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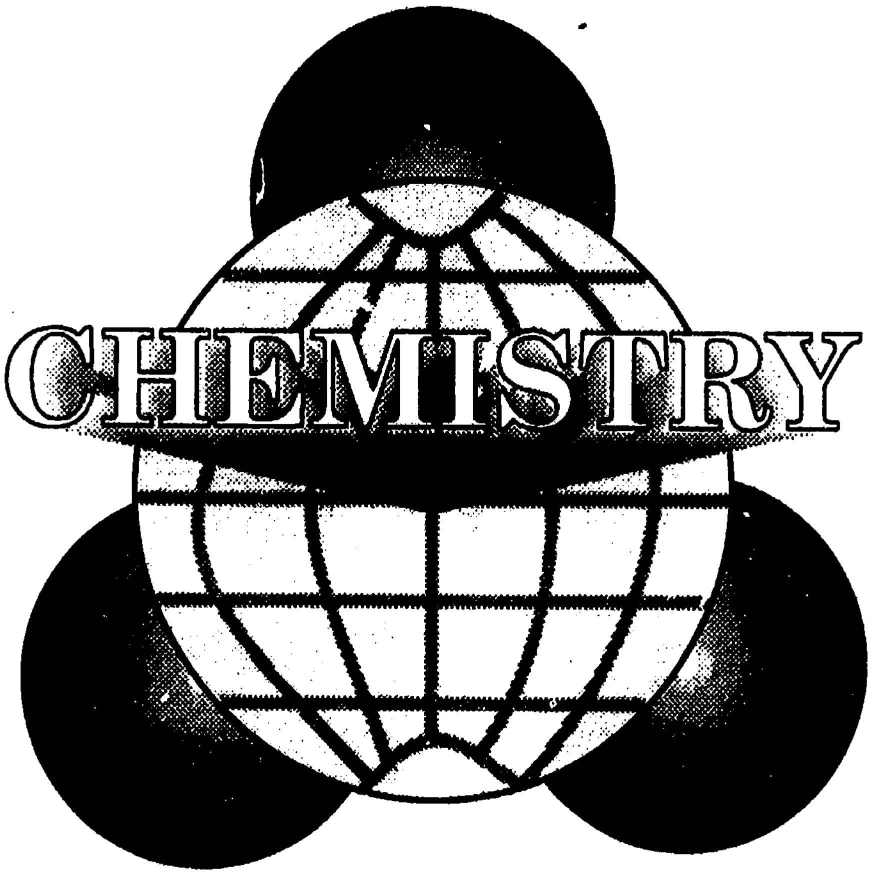
ABSTRACT

The proceedings of a program on teaching chemistry through energy and the environment that included plenary lectures, country and commission reports, introductions to new programs and materials, and an experimental approach to curriculum development across national boundaries via the production of an instruction unit are provided. The workshop participants included 34 nations, 4 ICSU teaching commissions, the American Chemical Society, and the World Bank. The participants were asked to develop an instructional unit in the context of an international meeting. The unit, entitled "Burning Fuels: How Can Chemistry Help Us Minimize Waste in Materials and Energy?", is included in this document. The instructional unit contains an introduction, the science content, pedagogical concerns, 5 model teaching unit plans, 20 classroom activities, societal/technological issues, general applications and illustrations, and other related disciplines and concepts. A synopsis of plenary lectures, abstracts and reports from each country, the instructional unit, a copy of the program, a participant list, a listing of the resource materials in the book bag that participants took home to their countries for further use, and a listing of audio-visual materials that were part of the evening program. Antigua, Australia, Brazil, Bulgaria, Canada, China, Denmark, Ethiopia, Finland, France, Germany, Ghana, Hungary, India, Italy, Jamaica, Japan, Jordan, Mexico, Netherlands, Norway, The Philippines, Portugal, Puerto Rico, Singapore, Spain, Sweden, Thailand, Soviet Union, United Kingdom, United States, Venezuela, and Yugoslavia were participating countries. (KR)

Proceedings

UNESCO



International Workshop/Symposium on Energy and Environment as Related to Chemistry Teaching

Lawrence Hall of Science

University of California at Berkeley

December 3rd through 8th, 1989

in cooperation with

IUPAC/CTC and DOE

Proceedings
UNESCO
International Workshop/Symposium on Energy and the Environment as Related to Chemistry Teaching

Lawrence Hall of Science
University of California
Berkeley, California 94720

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Introduction

From Sunday, December 3rd, through Friday, December 8th, 1989, 55 participants representing 34 countries participated in a workshop/ symposium at the Lawrence Hall of Science, University of California, Berkeley, under the title, "Energy and the Environment as Related to Chemistry Teaching." UNESCO initiated this program by inviting me as Director of the Lawrence Hall of Science, to serve as host and organizer for a small workshop on this theme. Because of high interest in the topic and its timeliness, it was decided to seek the resources to expand into a symposium/workshop for a larger number of participants. Invited participants were asked to cover their own airfares to the extent that they could. John Kingston in theDivision of Higher Education at UNESCO and the Department of Energy in the United States also facilitated this effort by making additional funds available. Alexander Pokrovsky, from the Division of Science, Technical and Environmental Education, provided the leadership from UNESCO, while Maurice Chastrette, Chairman of the Chemistry Teaching Committee, provided leadership from the International Union of Pure and Applied Chemistry, IUPAC.

A program evolved that included plenary lectures, country and commission reports, introductions to new programs and materials, and an experimental approach to curriculum development across national boundaries via the production of an instructional unit. The week was very intense and professionally exciting. A list of participants appears on pages 119. It represents 34 nations and four ICSU teaching commissions, as well as the American Chemical Society and the World Bank. The program appears on pages 117 and is followed by a listing of the resource materials in the book bag that participants took home to their countries for further use, and a listing of audio-visuals that were part of the evening program.

The program began with an opening reception on Sunday evening at the University Center, where greetings were presented from all sponsoring agencies. During the week, four excellent plenary lectures were presented by eminent scientists: Nobelists Glenn T. Seaborg and Y. T. Lee, and Senior Research Scientists Mark Levine and Arthur Rosenfeld from the Lawrence Berkeley Laboratory. Country and commission reports were rich in information about the teaching of chemistry and efforts from other sciences to bring concepts and issues of energy and the environment into classrooms. Evening sessions were devoted to opportunities to view the latest in audio-visual materials in the form of computer programs, video tapes, and laser disks. Informal evening discussions were common among participants.

The highlight of the week of cooperative work was an experimental effort to develop an instructional unit in the context of an international meeting. Henry Heikkinen and Lee Summerlin, worked with the conference organizer in the planning, and led this effort which resulted in a unit "Burning Fuels: How Can Chemistry Help Us Minimize Waste in Materials and Energy?," which is included in this proceedings on pages 105 through 116. The participants in the conference determined the theme to meet criteria established in advance: the unit must be related to energy and environment, be of importance in every country of the world, include laboratory and demonstration ideas using low-cost, readily available local materials, be readily adapted to local culture, context and conditions and promote knowledge and understanding of important principles and skills of chemistry. The participants not only developed the instructional unit, but plan to translate it to their own languages, adapt it to their own conditions, and find teaching partners in the schools to work with them in testing the 10-12 hour instructional unit. It is intended that these modified units, country by country, will be returned to the conference organizer by the end of May, along with feedback that includes comments and suggestions on this activity and the possibility of extending this effort internationally to other units. The results of this exercise will be compiled, analyzed, and brought to the next IUPAC Teaching Committee meeting, scheduled to be held at Moscow State University in the Soviet Union in September 1990.

I am sure that I speak for Alexander Pokrovsky (UNESCO), Maurice Chastrette (IUPAC/CTC), and Rollie Otto (Department of Energy) in expressing appreciation to everyone who helped in the organization of this important international gathering and who participated in it. Special thanks go to staff members at the Lawrence Hall of Science and the Lawrence Berkeley Laboratory for their excellent help: Augustus Schoen-René, for his outstanding work with the computer, including the desk-top publishing of this proceedings, Mickie Christensen, who handled most of the organizational detail, Eileen Engle, of the Lawrence Berkeley Laboratory, who provided resource material, buses for transportation, and backed up the organizers in every way and Marilyn Dromgoole for her efforts in the printing and distribution of the proceedings.

It was a great pleasure to have this wonderful collection of people from around the world here in Berkeley. They worked hard and generously together to learn from one another, to produce an instructional unit that could be tested internationally, and to consider how their own countries might better include concepts related to energy and the environment in their teaching of chemistry. It is hoped that this proceedings will remind each and every one of their participation and contributions. It is also hoped that the proceedings will be useful to a wider audience in learning about chemical education in the various countries and who might also want to test the instructional unit in their own classrooms. Particular appreciation should be expressed to Alexander Pokrovsky and UNESCO for their foresight in making such a meeting possible and for their professional and financial support. The Department of Energy should also be commended for its appreciation of the importance of the themes of this conference and its willingness to help facilitate this event.

Marjorie Gardner
Senior Research Associate
Lawrence Hall of Science

Synopsis of Lectures

It was not possible to reproduce the four plenary lectures in their entirety here. Capsule summaries of each lecture follows.

The first lecture was given by Professor Glenn T. Seaborg, Associate Director at Large at the Lawrence Berkeley Laboratory, Distinguished University Professor, and Chairman of the Lawrence Hall of Science. The theme of his lecture was, "Energy Sources for the Future." Dr. Seaborg received the Nobel award in 1951 for his seminal discoveries related to the chemistry of the transuranium elements elements. He is the co-discoverer of ten transuranium elements and an internationally known expert on nuclear energy. In recent years he has devoted time and effort generously to science education.

In a far-ranging lecture Professor Seaborg spoke about the various sources and processes of energy for the future. He began with improvements in the use of fossil fuels, including coal gasification and liquefaction of oil shale. He also discussed conventional nuclear energy, then breeder reactions and fusion reactions. Types of fusion reactions were discussed in some detail with the audience, and particular attention was given to three approaches to controlled thermonuclear fusion: magnetic confinement, laser implosion and heavy ion implosion. Dr. Seaborg outlined in detail the system for collecting sunlight through solar energy collectors and converting this energy to electrical energy. He briefly discussed geo-thermal energy and the possibility of energy from wind and water as he described several imaginative ways to harness solar energy or the energy from wind or geothermal sources. Dr. Seaborg concluded with an overview of energy resources for the world, pointing out that the age of fossil fuels is rather a short one; there is a finite amount of fossil fuel; it isn't a matter of *if*, it's a matter of *when* we will run out and have to use the other alternative sources.

On Tuesday, December 5th, Senior Research Scientist and Program Leader of the LBL Energy Analysis Program, Dr. Mark Levine, spoke on the theme, "Energy and Global Warming." Dr. Levine began his lecture with a presentation, through graphic material, of the increasing CO2 concentration in the atmosphere, as measured from 1958 to 1986. He then discussed with the audience the greenhouse gases and their contribution to global warming. Carbon dioxide is the largest contributor to the potential for global warming, but other greenhouse gases that are having an impact include methane, CH_4, N_2O, CFC 11 and 12, and trace gases that include halons, tropospheric ozone and atmospheric and stratospheric water vapor. All of these gases have the potential for global warming.

Dr. Levine also discussed the net release of carbon dioxide from tropical deforestation. Over half of the 1980 CO2 emissions from deforestation was produced by six countries: Brazil, Indonesia, Colombia, the Ivory Coast, Thailand, and Laos.

Dr. Levine then discussed per-capita energy use and production in various parts of the world. He compared the increase in per capita electricity consumption of energy in the United States, USSR, South Korea, India, and China. The world's primary consumption from 1985 projected through the year 2025 indicates that the growth of OECD nations such as the United States, Canada, Western Europe, Australia could increase by about 15%; China could increase by 24%; the less-developed countries, by far the largest increase, could grow by 45% or more; and other nations, which include USSR and Eastern Europe, a 16% increase.

