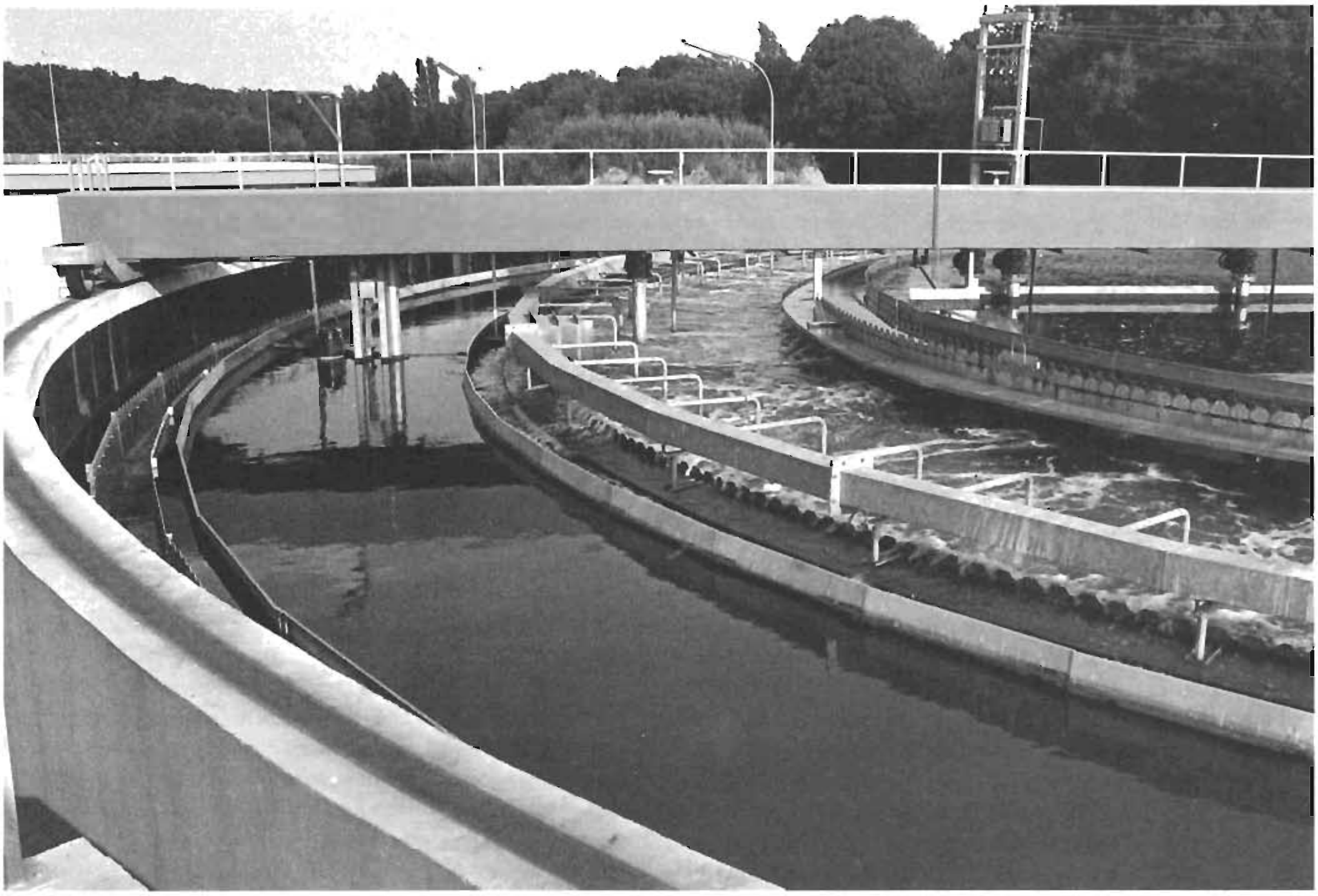
To begin with, there is the transition from one problem to many problems. The classical postwar problem of river pollution control in populous, industrialized regions has been to manage easily degradable organic wastes, a problem that itself succeeded an earlier concern with pathogenic pollution. For lakes, eutrophication has become the classical problem – the artificial acceleration of a natural ageing process due to the excessive discharge of nutrient materials (nitrogen and phosphorus) into the lake. Neoclassical problems have emerged from the shadows of these classical problems. The nitrate problem, partly created by the success of measures taken to control the problem of easily degradable organic wastes, is now thought to be critically important. At the same time, the ability to exercise increasing control over point-source polluting discharges – such as the well-defined discharges from wastewater treatment plants – has revealed a rising profile of nonpoint-source discharges, typically the not-so-well-defined discharges from urban storm runoff or the fertilizer-rich runoff from agricultural land. And so we have a nonpoint problem. Yet almost before there has been time to map the contours of these neoclassical problems, we have been overtaken by the frenzied rise to significance of the, at the moment, modern problem of toxic substances.