Dr. Levine defined the problem of energy consumption in the various parts of the world and the effect on the global atmosphere in increased greenhouse gases as measured. He noted that unless significant policy changes are initiated rapid growth in economies means rapid growth in energy use, degradation of the environment, and the question of where will we find our energy sources in the future and how will we protect the environment on this fragile earth. Of critical importance, in his view, is support for developing nations to improve the efficiency of energy production and use. He noted that significant increases in this type of energy assistance are needed. Without such aid, increases in energy efficiency in developing countries are not likely to occur. Without improvements in energy efficiency, global climate change will be much more costly and difficult to control.

Professor Y. T. Lee, Chemistry professor and LBL Research scientist who was honored with the Nobel award in 1986 for his work with molecular beam chemistry gave a lecture entitled, "Combustion of Fossil Fuels and the Human Society." This lecture was right on target with respect to the instructional unit under development.

Dr. Lee first traced the early development of mankind's skills, from the making of tools through the domestication of animals to the use of fire. He then defined the various usages of fire for providing heat, light, and the possibility of cooking. Combustion as a source of energy for human society was traced through its historical development, and the combustion of fossil fuels, including the evolution of CO_2 emissions as a result, was traced from the early 1800s through projections to the year 2100. Dr. Lee then turned to the birth and development of modern chemistry, beginning from the second half of the 17th century to the end of the 18th century. He described the development of the concept of chemical elements, the theory of phlogiston, the discovery of gases such as carbon dioxide, hydrogen, nitrogen, and oxygen, and the work done by Priestley and Lavoisier.

Dr. Lee then worked with reactions for the combustion of hydrocarbons, delineating reactants, products, and the molecular collisions that make chemical change possible. The mechanisms of the reactions of hydrocarbons with oxygen were described in more detail, with the many by-products that result from such reactions being carefully delineated. Dr. Lee described the crossed molecular beams apparatus with a mass spectrometer detector that is the apparatus used for oxygen and hydrocarbon reactions. As an example, he used the reaction of ethylene with atomic oxygen to describe both the energies available and the several products of the reaction through a reaction coordinate diagram. With graphics, he described the relationships among quantum mechanics, elementary chemical reactions, and macroscopic chemical processes.

Dr. Lee concluded his lecture with a concern on the excessive release of CO_2 in the atmosphere and a description of a steam reforming process of hydrocarbons that can be helped by high-temperature nuclear reactors to to form H_2 and CO_2. It is easier to find a sink for localized production of CO_2, and the energy distributed energy consumption by burning H_2. He took a very international view of energy sources and uses and the impact on the environment, using the United States and China, in particular, as his examples.

The final plenary lecture, "Global Warming: The Bad News, the Good News," was given by Arthur Rosenfeld, Senior Research Scientist at the Lawrence Berkeley Laboratory.

Dr. Rosenfeld discussed the risks of global warming if we continue to consume energy at the current rate. He called these risks "Betting the Planet." Dr. Rosenfeld pointed out that by using energy more efficiently, we can preserve our energy resources and slow down global warming.
He then noted that energy use and the gross national product are closely related and that energy efficiency savings can fuel growth

in the gross national product (GNP). For example, from 1974 - 1985, the U.S. GNP increased as much as 35% while energy use actually decreased; which translates into billions of dollars in avoided energy bills per year. Initial investments in efficient technologies are generally recovered in payback periods of three years or less.

Dr. Rosenfeld also discussed ways of saving energy in the household, by replacing incandescent bulbs with efficient fluorescent lamps, and installing low-emissivity windows. He noted that substantial amounts of coal, oil, and natural gas can be saved by using these energy efficient devices in the residential and commercial sectors. He discussed several other energy-efficient technologies, describing the current and predicted savings for: solid state ballasts in lighting, compact fluorescent bulbs, and efficient appliances such as refrigerators.

Dr. Rosenfeld concluded his lecture by proposing energy efficiency policy that reduces energy use 3.5% each year for the next 20 years, while promoting growth in the economy. He suggests that national policy must be changed: to encourage least-cost energy services, strengthen standards for automobiles and appliances, and require both commercial and residential adoption of efficient technologies that conserve energy. Such policies will decrease CO_2 and the other pollutants that result from fossil fuel use and combustion.

Dr. Rosenfeld's lecture was a message of hope. If we exert the willpower necessary, we can readily change our use of energy, and protect the earth's.

Following this lecture, the group to toured the Lawrence Berkeley Laboratory and had lunch in the facilities there.

Country Reports and Abstracts

ABSTRACT *Energy and the Environment in Chemistry Teaching - The Caribbean Experience* **Eustace W. E. Hill Science Co-ordinator, c/o Ministry of Education, Culture & Youth Affairs, Church Street, St. John's, Antigua** •The Caribbean Examinations Council (CXC) has tested its new Chemistry syllabus for secondary schools for the past five years (1985 - 1989). •One of the many emphases of this syllabus is a consideration of the impact of Chemistry on our daily lives both globally and in the Caribbean region. It is not surprising that issues related to the inter-relatedness between energy use and the environment are dealt with at various sessions of the syllabus. •Questions on energy sources, such as fossil fuels, alternative energy sources and also firewood and charcoal, are asked at levels ranging from simple recall of information to giving informed opinions on topical issues, such as oil spills and the greenhouse effect. •These types of questions have been used over the five years in the Multiple choice, Structured Essay papers and also in the school based assessment (SBA). •By first considering the historical basis which led to the change in emphasis of the Chemistry examinations and consequently the chemistry teaching in that region, the paper looks at how the creative examination strategies have attempted to aid Caribbean students to appreciate the interrelatedness between energy use and the environment. •The paper concludes that while the efforts of the Chemistry examiners are commendable, in particular the profile weightings, school education alone will not produce the desired result of a cleaner, healthier environment. The paper asserts that issues such as energy conservation and environmental protection require a quality of political will which is reflected in both school and public education, up-dated legislation and the enforcement of legislation.

Energy the Environment as Related to Chemistry Teaching - THE CARIBBEAN EXPERIENCE

Antigua

1.0 Introduction and Background

In 1985, the Caribbean Examinations Council (CXC) tested for the first time its Chemistry Syllabus aimed at the secondary level.

Prior to the establishment of the Caribbean Examinations Council, Caribbean students wrote secondary examinations administered by Overseas boards from the Universities of Cambridge and London.

The Council was established in 1972 by an agreement among English - speaking Caribbean Commonwealth territories. The fifteen (15) participating territories are Anguilla, Antigua and Barbuda, Barbados, Belize, British Virgin Islands, Dominica, Grenada, Guyana, Jamaica, Montserrat, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines Trinidad and Tobago, and Turks and Caicos Islands.

Specific treatment of how Antigua and Barbuda deals with the topic of "Energy and the Environment" will not be attempted here since Antigua and Barbuda and the Caribbean territories listed above all have the same syllabuses and examinations. The Caribbean experience instead will be analyzed.

Issues related to the environment are but one of the many topics which are dealt with by the CXC Chemistry Syllabus. However, to fully appreciate the strategies used by CXC to aid students in appreciating the interrelatedness of energy and environment, it is important to look at:

(a) The factors which influence the design of the syllabus;
(b) The assessment strategies, and
(c) The impact of these strategies.

2.0 Factors Influencing the CXC Syllabus Design

Two interrelated factors which influenced the design of the chemistry syllabus were:

(a) The growing dissatisfaction with overseas syllabuses and examinations, and also the poor performance of students in the examinations, and
(b) The world-wide trend towards integration.

2.1 Dissatisfaction with Overseas Examinations

As stated previously, Caribbean students before 1985 sat Chemistry examinations administered by overseas (British) examining boards, but there was growing discontent both among Caribbean and British educators.

The inappropriate and irrelevant Science Syllabuses were deemed responsible for the poor examination results. A study of the Caribbean's performance during the period 1971 - 1981 showed that only 10.3%, 6.8% and 15.0% of the students passed chemistry, physics and biology respectively.

The general dissatisfaction with the nature of the overseas syllabuses, coupled with the poor performance of the Caribbean students, made a change inevitable. The change was towards integration. Unfortunately, that change was largely short-lived.

2.2 The World-Wide Trend Towards Integration

Instead of offering the separate sciences, biology, chemistry and physics, CXC took the bold step of offering the new subject, integrated science, in 1979. The factors responsible for this include the world-wide trend towards integration, which was catalyzed by UNESCO, and the integrated science course School's Council Integrated Project (SCISP) of Britain.

The CXC Integrated Science Double Award has virtually died, only about ninety students took the examination in 1989. Integrated Science at both the general and basic proficiency level is more popular, averaging about 2,000. The single sciences, biology, chemistry and physics in contrast are done by about 6,000 students each.

One of the many accusations made against the single sciences was their inability to deal with environmental issues. The CXC chemistry examiners have tried in a number of areas to prove that statement incorrect through creative assessment strategies.

3.0 Syllabus Design and Assessment Strategies

3.1 Syllabus Design

The CXC examiners had to design a syllabus which showed chemistry as a product - the body of knowledge patiently acquired over centuries; chemistry as a process - a way of looking at our physical and biological world, and above all the way chemistry serves mankind.

The Syllabus is divided into three sections:

Section A: Principles pf Chemistry
Section B: Descriptive Chemistry
(1) Organic Chemistry
(2) Inorganic Chemistry
Section C: Chemistry in Industry

In these various sections of the syllabus issues related to energy and the environment are dealt with under such headings as:

major energy sources, alternative energy courses, efficiency of wood, peat, charcoal, carbon, nitrogen and water cycles, petroleum and conservation,

to mention a few.

The syllabus allows a fairly comprehensive treatment of energy and environment issues; however, it is the various assessment strategies as prescribed by the percentage weighting of papers and profiles which make the treatment of topical issues obligatory.

3.2 Assessment Strategies

Students are assessed in four (4) papers, namely: Paper 1 - multiple choice; Paper 2 - structured and essay questions; Paper 3 - practical examination; and Paper 4 - a school-based assessment of practical work. In the various papers, students are not only expected to recall and understand information but also to: demonstrate ability to handle information in novel situations, show a range of practical skills and to demonstrate good laboratory conduct and social awareness. An example from a past examination paper will undoubtedly adequately illustrate this point.

June 1986 *Paper 2B* *Question 9*

a) Discuss Two ways in which conservation of energy and/or material s achieved in one industry you have studied. Your answer should show knowledge of the processes involved in the particular industry (10 marks).

b) Referring to the industry named in (a) above, for each of the following give <u>one</u> rule which a government might make in an attempt to:

i. Ensure safer conditions for workers and
ii. Reduce Pollution

Give a reason for each rule. (4 marks)

c) The owners of the industry oppose the rules suggested in (b) above because they increase the cost of production. Discuss whether you think the rules should be enforced by law, if necessary.

In light of what has been mentioned already, the obvious question now is: What is the impact of the innovations of the CXC Chemistry examiners on Chemistry teaching and learning in the Caribbean as it relates to energy and the environment?

4.0 The Impact of CXC Examinations

A well accepted fact in the Caribbean is that instructional strategies in the classroom are determined by the kind of examination questions. CXC's creative examination questions have been instrumental in producing a new consciousness about environmental issues. Knowledge about energy sources has increased drastically. Whereas previously such information was almost the sole property of esoteric journals, today, every chemistry textbook which is used in the Caribbean schools has detailed information about fossil fuels, hydro-electric power, charcoal and firewood, biogas, solar energy as it specifically relates to the Caribbean region.

CXC chemistry has demonstrated that single sciences, not just integrated sciences, can adequately address environmental issues. Yet, though the efforts of CXC are commendable, they are not sufficient to produce an environmentally healthier, cleaner Caribbean. In fact, at a Subregional Training Seminar on the Incorporation of Environmental Education into Industrial Education for the Caribbean, sponsored by UNESCO - UNEP, in Jamaica in May 1988, the participants identified the various environmental problems in the region, traced their causes and effects and then suggested some preventative strategies. Education (both formal and informal), updated legislation and the enforcement of legislation were overwhelmingly identified as the way ahead for a cleaner, healthier Caribbean.

Efforts at both the regional and national levels in matters relating to the environment have intensified in the past two years or so. There has been a proliferation of seminars, conferences and workshops sponsored by regional and international bodies. Yet, regrettably, these efforts have not produced the necessary political will, in some Caribbean islands, to bring about lasting changes.