It would be convenient if the evolving character of water pollution problems were to remain one-dimensional at any point in time and space – presenting one independent problem at a time. One can see that the early use of ever more distant clean water supplies for the industrial cities of England was, fifty to a hundred years ago, a convenient and economical way of keeping separate the problems of water supply and waste disposal. But such an "expanding universe" theory clearly cannot progress beyond certain limits. Inevitably there is a point at which the growing number of activities using water resources in a region are constrained and must turn in upon themselves; the country of Israel and the Thames river basin in the UK both present examples well along the scale of intensively used water resource systems. Spatial and quantitative limitations are not the only constraints, however; we recognize that all the past and present problems exist now – to a greater or lesser degree they all occur simultaneously in any given region. Taken together they are multivariable and with this emerges the intrinsic importance of interactions: interactions among the problems, the strategic thinking about their solution, and the engineering facilities installed for their control. How many problems there are is not so important. Rather, the critical question is how significant are the interactions, both those to our advantage and those to our disadvantage.

## Equilibria and Oscillations

Secondly, there is the transition from static to shorter-term dynamic considerations, quite apart from the longer-term dynamics of problem succession. Over the past two decades water pollution control has been interpreted as a curative strategy. The key objective was simply to install sufficient capacity to treat a greater proportion of the wastes produced – and there may well be a growing awareness among the public that where such action has been taken water quality has improved. When a cure for the ills of the past is successful, it engenders, precisely because of its success, a growing responsibility to avert the problems of the future: especially so if the problems arising are more easily seen to be bad against the much-improved background conditions.

The problems of water pollution control do not simply shift or alter the focus of attention from one category of pollutants to another. The changes are more subtle, of a more structural character. Because of past success in management, there is now a greater responsibility to prevent failures in the system of pollution control. A greater number of sophisticated treatment facilities need to be operated in order to maintain the control effort, and any failure will be much more immediately apparent and more damaging. A transient pollution event, such as a spill of



Martin Schobel

hazardous chemicals, will be readily noticed in a river restored to good average quality. In an intensively used water resource system with many interacting elements, a failure in one component is much more likely to affect adversely the performance of other parts of the system. Ironically, it is as though water quality management has created for itself quantitative hydrology's classic problem of the flood. What is of concern is not merely the average equilibrium water quality to be achieved in the future but also the probabilities and magnitudes of fluctuations about this equilibrium level. In this sense, the problem changes are changes of a structural kind.

Control of both equilibria and oscillations may have to be developed jointly. For example, the near-term prospect of transient violations, and the longer-term prospect of persistent violation of the World Health Organization's (WHO) standards for nitrate concentrations in rivers used for supplying drinking water, as in the Thames, indicate the need for such an approach. For other problems there is a more distinct separation of concerns for the longer-term equilibria and shorter-term oscillations. The steady discharge of a toxic substance in very small quantities over a number of years, and its eventual static equilibrium distribution in an aquatic food chain, is an essentially different problem of management from the sudden accidental spillage of a large quantity of the same substance in a matter of minutes.

## Reorienting the Linear View

Thirdly, what can be said of the differences between linearity and nonlinearity? The design of a wastewater treatment plant reflects rather accurately the succession of pollution problems perceived in a one-dimensional and linear way. Primary treatment removes the grosser aspects of pollution in an essentially physical manner; secondary (biological) treatment broadly attacks the easily degradable organic wastes; and tertiary (often chemical) treatment is used to tackle more specific problems associated with removing and modifying pollutants; for example, important phosphorus-bearing substances. Given our insatiable appetite for discovering new problems, fueled partly by technological innovation (as we shall see in what follows), will tertiary treatment be followed by quaternary and quinary treatment stages, and so on? The strangeness of these adjectives – even their misuse – discourages thoughts of such a linear progression.

If, over the past two decades and in certain regions, the capacity installed for wastewater treatment has become sufficient, the important questions in the future for water quality management will center less on determining how much more of the waste to treat and more on how to treat it differently. It will not be predominantly a matter of beginning with entirely new facilities, of adding new processes, but rather a matter of adapting an existing infrastructure. The change from linearity to nonlinearity is significantly conceptual, not literal or mathematical: no one is suggesting with such a theory that wastewater treatment plants should be built backwards, in a circle, or laterally.