In Antigua and Barbuda, the recent setting up of a Historical Sites, Environmental and Conservation Commission and also an Energy Desk reflect the present seriousness of the government with regard to matters of energy and the environment.

ABSTRACT *Australian Environmental Chemical Education: Rhetoric or Reality* **Warren F. Beasley Department of Education, The University of Queensland, St. Lucia, Brisbane, Australia 4067** •The status of environmental chemical education in the Australian context reflects the long held view about the nature of the discipline of chemistry and how it should be taught and learned in both secondary schools and tertiary institutions. Environmental chemistry is dealt with as applications of previously learned concepts and as such rates a distant second to the conceptual structure of the discipline. In topics such as nuclear chemistry, industrial processing, energy and organic chemistry, the chemical facts and concepts are usually presented in a context which does not investigate the sociological/ technological/economic/ scientific links. The importance to the individual of the consequences of chemical and nuclear behavior of matter in the environment is lost in an ocean of concepts, facts and quantitative exercises. Environmental chemical education for citizenry still has a long way to go. •However, a number of more recent initiatives are attempting to redress this imbalance. •The Australian Academy of Science Chemistry materials do at least give a perspective of how chemistry is important in the Australian context, with a distinct emphasis on the industrial/economic concerns of the nation. As well, a new syllabus from the State of Victoria sets a new approach to chemistry by deliberately signalling their intent by listing fourteen focus questions for teachers to structure their approaches to four units of content - materials, chemistry in everyday life, chemistry and the market place, and energy and matter. The focus questions require the sociological/technological/economic/scientific dimensions to be integrated.

Australian Environmental Chemical Education: Rhetoric or Reality

"Environmental Chemical Education is dead; long live Environmental Chemical Education."

The Contextual Factors

To understand the competing and sometimes contradictory demands on science education in the Australian context, is to understand the contemporary history of the environmental science movement as it relates to chemical education.

For the past forty years two distinct societal demands have been placed on science education in many countries, including Australia. To keep pace with an ever-changing scientific and technological world, a demand for a highly-skilled work force was considered paramount.

As well, the need to produce more scientific literate citizens was recognized. It was intended that this second demand would encourage a reasonable balance of opinion about the competing interests of development and environmental concern. It is within this second demand that the importance of environmental chemical education has at least been acknowledged.

Australia

Meeting the national manpower needs in the areas of science and technology belongs in the realm of the universities, colleges and technological institutions.

For tertiary institutions there is a general agreement about the core knowledge and skills which graduates should attain through lecture and laboratory courses in chemistry. It is common to the extent to which the conceptual content is that which chemists use repeatedly. What follows is that the learning of these concepts and their precursors in the secondary school have the following characteristics:

* the rote recall of many, but not socially useful, facts and concepts;
* life experiences and social applications are used to illustrate an essentially abstract system of chemical knowledge rather than as the essence of the chemistry learning;
* the content prioritizes a quantitative approach which is greater than it is for many practising chemists.

The learning sequence for such conceptual knowledge can be illustrated as follows:

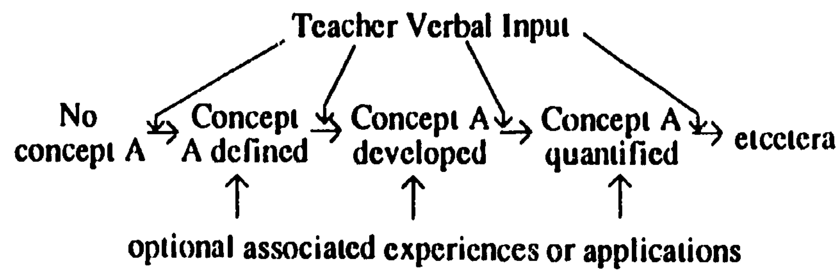

Fig. 1. *The learning sequence for conceptual knowledge*

Environmental applications in chemistry - the past and the present

The following example taken from the Chemistry Syllabus (1987) in the State of Queensland for Senior High School students is indicative of the past and present practices in most states of Australia.

The rhetoric which introduces the syllabus contains the following statements about the nature of chemistry education:

> *"The course is intended to provide students with a balance perspective of chemical science which will enable them to understand and interpret the chemistry of their surroundings and to appreciate the*

impact of chemical knowledge and technology".

This rationale is translated into a set of global aims which include the following:

> *"To lead students to understand the role of chemical science in the society in which they live and its importance in placing in proper perspective the occasional conflict between technology and society. Further, to introduce students to some of the economic considerations which influence the development of industries and the use of alternative materials and processes*".

The intent of the syllabus is provided by the listing of the specific objectives for the topics of 'Energy' and 'Important Substances'.

11.10 ENERGY

Content Objectives:

The student should have a knowledge of:

(a) the Law of Conservation of Energy;
(b) the meaning of the terms endothermic, exothermic, enthalpies of reaction, formation and combustion and calorimetry;
(c) the reversibility of a chemical reaction;
(d) common fuels, including fossil fuels and alternative energy sources (*e.g.* uranium, hydrogen, solar);
(e) the Joule as the unit of energy.

Process Objectives:

The student should be able to:

(a) identify endothermic and exothermic reactions and draw qualitative diagrams showing the relative change in energy during a reaction;
(b) write chemical equations to show energy involved in a reaction using:
  i. enthalpy of reaction as a term in the equation;
  ii. DH notation;
(c) compare the energy available from common fuels.

Skill Objectives:

The skill objectives should be developed by the practical work outlined below. The student should perform a simple calorimetric experiment.

Affective Objectives:

The student should have the opportunity to appreciate the importance of chemical energy to the maintenance of our society.

Electives:

1. Molecular energy (translational, vibrational, rotational), potential and kinetic energy, nuclear energy.
2. Bond energies, lattice energies.
3. More detailed study of one or more of the fossil fuels, *e.g.* coal, crude oil, natural gas.
4. More detailed study of one or more alternative energy sources and their applications, such as:
   i. nuclear energy - *e.g.* in nuclear power plants
   ii. solar energy - *e.g.* in solar hot water systems
   iii. electrochemical - *e.g.* in various types of batteries
5. Series of energy transformations, as in:
   i. production of electricity in hydroelectic plants
   ii. car engines
   iii. cooking
6. The differences between the heat absorbed in reactions carried out at constant volume and at constant pressure.
7. Hess' Law.

11.8 IMPORTANT SUBSTANCES

Rationale:

Throughout the course, various chemicals are mentioned during the discussion of principles, types of reactions, applications, etc. In this section, opportunity is provided for students to study chemicals in their own right. The depth of treatment should be such that this will occur.

Core:

The study of chemistry of one or more elements and one or more compounds.

The number of chemicals selected should not be such that only a superficial study of the chemistry of each is possible. The chemistry may involve, where applicable, sources, extraction or preparation, and properties, especially those which make the substance useful and/or relevant to people and the environment.

Throughout this study, every opportunity should be taken to consolidate the material developed in the other sections.

The approach in terms of content, process, and skill would depend on the location of the students, the abilities of the students, and the facilities available. However, it would be expected that the chosen substances would be such that maximum use could, where appropriate, be made of laboratory experiments, library research, and field experience.

Elements that might be suitable for study are:
oxygen, hydrogen, nitrogen, sulfur, carbon, aluminum, iron, zinc, nickle, lead, copper, the alkali metals, the halogens, a set of transition metals.

Compounds that might be suitable for study are:
water, sulfuric acid, carbon dioxide, ammonia, sodium hydroxide, sugar, one or more related fertilizers, a small selection of polymers.

Electives:

1. Study of additional elements and compounds.
2. Study of particular industrial extractions in more detail.
3. Study of specific properties of substances or groups of related substances.

A Current Alternative Approach

In an attempt to be different from conventional treatment of chemistry at the senior high school level, the Australian Academy of Science published a new generation chemistry course including a two-volume textbook entitled 'Elements of Chemistry - Earth, Air, Fire and Water'.

The rationale for such a course includes statements which have been adopted by individual State Syllabus committees such as those previously described for the State of Queensland. The structure of the course emphasizes our dependence on earth, air, energy and water sources, as well as on synthetic substances. Topics include air and water pollution, limitations of energy resources and available options, benefits and costs of the mineral industries.

This course structure has as one of its major aims:

> *"To encourage the study of factual material which will continue to be significant during the student's life. Thus to study the chemical processes that are related to resources and their development (with reference where applicable to local industries) and to study the properties and uses of substances, both natural and manufactured, which made up the students' environment".*

Present curricula in chemistry in Australian secondary schools are characterized by essentially an abstract system of scientific knowledge with examples of objects and events to illustrate this system rather than those aspects of the chemistry phenomena that enables some use or control of them to occur.

Future Initiatives in Environmental Chemistry Education

In the State of Victoria, a new curriculum design for introduction in 1991 has been released. The course content and approach is designed around four units and fourteen focal questions. The following table presents the units, areas of study and focal questions prescribed for each unit.

The difference in approach to environmental chemistry can be illustrated by the expanded treatment of waste materials shown in the following syllabus statement.

Waste Materials

This area of study introduces the concepts of waste and disposal. The focal question is: what makes a substance a waste material?
The key ideas for investigation are:

- the identification of waste materials and their properties and sources
- appropriate strategies for disposing of or treating these wastes within the constraints imposed by technology, economics and concern for the environment
- the energy costs involved in the re-use, re-cycling, transport, recovery and disposal of these wastes
- purification techniques appropriate to re-cycling processes; for example, simple and fractional distillation
- the measurement of concentrations of waste materials in ppm, ppb and g/L
- the classification of waste as biodegradable, non-biodegradable, tractable/intractable

The materials selected for study should include:

- solid wastes: paper, iron, aluminium, glass
- liquid wastes: oil, contaminated water
- gaseous wastes: sulfur dioxide, carbon dioxide
- radioactive wastes

Unit	Areas of Study	Focal Questions
1. Materials	1. Useful Materials	What properties of materials make them useful?
	2. Waste Materials	What makes a substance a waste material?
2. Chemistry in Everyday Life	1. The Atmosphere	How do we interact with the atmosphere?
	2. Water	Why is water essential to human society?
	3. A Chemical Product or Process of Local Importance	Why is this product/process important to our local community?
3. Chemistry and the Market Place	1. Consumer Chemistry	What means are available to ensure the quality of products we purchase?
	2. Industrial Chemistry	Which chemicals are produced in large quantities and why? What compromises must be made in the production of chemicals?
	3. Surfactants	How do surfactants work?
4. Energy and Matter	1. Supplying and Using	What factors influence the choice of energy sources?
	2. Food Chemistry	What principles does a chemist use to describe and classify foods?
	3. The Periodic Table: An Overview of Chemistry	How is chemistry of an element determined by its atomic structure? What are the origins of modern chemistry?

In Conclusion

This brief paper has not sought to abandon scientific concepts, processes and skills, as being of little worth to the majority of learners in our chemical education system. But more importantly it has argued that learning goals need to be embedded in knowledge content that has a strong claim in its own right, *i.e.* chemical knowledge of public worth. Environmental chemical education represents the opportunity to be socially useful in its focus and thereby educate future generations about maintaining planet earth as a viable place for human populations. It is now time to re-shape the chemistry curriculum on 'a need to know' basis rather than on the tradition of discipline based on purity.

References

Board of Secondary School Studies. (1987). *Senior Chemistry Syllabus*, Brisbane, Queensland.

Bucat, R. (1989). *The AAS School Chemistry Project: A Radical Curriculum Innovation*, in Science Education and the Quality of Life, ICASE Year Book, pp. 164-167.

Fensham, P.J. (1983). *Science for All.* Discussion paper of the Regional Meeting of UNESCO, Bangkok, August.

Victorian Curriculum and Assessment Board. (1989). *Chemistry Study Design*, Melbourne, Victoria.

ABSTRACT *Chemistry Related to Energy and the Environment in School Chemistry Education in Australia* **Robert B. Bucat, School of Chemistry, The University of Western Australia, NEDLANDS 6009, Western Australia, Australia** •Recent important innovations in Australian school chemistry curricula are briefly described. Without exception they attempt to portray and develop chemistry through its interaction with people as individuals and societies. The Australian Academy of Science School of Chemistry Project material includes a comprehensive coverage of environmental and energy-based chemistry as exemplars and applications within the course. In a more radical curriculum at the upper school level, a course to be implemented in 1991 in Victoria, is purely issue-based. Focus questions, many of which are related directly to energy and the environment are the vehicle for introduction of chemical facts, principles and concepts, which are introduced and developed only when necessary, and as far as necessary, to respond sensibly to the focus questions.

Chemistry Related to Energy and the Environment In School Chemistry Education in Australia

This report is selective in its choice of important examples and has not attempted to be comprehensive, nor exhaustive. In particular, it has focused on the formal education system only and has not considered the increasing availability of science centers, newsletters, information sheets, clubs and other resources provided by various agencies.

The first serious attempt to include (i) chemistry related to the environment and (ii) a study of energy in the context of real-world applications, in a significant curriculum in Australia is the Australian Academy of Science School of Chemistry Project materials "Elements of Chemistry: Earth, Air, Fire and Water", which is aimed at chemistry students in their final two years of secondary school. The philosophies underlying this course, which attempts to portray and develop chemistry through its interaction with people as individuals and as societies are described in the *Journal of Chemical Education*, Volume 65, No.9, September, 1988, pp.777-779.

As an indication of the extent of attention given to energy and the environment in this course, the directly relevant chapter headings or subheadings which provide the context for the chemistry content are shown in Table 1.

Table 1: Selected headings from "Elements of Chemistry: Earth, Air, Fire and Water"

1.9 Corrosion of Metals
- The Costs of Corrosion

1.11 Mineral Resources
- Economic Considerations of Mining
- Limitations of our Mineral Resources

1.12 Metal Extraction and Purification
- Energy Requirements of Reduction
- The Mining Industry

1.14 Carbon and its compounds
- Carbon Compounds from Fossil Fuel
- Coal
- Petroleum

1.16 Phosphorus and its compounds
- Phosphorus in Soils
- Phosphate Fertilizers
- Organo-phosphorus Insecticides
- Water Pollution by Phosphates

1.18 Halogens and their compounds
- Salt as a Raw Material
- Insecticides
- Herbicides
- Freons

2.1 Our Dependence on the Atmosphere
- Why is the Atmosphere Important to us?
- What is the Atmosphere made of?
- Layers in the Atmosphere
- Looking after the Atmosphere

2.2 The Gases of the Atmosphere
- The Carbon-Oxygen Cycle
- The Nitrogen Cycle

2.5 The Atmosphere as an Industrial Resource
- Where do the Chemicals that we use come from?

2.6 Air Pollution
- Common Pollutants of our Atmosphere
- Measuring Pollutant concentrations
- Localized Pollution of the Atmosphere
- Sulfur Dioxide
- Carbon Monoxide
- Photochemical smog
- Acid Rain
- Particles
- Global Pollution of the Atmosphere
- Carbon dioxide
- Freons
- Controlling Air Pollution
- Decisions by Society

3.1 Our Dependence on Energy
- Energy for Life
- Energy Usage through the Ages
- Energy Usage in Australia Today
- Our Responsibilities in Energy Usage

3.2 Sources and Forms of Energy
- Sources of Energy
- Depletable and Non-Depletable Energy Sources
- Forms of Energy
- Transformations of Energy
- The Law of Conservation of Energy

3.3 Fossil Fuels as Energy Sources
- What are fossil fuels?
- Our Uses of Fossil Fuels
- Reserves of Fossil Fuels
- Coal
- The composition of coals
- Heating value of coals
- The products of combustion of coal

Fuels produced from coal
Crude Oil
Combustion of fuels obtained from crude oil
Air pollution and the combustion of fuels
Energy or materials from crude oils
Petrol and Petrol Engines: A Case Study
Mechanical energy from petrol
The air: petrol ratio
Burning characteristics of petrols
Octane rating
Pollution control in cars

3.4 Alternatives to Fossil Fuels
Why do we need alternatives?
Nuclear Energy
Concerns about Nuclear Energy
Hydrogen
Hydrogen as a fuel
Storage of hydrogen
Solar Energy
Converting solar energy to heat
Production of hydrogen
Energy from Plant and Animal Matter
Ethanol from carbohydrates
Electrochemical Sources of Energy
Cells
The lead-acid battery as a source of power for cars
Electrochemical cells for the future
The Future

3.5 Food as Fuels: Carbohydrates
Our energy needs
The Origin of the Energy in Food
Enzymes, Energy Release and Energy Storage

3.6 Energy Transformations During Chemical Reactions

3.8 Energy and the Metals in Industry
Energy Usage in the Aluminum Industry
Energy Conservation in the Aluminum Industry
Links between Energy and Metals Production
The metals-energy spiral
Metals and coal
Metals and sources of energy other than coal
Metals and energy conservation
Preparing for the future

4.1 Our Dependence on Water

4.2 Water Resources: Quantity and Quality
Sources of Water
The Water cycle
The quality of Water From different sources
Some Effects of Human Activities
Measuring Water Quality
Water Quality Requirements for Different Uses
The Future

4.12 Water Treatment
The Need for Treatment of water
Treatment of Low-Salinity Water for Public supplies
Aeration
Removal of Suspended particles
Removal of dissolved organic matter
Disinfection
Addition of Chemicals
Hard Water
Softening Water by Boiling
Softening Water by Precipitation
Softening Water by Complex Ion Formation
Softening Water by Distillation
Softening Water by Ion Exchange
Softening Water by reverse osmosis
Desalination to produce Drinking Water
Waste Water Treatment

Each of the Australian States is responsible for the design and specification of its own syllabuses which, not surprisingly, vary considerably from State to State. Until now, energy (apart from academic treatments of heats of reaction and activation energy) and the environment have not been significant parts of formally stated school syllabuses, except as an optional topic in two States with a "core plus options" syllabus structure. So the Australian Academy of Science materials have not been produced as a response to innovative syllabuses. Rather, they attempt to lead the way. They additionally attempt to adequately serve existing traditional syllabuses by presentation of much of the standard content in new contexts (and new sequences). There is no doubt that these materials and their underlying philosophies have influenced attitudes around Australia and are now beginning to influence the design of school curricula. One particular example of this is the syllabus being developed in Victoria and which is briefly described below.

In South Australia, a curriculum team has produced innovative materials to suit a flexible syllabus definition at the Year 11 level (the penultimate year of secondary school). The South Australia Education Department's Year 11 guidelines, entitled "The Dimensions of Chemistry" are intended to assist schools to develop their own courses. They grew out of a concern that the content in Year 11 was influenced much more by the content of the matriculation course than by the content of the Science courses in Years 8 to 10. Course planning was still a "top-down" phenomenon. Not enough chemistry was taught in contexts which are meaningful to students.

The guidelines attempt to promote chemistry as a multi-dimensional subject with its social, economic, human, environmental, technological, industrial dimensions being important considerations in its presentation to students. It was accepted that chemistry taught should relate to everyday experiences of students through investigation of chemical issues and applications of chemistry.

Within the Guidelines there is a rationale and a minimum set of goals for the teaching of chemistry at Year 11. To support this brief "philosophical" statement a number of units have been written to exemplify the approach suggested. The titles of the units are - *Wine, Acids, Petrol, Tap Water, Sea Water, Iron and Steel, Agricultural; Chemicals, Copper and Electrochemistry.*

There are a number of important implications for teaching approaches and resources arising from the adoption of the Guidelines. To assist teachers implement the new approach proposed, a package of teaching resources has been put together for each of the above units. In-service activities based around teacher networks are proposed also to allow teachers to exchange ideas on teaching approaches.

An adventurous, issues-based curriculum is presently being designed for introduction at Years 11 and 12 in the State of Victoria. A basic assertion of the designers of this course is:

> *The study of chemistry should be set within the context of people, their environment and their society. For the majority of students, learning is more effective in the context of the application of chemical knowledge to technology and society. Therefore a thematic approach to chemistry has been adopted . . .*

The two-year course will consist of four units, each comprising three areas of study, which take materials and situations from everyday experience and use them to introduce students to chemical phenomena, knowledge, ideas and activities. Each area of study uses focal questions to define the breadth of the area within the context of chemistry-technology-society. Table 2 presents the units, areas of study and focal questions prescribed for this study design. An energy/environment component is obvious.

By way of example, classroom developmental questions seen to be appropriate for Unit 2, Area of Study 1:

- Why is the ozone layer important to life on Earth?
- How is "acid rain" produced and how can its effects be reduced?
- What is the greenhouse effect?
- What chemical reactions are brought about by lightning discharges?
- How can you stop your bicycle from rusting?
- How do we protect metals against corrosion?
- How does atmospheric pollution affect marble?

In case this description leads to the perception that the course is not real chemistry, the designers have analyzed the subject matter content related to this section, classified into eight "dimensions of chemistry". This analysis, performed similarly for each of the 12 areas of study, is displayed in Table 3.

The Victorian Certificate of Education course attempts to take learning beyond the recall of knowledge. For example, teachers are required to ensure that in each unit students should have experience of all of the following:

- Chemistry as a process which works towards solving real world problems using a variety of techniques.
- First hand data collection, its manipulation and interpretation.
- The use of chemical information and evaluation and decision making.
- Oral presentation of chemical information to a group, by extended classroom discussion or by formal presentation.
- Developing expertise in a specific area of chemistry and sharing that expertise with others.
- Considering the problems and responsibilities associated with handling potentially dangerous chemicals in the community.
- Reflecting on their own learning process.
- Working as a group to solve a problem.

There is a realization of the enormous teacher in-service task associated with this radical innovation.

Another current development is a decision by the Australian Academy of Science to produce eleven 64-page booklets making up an environmental sciences series which can form the basis for a two-year course of study at the senior high school. Production has commenced on modules entitled *Water, Soil, The Atmosphere, Forests, and Energy*, as well as an overview.

Tables 2 and 3 follow.

Table 2: Structure of the Victorian Certificate of Education Course

Unit	Areas of Study	Focal Questions
1. Materials	1. Useful Materials	What properties of materials makes them useful? How are materials produced, modified or treated to make them useful?
	2. Materials in Solution	Why is water essential to life?
	3. Waste Materials	What makes a substance a waste material?
2. Chemistry in Everyday Life	1. Chemistry of the Atmosphere	How do we interact with the atmosphere?
	2. Fibers andDyes	Why is water essential to human society?
	3. A Chemical Product or Process of Local Importance	Why is this product/process important to our local community?
3. Chemistry and the Market Place	1. Consumer Chemistry	How can we be assured of the quality of products we purchase?
	2. Industrial Chemistry	Which chemicals are produced in large quantities and why? What compromises must be made in the production of chemicals?
	3. Drugs and Surfactants	How does the human body deal with foreign chemical substances? How do cleaning products work?
4. Energy Matters	1. Supplying and Using Energy	What compromises must be made in the choice of energy sources?
	2. Food Chemistry	What are the characteristics of a nutritious food?
	3. The Development of Chemistry	What are the origins of chemical science? Who gave us the chemistry we have now?