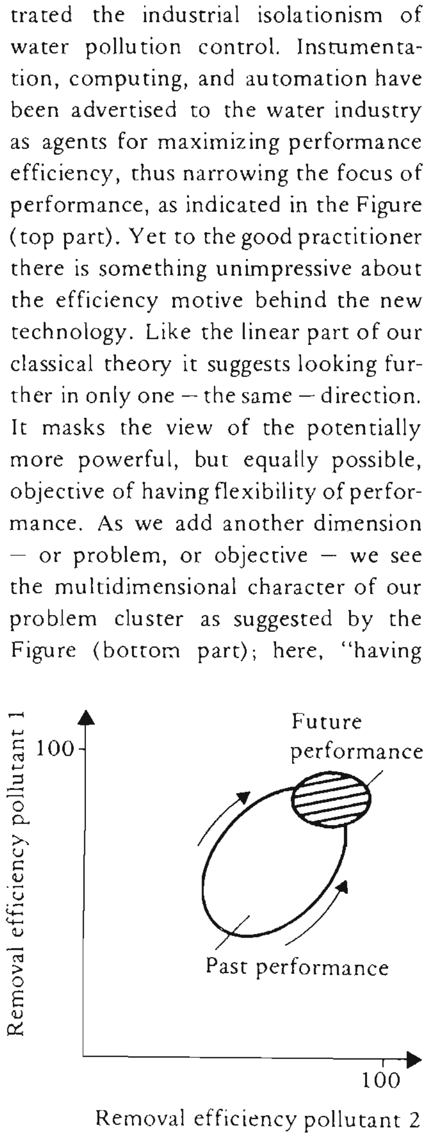
But the kind of tunnel vision that sees one problem to be solved at the end of the line should be repudiated. The problems lie one to another in a different plane. The elementary reorientation produced by introducing feedforward and feedback is suggestive of what is sought, not only in the obvious engineering sense, but also as reflected in the succession of problems. What new insights do the solutions of the modern problems hold for changing solutions to the classical problems?

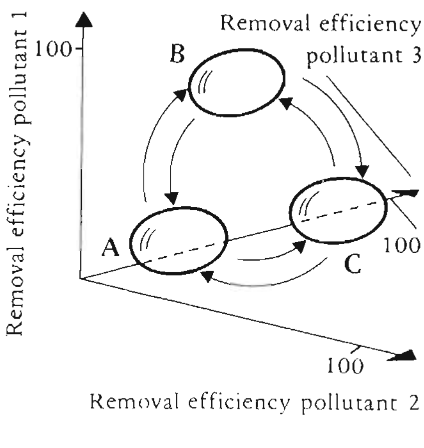
## Implications for Efficiency, Economics, and Technology

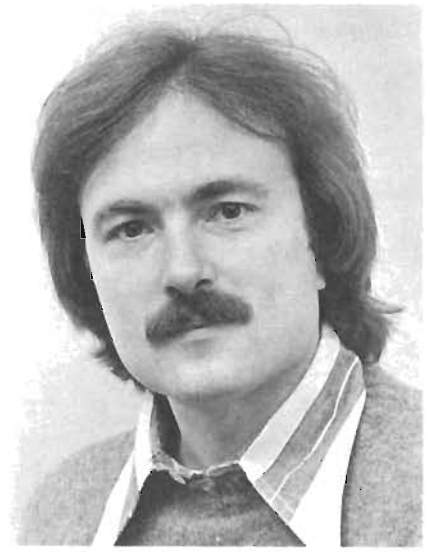
Our new theory states that nothing remains constant with time, because different problems emerge to join the problems already existing, and among this growing cluster of ever-present problems individual problems rise and fall from time to time in requiring priority of control action. Put grandly, there are important implications for technological innovation, and significant challenges to conventional views of the associated economics and notions of efficiency. Put humbly, there will be changes down at the sewage treatment plant.

For instance, it would clearly be inefficient to redesign and rebuild wastewater treatment facilities (and impossible to match the attitude of mind this betrays) every time a new problem is perceived when there is a cluster of problems having variable operational priorities. Meeting these changes of priority in an operational sense, let alone adapting to problem succession in the long term, requires an appropriate economic framework that can accommodate cost variability as a function of performance efficiency. When more than one type of pollutant must be removed, not all pollutants can be removed at maximum efficiency, and trade-offs among operations at less-than-maximum efficiencies must be evaluated. But such a framework for analysis is barely discernible at present – and not surprisingly so. Convention has it that treatment processes are operated at fixed and supposedly maximum efficiencies, because technically they cannot be operated otherwise, and because there has been no economic or legal incentive to design them for operating in any other way; thus there is no means of starting the new economic analysis from the record of the past.

A rigid conceptual view of the past can limit the vision of what ought to be expected of future technological innovation. The electronic age has penetrated the industrial isolationism of water pollution control. Instumentation, computing, and automation have been advertised to the water industry as agents for maximizing performance efficiency, thus narrowing the focus of performance, as indicated in the Figure (top part). Yet to the good practitioner there is something unimpressive about the efficiency motive behind the new technology. Like the linear part of our classical theory it suggests looking further in only one – the same – direction. It masks the view of the potentially more powerful, but equally possible, objective of having flexibility of performance. As we add another dimension – or problem, or objective – we see the multidimensional character of our problem cluster as suggested by the Figure (bottom part); here, "having more of the same" is complemented by "having something of the other." With multiple interacting problems, and with priorities shifting from time to time, the capacity to change performance from one domain to another – domains in which some pollutants are removed at less-than-maximum efficiency (as with A, B, and C in the bottom part of the Figure) – is the more relevant aspect of the innovative potential of electronic engineering equipment in operational water pollution control.



**Dr. Bruce Beck**

From a macroscopic viewpoint that keeps practical details in perspective, any theory of control tells us that there should be a reasonable overall degree of balance between a management system's capacity to observe and its capacity to act. There is little point in taking finely honed control actions if their effects on the response of the system can only be measured crudely. Equally, the sophisticated resolving power of a monitoring network is ultimately only as useful as the sophistication of the management actions that can be taken. So far, the predominant influence of electronic engineering innovations in the water industry has been to improve the capacity to observe. Indeed, it promises to be a profound influence as well: measuring more things, more frequently, at ever smaller concentrations, creates conditions ripe for an explosive growth in the number of problems perceived. We may therefore be approaching a situation in which management will be able to observe in splendid detail what is going wrong with the system, but will be powerless to take corrective action. An improving and expanding capacity to act depends much more on innovations in chemical and biochemical engineering.

It is thus not in vain that one asks whether the water industry can benefit from the advances in genetic engineering, with microorganisms tailored to remove specific pollutants. Such a necessary and delightful-sounding marriage between computer "chips" and genetically engineered "bugs," if our theory is correct, puts the humble sewage treatment plant of the future strangely close to two of today's most respectable and fastest-growing technologies.

## Theory Behind Practice

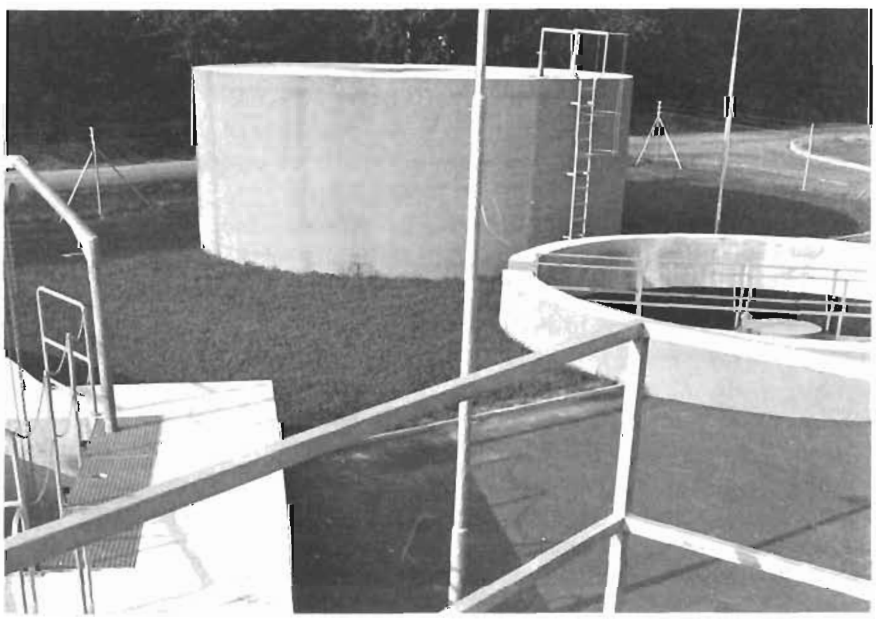
The theory presented here is neither a blueprint for solving all problems nor a framework through which all problems must be forced. It is too general to be a recipe for specific actions in specific situations. It is both an interpretation, open to close scrutiny, argument, and improvement, and a catalyst: a backdrop against which actual problem solving is to take place.