Table 3. Content analysis for "Chemistry of the Atmosphere" area of study in the Victorian Certificate Education Course

Dimensions of Chemistry	Must be covered in this area of study.	Must be covered in Unit 2. May be covered in this area of study	May be introduced or revisited in developing a pathway through this area of study
Activities of Chemists	•data evaluation	•corrosion protection •communication •investigation of properties	•separation of mixtures
Useful or Common Materials	•oxygen •nitrogen •ozone •carbon dioxide •nitrogen oxides •photochemical smog	•metals - iron, aluminium, copper, zinc	•atmospheric pollution, including acid rain •sulfur dioxide
Chemical Processes	•respiration •photosynthesis	•oxidation/reduction •energy transformations in galvanic cells •corrosion	•solubility of gases in liquids
Chemical Language	•allotropes •analysis	•oxidation/reduction half equations •corrosion •sacrificial protection •anode/cathode	
Classification		•oxidants and reductants	•acids and bases
Quantitative Chemistry	•gas laws •concentration	•composition •mole concept •molarity	•balancing equations
Energy	•greenhouse effect •depletion of ozone layer	•transformation of energy	
Particle Theory	•kinetic molecular theory	•electron transfer •mole concept •atomic/ molecular weight	

ABSTRACT *Chemistry, Technology and Society* **Reiko Isuyama Instituto de Quimicas, Universidade de São Paulo, Caixa Postal 20.780, CEP 01498, São Paulo, S.P., Brasil** •The extent of the impact generated by chemical industries far exceeds the physical limits of the plants. Examples in Brazil of disregard are: Paraná pine forests are practically razed to the ground to produce cellulose; the natural characteristics of the Amazon Basin river is considerably jeopardized by mining industries; unwanted genetic mutations as a result of polluting gases let out by Brazil's largest chemical industry conglomerate in Cubatão. •Hence the need for extension of scope in the study of chemistry to drill into students the responsibility, as chemist, in environmental clearance provisions. Such extension must reach from the origins of raw materials insofar as the consequences of their extraction, to the residues disposed in the atmosphere and hydrosystems. The concept itself of the system in chemistry must be expanded. The project "Chemistry, Technology and Society", underway in the Institute of Chemistry of the University of São Paulo, envisages to render didactic material for an undergraduate chemistry course withthis view. It will be in the form of subject modules, listing statistical data, processes, origin of raw materials and treatment of residues, introduced in the optic of economic and social issues. •Its development is being undertaken in a joint effort with the Department of Chemistry of the University of York, U.K.

Brazilian Energy/Environment Panorama

Brazil

I. Energy

Today's Brazilian energy production stands on the petroleum, biomass and hydroelectric sources tripod. Conservation of energy, which might result in an additional prop, is still not duly taken into account here as an investment.

Table 1(follows) shows rates of offer and consumption of energy in 1986, a projection to the year 2000 and the corresponding average rate of increase.

Table 2(follows) quotes the prices of the various energy sources in identical conditions, expressed in the same units.

I.1. Petroleum

The 70's petroleum price increase in the international market prompted the prospecting and production of that commodity in this country, as well as the definition of clear aims in energy conservation, to ensure reductions in the external dependence of energy: maximum utilization of national energy sources and to increase the production of national petroleum.

As a result, the petroleum consumption rate of 70% at the time dropped to 31.5% in the eighties. A projection of tendencies towards the year 2000 in petroleum by-products consumption looks quite preoccupying: liquefied gas rises from 12.7% in 1988 to 13.5% in 2000, medium distilate rises from 42.5% in 1988 to 49.6% in 2000, as well as the production of gasoline above its forseen consumption, require change in policy, to prevent a very serious picture in the year 2000.

I.2. Biomass

For tropical countries with large tree growing potential, like Brazil, the most adequate sources of energy are: alcohol, firewood and charcoal.

Bagasse (crushed sugar cane), offers a significant potential in the Brazilian energy matrix and could be used as a substitute for oil to co-generate electricity.

The alcohol program still faces economic difficulties due to the high cost of production, but considering its renewability and its political advantage, this program deserves attention and incentive from the government.

I.3. Hydroelectric/Electricity

In Brazil, the planning for this sector covers periods of 5, 10 and 20 years. The 2010 Plan, a 20-year program which started in 1987, is based on the principles of minimum cost and of respect for the environmental and technological and institutional aspects of natural resources.

An analogous initiative is the "Procel Program" which aims at economy of electric energy, forseeing for 2005 an economy of about 10% of global consumption.

Table 3 (follows) is a breakdown of contributions of main energy generation resources in percent

In the 2010 Plan we expect an investment of US\$ 24000 x 10^6 for 1989/1998, for the construction of 41 hydroelectric, 5 thermoelectric and 2 nuclear plants. A shortage of funds for investment in this sector is causing serious delays which certainly will entail energy deficits very early in the next decade, thus jeopardizing the country's economic growth.

II. Environment

In Brazil, after 1981, with the establishment of the National Program for Environment, all technological development projects must include environmental planning as one of the requirements for the analysis of feasibility; but a number of hindering factors, such as: insufficient allocation of funds to implement an environmental program; deficit of qualified personnel; lack of interaction between economic growth and nature conservation programs; our population's very limited acquaintance with environmental principles, have brought in their wake interruptions or delays to important projects.

From the environmental view point, issues associated with the *usage* of energy sources are in a better situation than those realted to the *generation* of energy. For instance, in the metropolitan region of São Paulo, where a severe control on the industries has been kept, pollution rates were reduced to a plateau from which further reductions can only be attained by means of a significant improvement on motors. Recently, in 1986, a law was passed, forcing the automobile industry to control the emission of pollutants by cars.

A re-forestation program is being developed in the University of São Paulo, aiming at producing raw-materials, and the protection of and deceleration of the devastation of the Amazon forest. An additional objective of this program is to combat the greenhouse effect worsened by forest fires. A thorough new mapping will permit identification of areas where sylviculture should be stimulated.

The establishment of an under-graduate course on ecology at the State University of São Paulo, as of 1990, for specialized professionals majoring in this area should open horizons to an effective planning and usage of natural resource without injuring the nature around us.

References

This article, including data, is based on a series of seminars entitled: "Year 2000, an Energetic Matrix", promoted by São Paulo State Federation of Industries and the Department of Energy

Table 1:

Energy Sources	1986		2000		Average rate increase	
	% offer	% consu	% offer	% consu.	% offer	% consu.
Petroleum and by-products	30 2	33 0	25 5	28 1	4 2	4 2
Natural gas	1 8	2 0	7 9	5 3	17 4	13 2
Coal and coke	5 7	5 8	7 3	7 6	7 4	7 5
Hydraulic	31 8	30 5	37 5	37 2	6 8	7 8
Fire wood and charcoal	17 6	14 6	9 7	8 5	1 2	1 4
Suger cane and by-products	12 3	13 4	1 0	12 1	4 6	4 7
Other sources (including uranium)	0 6	0 7	1 2	1 2	10 6	10 4

Table 2:

<u>Energy Sources</u>	<u>US$/t PE</u>
Petroleum	93.20
Natural Gas	93.20
Alcohol	298.00
Fire Wood	193.10
Electricity from:	
- hydraulic sources	140.00
- coal	224.50
- oil	370.70
- nuclear sources	265.90
- bagasse	167.60

Table 3:

Resources	1986	1990	1995	2000	2005	2010
Hydro	90.2	91.3	91.0	90.6	89.4	88.6
Thermal	9.8	8.7	9.0	9.4	10.6	11.4
- Charcoal	1.6	2.2	2.3	2.9	3.5	4.1
- Nuclear	1.4	1.0	2.3	3.6	4.3	5.1
- Others	6.8	5.5	4.4	3.5	2.8	2.2

ABSTRACT *The Strategy of Environmental Education in Bulgaria* **Panayot R. Bontchev, University of Sofia, Faculty of Chemistry, 1 Anton Ivano Str., Sofia 1126, Bulgaria** •Environmental education is a basic component of the ecological policy of our state and of our educational system. The efforts in this field are concentrated mainly in four directions: 1) Ecological education of the young generation, cultivating in it a system of ecological knowledge and of a relevant way of thinking and of action; 2) Creation of ecological culture among all different groups of the population and not only among those engaged in material production; 3) Appropriate training of the future specialists, educated in the sphere of secondary and higher education, to enable them to make proper decisions and take actions having always in mind the ecological aspects of the problems; 4) Post graduate training of all technical specialists on environmental protection and on the rational utilization of national resources, making them ready to organize, conduct and control the research organization, design other activities in this field on a local, regional or national scale. For this purpose a national system is developed and put in action for environmental protection education and propaganda.

Energy and Environment - National Problems and their reflection on teaching Chemistry in Bulgaria

Bulgaria

The problem for power development in Bulgaria is strongly embarrassed by the shortage of resources, both of water and fuel. The country is not rich of rivers and in addition, most of our rivers are quite small. The restricted capacity of waterpower is practically completely utilized and does not offer another possibility for the building of new hydro-power systems.

On the other hand, the country is deficient also in sources of coal and oil. Most of the coal-fields are of low or very low quality, with a low caloricity and a higher sulphur and ash content. This fact creates a lot of problems, the central one being the high extent of pollution with sulphur oxides connected with the utilization of these coal-beds. At the moment, the thermo-electric power stations are among the biggest sources of air pollution in this country.

Additional troubles arise from the immense amounts of ash, utilized only to a small extent, and deposited as huge hills around the power stations. This waste product is obtained in a finely dispersed form, and hence is very easily scattered by winds and the rains, creating additional pollution problems despite the efforts for their grassing and being planted with shrubs and trees.

The use of fuel oil instead of coal, that was realized partially some 15-20 years ago, did not change essentially the situation due to the relatively high level of sulphur content both in the Bulgarian oil and in the imported oil as well. The only advantage of this substitution was the absence of the hills of ash around the stations of this type, but on the other hand, due to the higher temperatures realized, the percentage of nitrogen oxides in the flue gases was higher. The level of air pollution still remained quite high and finally resulted in two very important decisions taken on a governmental level:

- to stop further power development on the basis of thermal power stations using liquid and solid fuel; and
- to close thermal power stations that contribute most of all for the pollution with sulphur oxides and the acid rains formation connected with it.

The general trend now in the Bulgarian energetics is the development of its nuclear branch. At present, about 40% of the energy produced in our country comes from nuclear power stations and the tendency is to increase further this percentage. After the Chernobil tragedy, however, the Bulgarian government invested appreciable funds for additional improvement of the protective and control systems of the nuclear power-stations in order to guarantee their safe and normal work, even in extreme conditions, as for example, during earthquakes.

All these problems and characteristic features of the Bulgarian energetics of today reflect in the curriculums of secondary school and university education, and on a first place - in the curriculums of chemistry.

The general and the special national problems concerning the air-pollution with sulphur and nitrogen oxides from the thermal power stations are discussed in the following parts of these curriculums:

- inorganic chemistry: i) carbon; coal and solid fuels; sulphur content of coals and the ecological importance of this parameter; ii) sulphur and nitrogen; sulphur and nitrogen oxides and their role as pollutants; the problem of acid rains;
- organic chemistry: i) petroleum and its derivatives as liquid fuels; sulphur content of petroleum; ii) ecological evaluation of the liquid fuels;
- chemical technology and energetics: i) chemical sources of energy and evaluation of their ecological purity; ii) nuclear energetics and the problem of the radioactive contamination; iii) utilization of the waste products from the industry and energetics.

It must be emphasized that some aspects of these topics are included and discussed not only in the curriculum of chemistry but also in the specialized ecological courses planned for the last year of the secondary and special technical schools. They are partially included also in the curriculum of some other disciplines such as biology, physics, geography etc.

Recently, pupils of many Bulgarian secondary schools participate also in practical out-of-school activities directed towards the determination of many pollutants in air, fresh waters, soils, plants, food etc. The determination of sulphur and nitrogen oxides in air particularly in industrial regions, of the acidity of rain water, of water samples from rivers, lakes etc, are among the experimental studies accepted readily by the pupils and provided most widely by them.

As to the university education, these problems are included in the curriculums of chemistry and chemical technology for all students of chemistry and in the curriculum of chemistry for the students of physics and biology, in the curriculums of the technical universities, preparing engineers of different kinds, including chemical and power engineers and other technical specialists.

ABSTRACT *Where has all the Energy Gone?* **Reg Friesen, Department of Chemistry, University of Waterloo, Waterloo, Ontario, Canada N2L 3G1** •Energy is ubiquitous. We demand it, it is supplied to us, we consume it, and we release energy to our environment. We cannot create energy; we can only find it and use it. Every physical and chemical act is an energy transaction. Every energy transaction is inefficient. Every act degrades the available energy. To be the best energy stewards, we should reduce energy use to zero. Yet, to stay alive and be social, we must use energy. Will future generations think that we acted wisely on their behalf? How shall we decide which energy conversions are allowable, and which are too inefficient? Increasingly, this global responsibility will limit personal and local freedoms in energy matters. Energy sources, consumption and release can be studied in every science curriculum. But energy in particular Canadian curricula is viewed in limited, idealistic terms. My paper is simply a summary of the presentation of energy in Ontario science curricula.