What our theory needs most is a testing case study, one that arises quite naturally to facilitate the opportune union of the right problem and the right approach. This will therefore be not just any case study, but one that satisfies quite a specific set of prerequisites, not the least important of which will be a unique convergence of technology, economics, and individuals. A menu of prerequisites can be easily prepared: the regional water resource system will be used intensively; will have a complex infrastructure ripe for adaptation and not reconstruction; will have a single institution responsible for exercising management; will be vulnerable to failure and transient crises; will be subject to non-negligible and variable operating costs; will operate within legislation sufficiently liberating to condone the inevitable errors of innovation; will possess a reasonable telemetry network for the provision of current information; and will possess a style of management that is committed to automation and computers for supporting and not eliminating the role of operator/manager decision making.

But to provide the initial impulse to change, four ingredients are necessary: just enough practical operating experience from which to infer the costs and significance of "oscillations" *versus* "equilibria" as criteria for management; the same amount of experience with which to break the circular arguments about the efficiency and economics of performance; a control capability almost sufficient to have been able to make manipulations consistent with variable operational priorities; and a problem – such as the nitrate problem, in fact – with manifold interactions that cannot be made negligible in all but one dimension. Far from being idealized extensions of the theory, although any theory must be able to specify an appropriate experiment, such candidate problems as those described above can already be found: for example, in the Thames and the Bedford-Ouse river basins in England.

There is, then, a convergence between theory and practice that creates conditions favorable to change; conditions made all the more favorable by the publicity given recently to the problems of inadequately performing wastewater treatment facilities in the 1979 US Water Pollution Control Federation white paper by Hill, Regan, and Zickefoose. The mood of critical reflection thus emerging from undoubtedly practical considerations has itself permitted and stimulated changes in the outlook for theory. A response to a problem and the exploitation of a convergence between theory and practice were both motives for a collaborative study undertaken at IIASA between 1979 and 1981. But the primary purpose of that study was to clarify some of the contemporary issues of water pollution control before the receptive mood of critical reflection passed again and to identify promising avenues for developments in practice before proceeding further.

No one expects rapid change in these matters, and the skeptic will raise his hand to point out that the theory is nothing more than what he has arrived at intuitively over long years of experience: just as well then that this experience and intuition is committed to print for open discussion. The theory as catalyst is an apt analogy: something promoting change but not necessarily seen to be doing so, and something not necessarily apparent in any new style of management evolving as the product of change.



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Dr. Bruce Beck came to IIASA in 1977 from the University Engineering Department, Cambridge, UK. While at IIASA he led research into the modeling of poorly defined environmental systems and the analysis of water quality management policy, which resulted in IIASA Executive Report 7, *Operational Water Quality Management: Beyond Planning and Design*. Dr. Beck returned to the UK in October 1982 to take up an appointment at Imperial College of Science Technology, London University.

# News from the Institute

## IIASA–WHO/EURO Joint Workshop

Sulfur dioxide emissions are predicted to remain at about the current levels in Europe through the 1990s. Nitrogen oxide emissions are expected to increase. These emissions, primarily from power plants, become the sulfuric and nitric acid rains which have had profound negative impacts in Europe, North America, and Japan. These acidic compounds have harmful effects on surface- and groundwater, soil, trees, crops, buildings, monuments, and can affect people.

Much information has been accumulated concerning airborne pollution and its effects, and certain control and abatement mechanisms have been developed. However, there is still a lack of understanding of the long-term and long-range effects of the chemical and physical processes responsible for the concentration, transmission, transformation, and deposition of pollutants. Moreover, the prediction in certain cases of the hazards to the well-being of the population and of the cost to national economies due to pollution is still an art in its early stages.

The range of disciplines seeking to resolve air pollution issues is very broad, and communication barriers need to be overcome. In a systems analysis context, the major problem is the identification for a specific discipline of what will contribute to an overall management strategy. It was therefore appropriate that the World Health Organization Regional Office for Europe and IIASA should organize a Workshop in July attended by meteorologists, modelers, chemists, environmental and chemical engineers, plant physiologists, foresters, physicians, epidemiologists, and environmental planners from seventeen countries. There were also representatives of the World Meteorological Organization and the Commission of the European Communities. The presence of such a broad range of specialists created some initial communication problems, but proved to be useful.

The two major themes underlying the Workshop were that "it seems to be a question of when, not whether, any ecological effects appear" caused by pollutants and that science "needs to know more before we can prevent all these harmful effects."