Where Has all the Energy Gone?

First, some energy-related excerpts from Ontario Curriculum Guidelines:

Chemistry (school-leaving year):

Attitudinal objective: Students will be encouraged to develop an appreciation of the fact that energy change is one of the more important features of all chemical reactions. Skill objectives: Students will have the opportunity to develop skill in calculating the heat of reaction from a set of calorimetric data, and by summation given appropriate equations and their heats of reaction, and using standard heat-of-formation tables. Knowledge objectives: Students will be expected to define or state the meaning of the following: energy (exothermic, endothermic, enthalpy); change of enthalpy or heat of reaction; Hess's law (an example of the law of conservation of energy); standard heat of formation; translational, vibrational and rotational molecular enthalpy; molar enthalpy; explain the storage of energy by molecules in terms of potential and kinetic energy; compare the magnitudes of the energy involved in physical, chemical and nuclear changes.

Applications: Energy is released slowly from food; quickly, but in a controlled manner, from fuels; and at an uncontrolled, rapid rate from explosives. Nuclear reactions produced through the CANDU reactor provide a significant proportion of our electrical energy. Through electrolysis, hydrogen can be used as a means of storing energy from another source in a form that is more easily transported. Coal gasification is useful for similar reasons.

Societal implications: The process of coal gasification requires energy input. The amount of energy required must be taken into account in calculating the net energy available in the final fuel. Although the heats of reaction can be theoretically calculated, not all of this energy is actually available, because some is always lost during conversion. The production of electrical energy from nuclear reactions has both positive and negative implications.

Science in Society (School-leaving year):

Attitudinal objectives: an appreciation of the importance of energy in our lives; a commitment to active responsibility to maintain and improve the quality of the physical environment.

Knowledge objectives: explain how a lifestyle of high energy consumption affects the environment; compare and contrast various sources of energy in terms of their cost, availability, environmental impact, and social implications in order to understand their advantages and limitations in a Canadian context; define *nuclear energy*; explain how nuclear energy was first produced and the milieu of its origin; describe several positive applications of nuclear energy (*e.g.*, electricity generation, cancer treatment, radioisotopes) and indicate their effect on society; describe the potential dangers of nuclear energy (*e.g.*, meltdowns, radiation leaks, contamination, nuclear weapons), compare different types of nuclear reactors with respect to their design, efficiency, and safety; determine the possible consequences of eliminating nuclear energy from the power grid in Canada.

Canada

Societal Implications: education may be needed to help people determine attitudes, policies, and lifestyles required for the maintenance of a healthy environment.

Environmental Science (Grade 10; Energy Systems; 15% of course):

Attitudinal objectives: an appreciation of human dependence on energy for survival; a questioning attitude concerning human dependence on non-renewable energy; a curiosity about the benefits and disadvantages of developing renewable energy forms; a desire to change their own lifestyles in order to conserve energy. (There follow two pages of skills and knowledge objectives, student activities, applications, societal implications, evaluation and teaching suggestions.)

Environmental Science (Grade 12; Energy Resources; 15% of course):

Attitudinal objectives: an appreciation of the dependence of all organisms on energy for survival; a concern for the heavy reliance of the Western world on non-renewable energy forms; a questioning attitude towards lifestyles that involve a wasteful use of energy; a supportive attitude towards scientific research that is aimed at increasing the efficiency of energy use. (There follow two pages of skills and knowledge objectives, student activities, applications, societal implications, evaluation and teaching suggestions.)

Biology (school-leaving year):

Knowledge objective: explain the concept of bond energy and use this concept to account for exergonic and endergonic chemical reactions; describe, in general terms, how the first and second laws of thermodynamics apply to energy use and transformation in the biosphere and in the living cell; explain and compare the release of energy and the production of ATP that results from the anaerobic (glycolysis and lactic acid fermentation) and the aerobic (citric acid cycle) catabolism of glucose.

Physics (school-leaving year):

Attitudinal objectives: an appreciation for the importance of the conservation of energy and momentum in the analysis of collisions between objects; some interest in careers in technology and engineering that require an understanding of momentum and energy.

Societal implications: the increasing use of energy in contemporary society has led to research into and development of more efficient methods of energy transfer. For example, cars have become more fuel-efficient, smaller, more aerodynamically designed, and safer in the event of a collision; the need for more energy has led to the development of new technologies involving the conversion of energy from the sun, wind and tides. This activity has also provided new career opportunities.

And now, my own remarks:

The uses of chemicals fall under two main headings:

(a) As a source of energy for living organisms, heating, explosions, running machines and vehicles;

(b) As a way of doing useful things for pleasure.

Under heading (b) we make pharmaceuticals or we use natural products to arrest diseases. Fertilizers increase crop production. Perfumes, cosmetics and dyes give pleasure. Extensive oxidation or combustion are not characteristic of these uses. It is more common to find small functional group modifications in the chemicals. The energy involved in the chemical transformation during use is not the principal criterion for choosing to use the chemical. The modified chemical may harm the environment, it may be judged harmless, or it may benefit the environment.

Under heading (a) the chemicals, foods and fuels, are largely destroyed by extensive oxidation or combustion. It is the release of energy that is the criterion of usefulness. In these applications, fuel consumption is commonly on a large-scale, and there may be supply problems. The main products may be water and carbon dioxide. The minor products (carbon monoxide, oxides of nitrogen and sulfur and many others) may be more obviously deleterious; the difficulty is that the minor products are part of such a large-scale operation that they are produced in quantities that influence the environment seriously.

While one of the first things we teach in chemical and physical changes is that 'energy is conserved,' we often fail to emphasize that such changes always involve some dispersal of energy to places where it is much less accessible than before. There is also an increase in disorder. This cost in degraded energy is one of the concerns confronting the use of energy in the world. Bleakly, to conserve energy, *do as little as possible.* If you insist on eating, travelling, building, healing, writing - in short, living the life you probably do - your existence has its toll on this planet. A corollary point is that five billion people on Earth will waste more than four billion.

So we do need to know a lot about the energy stored, or that can be stored, in chemical bonds. How can we organize energy storage most efficiently, given that every operation we try to do with energy will lose some? Is there a way to catch the radiation from our great, beneficent nuclear reactor, the Sun, directly into a chemical storage device (photocell)? Of coal-burning, petroleum, natural gas, hydroelectric power, ocean-wave energy, wind, nuclear reactions, fusion, geothermal sources, what is the most acceptable energy source? What are the most efficient ways to transport energy?

ABSTRACT *Energy in Alberta's Proposed Science 10 - 20 - 30 Program* Oliver C. Lantz, Curriculum Support Branch, Alberta Education, 5th Floor, Devonian Building, 11160 Jasper Avenue, Edmonton, Alberta, Canada T5K 0L2 •The secondary school science program in Alberta is currently undergoing a major revision. The planned changes for senior high school include the introduction of two new general science sequences, Science 10 - 20 - 30 (advanced diploma) and 14 - 24 (general diploma), as well as major revisions to the existing biology, chemistry, and physics courses. The new science program will emphasize the interactions among science, technology and society (STS) in all junior and senior high school science courses. Through the STS approach, environmental concems will be addressed in all the new science courses in Alberta. •The topic, "Energy and Environment", will be dealt with extensively in the Science 10 - 20 - 30 program, a three course sequence that allows students to meet the science credit requirements of the Alberta Advanced High School Diploma. The concept of energy is a key element in the conceptual framework of the program, Each year of the program includes a unit of study on energy, with each unit taking a different perspective on the topic. The Science 10 unit, :Energy Systems", emphasizes the nature of science; the Science 20 unit, "Biomass Energy". emphasizes the interrelation of science and technology; and the science 30 unit, "Implications of Energy Use", emphasizes the interconnections of science, technology, and society.

Energy in Alberta's Proposed Science 10-20-30 Program

The secondary school science program in Alberta is currently undergoing a major revision. The planned changes for senior high school include the introduction of two new general science sequences, Science 10-20-30 (advanced diploma) and Science 14-24 (general diploma), as well as major revisions to the existing biology, chemistry, and physics courses. The new science program will emphasize the interactions among science, technology, and society (STS) in all junior and senior high school science courses. Through the STS approach, environmental concerns will be addressed in all the new science courses in Alberta. The topic, "Energy and the Environment," will be dealt with extensively in the 10-20-30 sequence.

The proposed Science 10-20-30 program provides a three-course sequence that will allow students to meet the science credit requirements of the Advanced High School Diploma. The Science 10-20-30 program is outlined in Figure 1. Each year of the program includes a unit of study on energy, with each unit taking a different perspective on the topic. The Science 10 unit, "Energy Systems", emphasizes the nature of science; the Science 20 unit, "Biomass Energy", emphasizes the interrelation of science and technology; and the Science 30 unit, "Implications of Energy Use", emphasizes the interconnections of science, technology and society. The following excerpts from the program of studies indicate the concepts that are to be developed in each of the three energy units.

Science 10 (Unit 4) Energy Systems

1. *Students will be expected to* demonstrate an understanding that energy can be measured in quantitative terms.
   - 1.1 Recall from Grade 7 science, Unit 3, the concepts of force and motion.
   - 1.2 Determine, from experimentation, the relationship among distance, speed and time.
   - 1.3 Define acceleration as a change in speed over time.
   - 1.4 State Newton's First and Second Laws of Motion, and use the second law to relate force, acceleration and motion.
   - 1.5 Define *work* as the transfer of mechanical energy, and as a function of force times distance.
   - 1.6 Recall from Grade 9 science, Unit 3, that heat is a form of energy, and list other forms of energy.
   - 1.7 Define *energy* as the ability to do work.
   - 1.8 Identify and define various units of energy (calorie, joule, kilowatt-hour).
   - 1.9 Derive joules and kilowatt-hours from fundamental SI units.
   - 1.10 Derive joules from kilowatt-hours and vice versa.
2. *Students will be expected to* demonstrate an understanding that a model of an energy system can be organized into input energy, conversion and output energy.
   - 2.1 Recall, from Grade 8 science, Unit 2, the concept of energy systems, and identify and describe the input and output component in selected energy systems.
   - 2.2 Define *mechanical energy* as the sum of potential energy and kinetic energy.
   - 2.3 Describe qualitatively and quantitatively the conversion of energy in a given system.
   - 2.4 Recall from Unit 3, *heat of fusion*, *heat of vaporization*, and *specific heat capacity*.
   - 2.5 Recall from Grade 8 science, Unit 2, that mechanical systems convert energy from one form to another, and trace the energy inputs, conversions and outputs of several different energy systems.
   - 2.6 Compare and contrast selected technologies (toaster, microwave

oven, gasoline engine, water turbine) in terms of the energy system model.

3. *Students will be expected to* demonstrate an understanding that energy appears to be conserved during interactions between objects.
   - 3.1 State the law of conservation of energy as the sum of initial energies is equal to the sum of final energies in a system.
   - 3.2 State the first Law of Thermodynamics as an application of the Law of Conservation of Energy.
   - 3.3 Apply quantitatively the Law of Conservation of Energy to energy conversion and transfer.
   - 3.4 Describe with examples, how the Law of Conservation of Energy was developed through observation and interpretation.
4. *Students will be expected to* demonstrate an understanding that energy can be lost from an energy system.
   - 4.1 Quantify the energy inputs and outputs of everal energy systems.
   - 4.2 Calculate the amount of energy apparently last from a selected system.
   - 4.3 Relate the concept of conservation of energy to explanations for apparent loss of energy from energy systems.
   - 4.4 Define and calculate "power" as the rate of energy transfer.
5. *Students will be expected to* demonstrate an understanding that the efficiency of an energy system can be calculated.
   - 5.1 Define *efficiency* of an energy system as the ration of energy input to useful energy output.
   - 5.2 Calculate the efficiency of a selected energy system.
   - 5.3 Compare and contrast the energy efficiency of several selected energy systems.
6. *Students will be expected to* demonstrate an understanding that awareness of personal energy consumption patterns can facilitate responsible energy use.
   - 6.1 Analyze personal lifestyles to identify minimum personal energy requirements.
   - 6.2 Evaluate personal energy alternatives in terms of efficiency (*e.g.*, microwave or conventional oven, forced air or hot water heating).
   - 6.3 Apply knowledge of efficiency of alternative energy systems to make responsible choices regarding personal energy consumption.