It was recognized that control actions can be effective at a given site and detrimental at another, or transfer the pollution from one environmental medium to another. The reduction of ground-level concentrations of pollutants by the construction of tall stacks, for example, resulted in an increase of long-range transport of pollutants. There is need for further development of analytical tools to describe the comparative effectiveness of different air pollution abatement strategies. This is especially urgent within the context of the long-range transport of air pollutants, which deposits pollutants across boundaries so that the source and reception areas are in different countries.

It was recommended that the dry and wet deposition of sulfates be reduced to 0.5 gram per square meter annually to avoid further damage to the ecosystem. The present rate of sulfate deposition ranges from 1.0 to 3.0 grams per square meter per year, and is even higher in densely populated and industrialized areas.

The meeting also dealt with the predictions of health effects from air pollution episode cycles. Such cycles appear annually during specific seasons in various cities and are assumed to cause significant economic damage to human health and the environment as they are repeated over many years.

Papers were not "read" in the traditional way, but provided the background information for the round-table discussions that formed the Workshop. The papers are to be published in a special issue of *Atmospheric Environment*.

IIASA Dr. Eliodoro Runca
WHO/EURO Dr. Michael J. Suess

## NMOs

The American Academy of Arts and Sciences will take over as the new USA member of IIASA, replacing the US National Academy of Sciences (NAS), starting 1 January 1983. This transfer of membership had become necessary after the NAS withdrawal from the Institute following the decision to end USA government funding for IIASA. After the NAS withdrawal, the Royal Society of London also gave notice of its intent to withdraw from membership in IIASA at the end of 1982, but a transfer of UK National Member Organization from the Royal Society to the Fellowship of Engineering is now also agreed in principle. However, it is not yet certain that the Fellowship will acquire sufficient financial resources to assume the rights and duties of membership.

In addition, to strengthen Sweden's ties to IIASA, the Swedish Council for Planning and Coordination of Research took over membership in the Institute from the Swedish Committee for Systems Analysis.

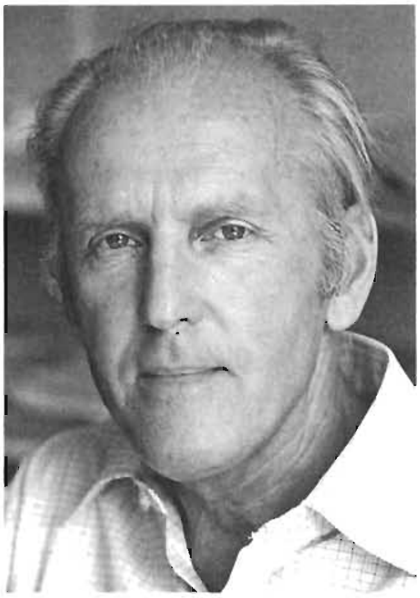
These transfers of membership were approved by the IIASA Council, the Institute's governing body, at its meeting 11–12 November 1982. The Council also approved the proposed research plan and budget for 1983.

Professor Howard Raiffa, IIASA's first Director and Frank P. Ramsey Professor of Managerial Economics at the Graduate School of Business of Harvard University, has been appointed by the American Academy as their representative on the IIASA Council. The American Academy's Committee for IIASA is chaired by Professor Harvey Brooks, Benjamin Pierce Professor of Technology and Public Policy at Harvard University, with Vice-Chairmen Professors Raiffa and Carl Kaysen, Director of the Institute for Advanced Studies at Princeton University. The Committee members include Nobel Laureates Lawrence Klein and Tjalling Koopmans, former IIASA Director Roger E. Levien, McGeorge Bundy, Robert McNamara, Elliot Richardson, T. Keith Glennan, John R. Meyer, and others from academia, public service, and industry.

Professor Anders Karlqvist of the University of Linköping will be the new Swedish representative on the IIASA Council. Professor Emeritus Carl Gustav Jennergren, his predecessor from the Swedish Council's previous National Committee for IIASA, was awarded the title of "IIASA Honorary Scholar".

Nuclear physicist Professor Victor Weisskopf, a past president of the American Academy of Arts and Sciences and former Director-General of

## In Memoriam



Professor Boris Leonidovich Issaev, head of the Regional Development project at IIASA since January 1981, passed away in Vienna on 16 October 1982.

Professor Issaev had worked on formulating economic policy at the Soviet Ministry of Foreign Trade and as Head of Laboratory in the Central Economic and Mathematical Institute of the Academy of Sciences of the USSR. He was Professor of Statistics at the Moscow Institute of the National Economy.

From 1956 to 1962 Professor Issaev was with the United Nations Economic Commission for Europe and from 1974 to 1975 with the United Nations Development Program.