<u>Science 20 (Unit 3) Biomass Energy</u>

1. *Students will be expected to* demonstrate an understanding that life on earth depends upon a continual supply of solar energy.
   - 1.1 Outline the sequence of events in the fusion of hydrogen that result in the production of solar energy.
   - 1.2 Describe the forms of energy that radiate from the sun as a result of the fusion reaction.
   - 1.3 Recall from Science 10, Unit 1, mitochondria as the site of respiration, and identify chloroplasts as the site of photosynthesis.
   - 1.4 Describe, in terms of energy flow, the relationships among solar energy, photosynthesis, respiration and the maintenance of life.
2. *Students will be expected to* demonstrate an understanding that technology has played an important role in scientists' understanding of the process of photosynthesis and biomass energy.
   - 2.1 Explain the relationship between photosynthesis and biomass energy.
   - 2.2 Identify chlorophyll as the main plant pigment that absorbs solar energy.
   - 2.3 Explain in general terms how, by initiating a series of chemical reactions in chlorophyll, the sun's energy is incorporated into the energy-rich molecules (carbohydrates) that compose biomass.
   - 2.4 Explain why the overall reaction of photosynthesis can be summarized as $6CO_2 + 12H_2O$ + sun's energy $\longrightarrow C_6H_{12}O_6 + 6O_2 + 6H_2O$.
   - 2.5 Describe how the technological application of isotopic tracers and chromatography techniques assists scientists in deciphering the series of chemical reactions that comprise the process of photosynthesis.
   - 2.6 Describe in general terms the progress that is being made by scientists to simulate photosynthesis in the laboratory and evaluate the potential implications that such a breakthrough would have on food production.
   - 2.7 Evaluate the effect of one or two human activities (*e.g.*, over-exploitation of timber resources, diversion of water to cities, desertification from overgrazing, monoculture, atmospheric pollution) on global photosynthesis.
3. *Students will be expected to* demonstrate an understanding that consumers reverse the photosynthetic reaction by releasing biomass through cellular respiration.
   - 3.1 Explain why cellular respiration occurs in producers as well as consumers.
   - 3.2 Compare aerobic respiration with anaerobic respiration as to end products and the amount of useable energy released.
   - 3.3 Outline why the process of aerobic respiration can be summarized as $C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O$ + energy.
   - 3.4 Compare cellular respiration to combustion of fuels.

3.5 Compare and contrast photosynthesis and respiration.

3.6 Recall from Science 10, Unit 4, the concept of energy systems, and summarize how the conversion of solar energy into chemical energy for life processes through photosynthesis and respiration comprises an energy system.

4. *Students will be expected to* demonstrate an understanding that the technology of producing alcoholic "spirits" is based on the biochemistry of alcoholic fermentation.

4.1 Define *fermentation* and classify the types on the basis of end products.

4.2 Identify the categories of organisms (bacteria and yeasts) that carry out fermentation.

4.3 Describe the kind of organisms (yeasts) that can carry out alcoholic fermentation.

4.4 Summarize the process of alcoholic fermentation as $C_6H_{12}O_6 \longrightarrow 2C_2H_5OH + 2CO_2$ + energy.

4.5 Describe one or two technologies that have adapted alcoholic fermentation to the brewing and baking industries.

5. *Students will be expected to* demonstrate an understanding that the production of biofuels depends upon fermentation.

5.1 Describe the kind of organisms (bacteria) that can carry out non-alcoholic fermentation.

5.2 Explain how different end products of fermentation are used in the production of biofuels.

5.3 Explain how recent biotechnical research has increased the efficiency of the fermentation process.

6. *Students will be expected to* demonstrate an understanding that scientists are developing technology to produce biofuels.

6.1 Recall from Science 20, Unit 1, the combustion of fossil fuels, describe the composition of biogas and identify methane as the major fuel ingredient.

6.2 Outline the technological process used to produce biogas.

6.3 Identify the uses of methane as a fuel.

6.4 Outline the technological process and the chemical sequence of events used to convert methane into methanol.

6.5 Evaluate the advantages and disadvantages of using methanol as a fuel.

6.6 Describe a Canadian technology designed to produce fuel out of the sludge that remains after biogas generation.

6.7 Recall from Science 20, Unit 2, considerations of food production, and explain how ethanol can be produced from food crops such as grains, corn, potatoes, sugar beets, and sugar cane.

6.8 Identify the uses of ethanol as a fuel.

6.9 Evaluate the issue of growing food crop plants specifically for their energy content.

6.10 Compare the use of biomass as an energy source in Canada with that of other countries.

6.11 Evaluate the advantages and disadvantages of using biomass for fuel in Alberta.

<u>**Science 30 (Unit 2) Implications of Energy Use**</u>

1. *Students will be expected to* demonstrate an understanding of the scientific principles related to solar, chemical, geothermal, hydroelectric, wind, tidal and nuclear energy resources and conversion technologies.

1.1 Apply quantitatively the mass energy equivalency to the solar fusion reaction.

1.2 Define *waves* as a means of energy transmission.

1.3 Recall electromagnetic radiation from Science 20, Unit 4, and state that electromagnetic radiation exhibits both wave and particle behaviors.

1.4 Recall from Science 20, Unit 4, that the sun plays the major role in providing energy to earth, and describe quantitatively the conversion of solar radiation to electrical energy.

1.5 Compare and contrast the bio-geological processes by which solar energy is converted to cola and crude oil.

1.6 Compare and contrast the geophysical and meteorological characteristics that affect the availability of geothermal, hydroelectric, tidal and wind energy resources.

1.7 Apply quantitatively the mass energy equivalency to the nuclear fission reaction.

1.8 Describe the scientific and technological processes by which nuclear energy is converted to heat energy in the CANDU reactor.

1.9 Recall from Science 10, Unit 3, that water is abundant and easily converted to steam, and explain qualitatively the physical principles employed in the functioning of steam, water and wind turbines.

1.10 Apply the principles of electromagnetic induction when explaining the structure and function of the simple generator and the motor.

1.11 Compare and contrast the simple generator and the motor.

1.12 Compare and contrast the simple AC and DC generator and the motor.

2. *Students will be expected to* demonstrate an understanding that responsible energy use underlines the need for technologies that increase efficiency and conservation.
   - 2.1 Outline a method of energy collection, conversion, or storage that illustrates how changing technologies have enhanced these methods.
   - 2.2 Recall from Science 10, Unit 4, that energy inputs and outputs can be determined, and describe the factors of an energy conversion system which reduce/enhance efficiency.
   - 2.3 Compare old and new technologies of energy conversion in terms of efficiency.
   - 2.4 Compare fuels as to energy efficiency.
   - 2.5 List socio-economic and environmental reasons for concern regarding the efficiency of energy conversion systems.
   - 2.6 Describe qualitatively, using appropriate scientific principles, the operation of the catalytic converter and the electrostatic precipitator in reducing emissions of pollutants.
   - 2.7 Describe energy conservation methods (*e.g.*, insulation technology, recycling of waste heat, lifestyle adjustments, energy efficient machines.)
   - 2.8 Analyze a selected system or institution for energy conservation (*e.g.*, the school, or a furnace).
3. *Students will be expected to* demonstrate an understanding that distribution and use of energy resources varies globally and has environmental, societal, economic, and political implications.
   - 3.1 Recall from Social Studies 20 the interdependence in the global environment, and relate global energy resource distribution to global energy use.
   - 3.2 Itemize and classify Canadian energy resources as renewable or non-renewable.
   - 3.3 Compare the geographical distribution of energy resources with energy requirements in Canada.
   - 3.4 Compare and contrast one renewable with one non-renewable Canadian energy resource in terms of availability, cost and environmental impact.
   - 3.5 Compare and evaluate Canadian resource availability to the global scene.
   - 3.6 Identify the energy resources that fuel Alberta's economy.
   - 3.7 Recall from Science 30, Unit 1, the oil and natural gas industry, and describe how each of the steps (*i.e.*, procurement, refinement, conversion, transmission, transport) involved in energy use affects the environment.
   - 3.8 Relate from an historical perspective, energy consumption patterns to technological advances.
   - 3.9 Describe and classify global patterns of energy use in terms of economic development.
   - 3.10 Compare and contrast energy consumption in an industrially underdeveloped nation with energy consumption in Canada.
   - 3.11 Recall from Science, 10 Unit 2, the model of the atmosphere, and from Science 20, Unit 1, the damage being done to the environment, and predict the effect of increased fossil fuel consumption, deforestation, and increased particulate matter in the atmosphere, upon the planetary energy balance.
   - 3.12 Discuss the significance of environmental, economic, societal, and political factors, that impact on the development of an energy resource such as nuclear power or hydropower.
4. *Students will be expected to* demonstrate an understanding that technological advances and altered societal demands have to be considered in planning for future energy requirements.
   - 4.1 Predict future energy requirements regarding population growth, industrial expansion, and historical patters, given relevant data.
   - 4.2 Compare current energy reserves with predicted needs for Canada.
   - 4.3 Discuss the possibility of future energy shortages.
   - 4.4 Assess the impact of current societal factors for their impact on energy needs of the future.
   - 4.5 Differentiate between conventional and alternative energy sources and give examples of each.
   - 4.6 Cite on or two examples of how emerging technologies can change the balance between renewable and non-renewable resource use.

Science 10 (5 credits)

← Required Component (80%) → *Elective Component (20%)*

Unit	*Emphasis*
1. Body in Balance	**ST**
2. The Changing Earth	**NS**
3. Importance of Water	**STS**
4. Energy Systems	**NS**

Enrichment

Remediation

Innovation

Science 20 (5 credits)

Required Component (80%) → *Elective Component (20%)*

Unit	Emphasis
1. Chemical Change in the Environment	STS
2. Technology and Fcod	ST
3. Biomass Energy	ST
4. The Expanding Universe	NS

Elective Component: Enrichment, Remediation, Innovation

Science 30 (5 credits)

Required Component (80%) → *Elective Component (20%)*

Unit	Emphasis
1. Canadian Chemical Industries	ST
2. Implications of Energy Use	STS
3. Distance Communications	ST
4. Genetics and Biotechnology	STS

Elective Component: Enrichment, Remediation, Innovation

NT - Nature of Science
ST - Science and Technology
STS - Science, Technology and Society

Figure 1: Science 10-20-30 Program Overview

ABSTRACT *Chemistry in Interdisciplinary Environmental Science Teaching* **Birgit Tejg Jensen, Department of Chemistry, Aarhus University, DK - 8000 Aarhus C, Denmark** •An inter-multi disciplinary environmental science course at masters degree level has been held for six years at Aarhus University. The course involves students and teachers from four faculties and is also offered as in-service training. •Energy-environment is a central theme in the course because all disciplines can give an important professional contribution to the subject. •In Denmark, the environmental aspect of energy production plays an increasing role. The demands to the power plants to introduce clean technology and end of line cleaning are tightened up. This development is a special challenge to the chemist. At first it requires to being up to date and finding new teaching material each year. Secondly, the opportunities to illustrate aspects of classical and environmental chemistry are manifold.

Energy-Environment Situation in Denmark, 1989

The three influential aspects of decisions in energy planning are:

1. Secure fuel and energy supply.
2. Economy.
3. Environmental effects.

The first severe influence of environmental aspects was when Denmark, in the seventies, decided not to introduce nuclear power plants. As a consequence of this decision and the oil crisis, electricity production is mainly based on coal.

The economic situation urged Denmark to minimize fuel consumption in the early eighties. The initiatives were reconstruction of the power plants to power-heat plants, development of district heating and energy saving programs with the main emphasis on house isolation. The fuel in private houses is mainly natural gas or oil. The district heating energy sources are oil, natural gas, straw, garbage, and sludge from waste water treatment plants.

Denmark

Growing public concern for the environment is shown by the interest in non-governmental nature organizations. They count far more members than the political parties. The public opinion has induced a green policy in the political system. The concrete results in the energy sector is that the first power plant desulfuring equipment was set in operation in 1989. The windmill industry has been supported by the government. In 1988 around 2,300 wind power plants were in function.