Not only did he open up new avenues for IIASA work in developing the Regional Development project; the advances in that field of science and their application in practical use today further enhance his distinguished reputation. *Multiregional Economic Modeling: Practice and Prospect*, recently issued by North-Holland Publishing Company, was his last publication.

Professor Issaev will be warmly remembered both for his qualities as a man and for his achievements as a scientist.

the European Organization for Nuclear Research (CERN), delivered a Distinguished Lecture under the title *Science, Technology, and Society* to Council members, Austrian dignitaries, members of the diplomatic corps, and IIASA staff.

## New Titles

### IIASA Proceedings Series

Volume 17 **Mathematical Models for Planning and Controlling Air Quality**. G. Fronza and P. Melli, Editors. 255 pp.

Available from Pergamon Press Ltd., Headington Hill Hall, Oxford OX3 0BW, UK, or Pergamon Press Inc., Fairview Park, Elmsford, NY 10523, USA.

### IIASA Collaborative Proceedings Series

**CP-82-S5** Modeling Agricultural—Environmental Processes in Crop Production. G.N. Golubev and I.A. Shvytov, Editors.

**CP-82-S6** Liquefied Energy Gas Facility Siting: International Comparisons. H.C. Kunreuther, J. Linnerooth, and R. Starnes, Editors.

### Research Reports

**RR-82-21** A Multiregional Planning and Forecasting Model with Special Regard to the Public Sector. F. Snickars and A. Granholm. Reprinted from *Regional Science and Urban Economics*.

**RR-82-22** Innovation, Efficiency Cycle, and Strategy Implications. H. Maier and H.-D. Haustein. Reprinted from *Technological Forecasting and Social Change*.

**RR-82-23** Public Facility Location: Issues and Approaches. G. Leonardi, Editor. Reprinted from *Sistemi Urbani*.

**RR-82-24** Urbanization and Development in the Third World. A. Rogers and J.G. Williamson, Editors. Reprinted from *Economic Development and Cultural Change*.

**RR-82-25** Long-Term Prospects for Agricultural Development in the European CMEA Countries including the Soviet Union. C. Csaki.

**RR-82-26** A General Regional Agricultural Model (GRAM) Applied to a Region in Poland. M. Albegov, J.W. Kacprzyk, W. Orchard-Hays, J.W. Owsinski, and A. Straszak.

**RR-82-27** The Videodisc Revolution. I. Sebestyen. Reprinted from *Electronic Publishing Review*.

**RR-82-28** Migration and Settlement: 15. France. J. Ledent with Daniel Courgeau.

**RR-82-29** Immigration and the Stable Population Model. T.J. Espenshade, L.F. Bouvier, and W.B. Arthur. Reprinted from *Demography*.

**RR-82-30** Simplified Multiple Contingency Calculations. N. Keyfitz and A. Rogers. Reprinted from *Journal of Risk and Insurance*.

**RR-82-31** Technological Learning, Technological Substitution, and Technological Change. J.M. Robinson. Reprinted from *Technological Forecasting and Social Change*.

**RR-82-32** Migration and Settlement: 16. Czechoslovakia. K. Kühnl.

**RR-82-33** Migration and Settlement: 17. Italy. D. Campisi, A. La Bella, and G. Rabino.

Single copies of journal reprints are available free of charge. All other publications can be ordered from the Publications Department, IIASA.

*National Member Organizations*

**Austria** — The Austrian Academy of Sciences; **Bulgaria** — The National Committee for Applied Systems Analysis and Management; **Canada** — The Canadian Committee for IIASA; **Czechoslovakia** — The Committee for IIASA of the Czechoslovak Socialist Republic; **Finland** — The Finnish Committee for IIASA; **France** — The French Association for the Development of Systems Analysis; **German Democratic Republic** — The Academy of Sciences of the German Democratic Republic; **Federal Republic of Germany** — The Max Planck Society for the Advancement of Sciences; **Hungary** — The Hungarian Committee for Applied Systems Analysis; **Italy** — The National Research Council; **Japan** — The Japan Committee for IIASA; **Netherlands** — The Foundation IIASA—Netherlands; **Poland** — The Polish Academy of Sciences; **Sweden** — The Swedish Committee for Systems Analysis; **Union of Soviet Socialist Republics** — The Academy of Sciences of the Union of Soviet Socialist Republics; **United Kingdom** — The Royal Society of London; **United States of America** — The National Academy of Sciences.

# Director's Corner:
## *Patterns and Policies*

Ecological systems are neither systems of equilibrium nor of disequilibrium. Each condition is present at different periods, but the essence of their total structure can hardly be captured by either label. Early in the century, ecological thinking was dominated by a view of the succession of species leading inexorably to a stable "climax" of forest or grassland. But that view emerged because the patterns of change had a time rhythm so much longer than an individual's time window of perception and so much shorter than the evolutionary times that can be read, in leisure, from the fossil record.

Forest fires, pests, and storms seemed to be rapid and passing events in the perception of individuals. They seemed to scientist and nonexpert alike to be transient intrusions that were abnormal, external, and, once past, easily forgotten. Only when the geographical scale of these events became very large did they become more deeply embedded in sustained awareness — the snowshoe hare/lemming cycle that dominates much of arctic North America; the locust swarms of the Middle East; the migration of ungulates over large areas of east Africa. But many such agents of change operate on a smaller scale, out of synchronization with each other. Again, because the scale is small relative to our perception, the patterns remained hidden from awareness. It is this mismatch between the time and space dynamics of a system and man's individual experience with time and space that frustrated understanding and distorted renewable resource policy. Viewpoints and policies were dominated by the sense of gradual growth to a richly interconnected system of organisms in a sustained balance with the physical and chemical environment.

That view dominated ecological research for many years. It dominated and, to a major degree, still does dominate policies for ecological and resource management. The focus of such policies is to maximize sustained production in part by eliminating, or at least reducing, those phenomena that lead to variability in the resource base caused by the death of forests, overgrazing, and disease. By and large, those policies are effective for the short term. Insecticide spraying, forest fire control practices, fish enhancement, and "optimal" stocking of rangeland are the kinds of things that technological and administrative man can do well. But by the very success in changing the temporal pattern, the natural system evolves to one that is less diverse, with fewer species, fewer age classes, and more homogeneity in physical structure and spatial extent. The systems self-simplify in response to reduced variability, leading to ones that are less resilient and more subject to extensive and intensive damage to the resource base. In the face of growing dependencies on continued production, the only alternative seems to be more intense control, greater vigilance, and more effective technology. Because of our deeper understanding, however, policies are now emerging that yield short-term benefit but that use variability to produce systems that are more diverse and less vulnerable over a longer term.

Economic systems are scarcely the same as ecological ones. But formally equivalent causal forces that are known to generate the ecological patterns in space and in time also occur in economic systems. Some are amplifying or accelerating in their positive feedback effect. Others are damping or controlling through negative feedback effects. And the sets of interacting variables themselves act on different time and space scales — some fast and some slow; some local and some extended. There is at least the potential, therefore, that macroeconomic systems can generate patterns of behavior in space and time that have the features of discontinuity and multiequilibria states that are found in biophysical systems. Certainly at the edges of economic and social analysis, long-term patterns such as the Kondratieff cycles have been proposed to be the consequences of periods of innovation generating a wave of growth, followed by stability and senescence as the set of industrial and institutional structures and policies evolve towards more and more intricate interrelations and rigidities. On the one hand, they become deeply resistant to restructuring for good human and economic reasons. On the other, they bear the seeds of their own change and renewal within them because of their growing ineffectiveness in achieving the goals of social and economic well-being. In an ecological sense this is a time of discontinuity, change, and renewal that again opens opportunity. In a human sense this is a time of crisis and loss of certitude.

Such analogies are dangerous. But at least they can provoke questions concerning the articulation and implementation of policies. Such patterns have a time and space dynamic that does not match well with man's own perceptions. The Kondratieff cycles, for example, are argued to have a period of somewhat more than fifty years. During the 1950s and 1960s the industrialized world was in a period of growth and enrichment. And the sustained nature of that growth led to public attitudes, policies and research that spoke to the recent past with little sense of longer term dynamics. So many of the world's present problems seem to have emerged from such myopic views, that did not recognize the slowly accumulating changes in industrial stocks, social infrastructure, resource availability, environmental constraints, and population age structure.

Now those problems are vividly evident. And they come at a time when the very success, in the short term, of past developments has led to fragile interdependencies between all peoples and nations of the world. It is a system of great vulnerability.

But it is also a time when the very perception of that vulnerability gives the possibility of a larger and longer term view. Inherent in that is the need for policies of the moment that are driven by realities of the next century and not by short-term expediency. Those realities must deal with at least two facts: first, an ageing population in the industrialized world and the reverse occurring in the developing world; and second, the constraints of the regional and global biophysical environment. It requires an economic emphasis that is balanced by social and environmental concepts, methods, and perceptions. And it requires a comparative approach across nations and socioeconomic systems in order to avoid the monotheoretical trap that assumes a single set of behavioral assumptions, concepts, and methods.

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