The local authorities and the government are now preparing energy plants for the future. The planning is accelerated by the international follow-up of the Brundtland report. The NGO's in the EEC countries have already prepared: "Energy action plan for sustainable development" for the international meeting in Bergen, Norway, May 1990.

Energy-environmental teaching

The presentation of the energy-environment situation in Denmark shows that the topic is multi-disciplinary from the educational point of view.

In Denmark we have two environmental science courses involving students and teachers from the relevant disciplines. At Aarhus University in the environmental course energy-environment is a central theme. The disciplines involved in the teaching are: history, medicine, social science (politics, planning, law), biology, geology and chemistry.

The emphasis is on coal-fired power plants. The teaching includes excursions to: the power heat plants; the location with lime resources for the desulfuring and at the same location for deposition of desulfuring waste and flyashes; an active coal mine in Poland; and Polish examples of severe effects of SO_2 and NO_x emissions (culturally valuable buildings in Krakov and dying forests in the mountains).

For a chemist the theme is a fascinating challenge, covering a wide spectrum of classical chemistry: chemical energy, the thermal and chemical properties of oxides, mass balances, electrochemistry, etc. The environmental chemistry is illustrated with reactions in the atmosphere, aquatic chemistry, leaching from deposits, conversion of one waste problem to another. Ex: Alteration of the fate of mercury from atmospheric emissions to aquatic emissions by introducing the wet CaO-desulfuring process. Only the time and the aim of teaching set a limit to the possibilities.

ABSTRACT *Energy and Environment as related to Chemistry Teaching in Ethiopia* **Theodros Solomon, Department of Chemistry, Addis Abada University, P.O. Box 1176, Addis Ababa, Ethiopia** •The energy and environment situation in Ethiopia is presented. The major dependence on traditional biomass fuels to meet the country's energy needs has resulted in massive deforestation and soil erosion. Tables are given showing the energy consumption per energy type and per economic sector, as well as rate of deforestation. The country's energy potentials are also discussed, and the need to tap these judiciously to prevent the present environmental situation is emphasized. Attempts made to introduce environmental education in schools and universities are also discussed.

Energy and Environment as related to Chemistry Teaching in Ethiopia

Energy and Environment and how these relate to chemical education, has been selected as the theme of this workshop, and therefore, in presenting a country report on this topic, a brief picture of the energy and environment situation in Ethiopia will be given, followed by a mention of the attempts being made to include these in chemical education in the country.

Out of the total energy utilized in Ethiopia for household, industry, and service purposes, 93.4% is drawn from traditional biomass fuels such as firewood, charcoal, crop residues and cattle dung. Only the remaining 6.6% is energy from petroleum and hydroelectricity (1). Table I (follows) shows the energy consumption per energy type, whereas Table II (follows) gives the energy consumption per economic sector (2). The dependence of Ethiopia on traditional biomass fuels for its energy has resulted in tremendous and awesome consequences on the environment.

Ethiopia

At the beginning of this century, it is estimated that roughly 40% of the total area of Ethiopia (viz. 41.2 million ha. out of a total of 114.4 million ha.) was covered by forests. The present figure is 3%. The forest area in Ethiopia during the period 1955-79 is shown in Table III (3)(follows). In the twenty five years since 1955, 13 million ha. of land has been deforested at an annual average destruction rate of 0.5 million ha./year.

The massive annual soil erosion is equally alarming. Deforestation reduces fuel-wood supplies and forces people to rely more on crop residues and manure for fuel; this in turn intensifies soil erosion and water runoff and consumes valuable nutrients. At present, about 14 million ha. of land in Ethiopia is estimated to be "severely degraded", whereas the soil has been lost forever on 2 million ha. (4). The estimated amount of silt transferred from the ten major rivers of Ethiopia is 1.1 billion tons/year (5). The degradation of soil by erosion is a very crucial and urgent problem, since soil reformation is an extremely slow process. Under tropical and temperate agricultural conditions, the renewal rate is about 0.3-2 tons/ha./year (6). The rate of loss cannot compare with this slow rate of reformation.

There are many factors contributing to this alarming rate of deforestation. The following two may be mentioned as deserving great attention: 1) the need for energy and building materials, 2) the need for ever increasing farming and grazing land as a result of population increase, land degradation, poor farming technology, low crop productivity, and inequitable distribution of land, energy, and food. These needs have not been reconciled with the resulting long term effects of deforestation. For tropical regions as a whole, 10 ha. of forest land are cleared for every one ha. planted. In Africa, the ration is 29:1. At present, there is an ongoing plan to increase the forest cover in Ethiopia from 3 to 7%, and tree planting activities are taking place in most parts of the country.

In view of the alarming rate of deforestation and soil erosion, it appears that a major focus should be made to search for alternative energy sources and to adapt appropriate technology. For this reason, it is instructive to take a general look at Ethiopia's energy potential (excluding traditional biomass fuel and oil). Table IV (follows) shows the current estimates of (a) natural gas, (b) hydroelectricity, (c) geothermal energy, and (d) solar energy (1, 2). Clearly, the energy potential of the country is by no means low. However, several factors combine to make these potentials not within immediate reach at the moment. But these potentials *must* be tapped *judiciously*, since the alternative is a vicious cycle of deforestation, environmental degradation, and famine. At present, hydroelectric dams are being built, and geothermal wells drilled to generate energy, whereas the effort continues to explore for crude oil deposits.

Turning now to the steps that have been taken to include energy and environment in chemical education in the country, the following may be mentioned. The Curriculum Department of the Ministry of Education, as the body responsible for the preparation of teaching materials for the nation's schools, has included chapters on Energy and Environment in the 12th grade chemistry curriculum. Alternative energy sources and pollution problems are discussed. The Universities of Ethiopia, however, have so far not introduced courses or programs devoted exclusively to either energy or the environment. (The only exception is the "Environmental Chemistry" course which was introduced by the Chemistry Department of the Addis Ababa University during 1978-80 but was later abandoned due to shortage of manpower.) This is a major omission, and attention has already been drawn to it (8).

Other activities relating to environmental education are the Southern and Eastern African Environmental Workshops held regularly in different parts of the sub-region since 1978. Ten workshops have so far been held (one in

Ethiopia), and their overall aim is to create groups of scientists with expertise in the fields of Environmental Chemistry and pollution monitoring and control. I hope that these have helped in raising the level of awareness of participating countries regarding environmental education. Some, in fact, have launched programs on environmental chemistry and it is hoped that the Addis Ababa University will reinstate the course that it had introduced over a decade ago.

REFERENCES

1. *Assessment of Current Situations and Problems of Science and Technology in Ethiopia*, Ethiopian Science and Technology Commission, Vol. I, August 1989, Addis Ababa, Ethiopia.
2. *Energy Policy in Ethiopia*, (in Amharic), Ministry of Mines and Energy, Ethiopian Energy Authority, July 1989, Addis Ababa.
3. *Forestry for Community Development*, Community Forest Development Department, Forestry and Wildlife Conservation Development Authority, 1982, Addis Ababa. (Quoted by Dr. Legess (5)).
4. D. MacKenzie, New Scientist, 24 Sept., 1987, p.54.
5. Dr. Legesse Negash, Biology Department, Addis Ababa University, personal communication.
6. D. Pimental et al., BioScience, 37(4), 277 (1987).
7. T. Solomon, Bull. Chem. Soc. Ethiop., 2, 89 (1988).

Table I. Energy Consumption in Ethiopia (1987)

Energy Type	Consumption (tcal)	Percent
Traditional Biomass fuel	129,213.6	94.4
Electrical	782.3	0.6
Petroleum	6,891.8	5.0

Table II. Energy consumption per Economic Sector (1987)

Sector	Percent
Household	89.0
Cottage Industry	5.6
Transport	3.4
Medium and Heavy Industry	1.3
Agriculture	0.3
Others	0.4

Table III. Forest Area in Ethiopia from 1955 - 79

Year	Area(%)	Area (million ha.)
1955	15	17
1967	7	7.958
1976	4.5	4.5 - 5.67
1979	3 - 4	3.4 - 4.53

Table IV. Energy Potential of Ethiopia

Energy Type	Potential
Natural Gas	30 billion m^3
Geothermal	1000 MW
Hydroelectric	650 TWh/year
Solar	5.2 kWh/m^2/day

ABSTRACT *Environmental Education in the Federal Republic of Germany*

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•With the beginning of the 80's the authorities of the 11 "Länder" (states) of the Federal Republic of Germany have ensured that environmental themes became part of the curriculum in all school levels. An empirical study, which was made for the 4th, 9th and 12th grade, demonstrated that these regulations are beginning to have consequences in school practice. In the 9th and 12th grade, approximately 20 to 24 lessons per school year are assigned to environmental education. Above all, there are 5 main subjects to incorporate environmental issues. Each of them has its content area: biology (eco-systems), chemistry (atmosphere), geography (environmental problems in other countries), physics (energy), religion (global environmental problems). The treatment of atmosphere includes the treatment of energy production from fossil fuels. •The teaching method in environmental education is still less satisfactory. Only a share of approximately 15% is situation- and activity-oriented; verbal and discipline oriented treatments are predominant. Furthermore, there are symptoms that the scientific energy concept taught in schools does not enable the students to understand problems of energy supply and energy saving in daily life.

Environmental Science Education including Energy Education in the Federal Republic of Germany

A. The Present State of Environmental Education

Since the beginning of the eighties, the Ministries of Education of the 11 "Länder" (states) in the Federal Republic of Germany have ensured that environmental issues became part of the syllabi for all schools and school levels. In 1985, EULEFELD et al. (1988, 1989) investigated to what extent these guidelines influenced practical teaching in grades 4, 9 and 12. They questioned 700 teachers from 60 schools in 10 of the 11 Länder about contents, extent and method of teaching. 431 teachers returned their questionnaires; 193 of them had already taught one or more environmental topics; 379 themes were mentioned. These themes can be classified into 13 areas. The following table shows typical examples.

Federal Republic of Germany

Content Area	No.	Typical Theme
Eco-Systems	30	A lake as an eco-system
Energy	53	Pollution from power stations
Water pollution	49	Problems of water
Air	53	Air pollution and its con sequences
Woods and forests	22	Endangered woodlands
Noise	8	Noise in our environment
Consumption/waste	20	Consumer behavior environmental problems
Towns and traffic	13	Industrial sites/environmental problems
Nutrition	7	Pollutants in food chains, foodstuffs
Workplace	14	Economic growth and environmental problems
Soil, agriculture, horticulture	29	Ecological problems of agricultural production
Environmental problems in other countries	26	Drought in the Sahel zone (desertification)
Global Environmental problems	55	Christian Responsibility for environmental conservation; chemistry and the environment

Table 1: Classification of themes

When the above mentioned 379 themes are related to certain subjects, 5 subjects emerge as important ones, each of them with a special content area: Biology (eco-systems), Chemistry (air), Geography (environmental problems in other countries), Physics (energy), Religion (global environmental problems). The problems of producing energy from fossil fuels will be dealt with in conjunction with the treatment of air.

In grades 9 and 12 between 20 and 24 periods a year are used for teaching environmental themes. EULEFELD et al. differentiate three procedures in view of the teaching method:

Type 1: The environmental problems are taken from the surroundings of the students and are treated in an interdisciplinary, situation-oriented problem-solving manner.

Type 2: The themes are dealt with by problem solving and by making environmental problems the focal point. This is, however, mainly done with verbal presentation and written material.

Type 3: Neither the characteristic traits of type 1 or those of type 2 are evident. 15% of environmental teaching is according to type 1, 46,5% according to type 2 and 38,5% according to type 3. Environmental teaching in chemistry clearly falls short of these numbers: here only 8% were taught according to type 1, 36% according to type 2 and 55% according to type 3.

B. Energy Supply, Energy Saving, and the Scientific Concept of Energy

with the scientific concept of energy (DUIT 1988). Even after thorough study of energy in the classroom, students fall back upon their everyday concept of energy whenever, outside the classroom, they are confronted with problems of energy supply and energy saving. Furthermore, the everyday concept of energy suffices even in school, *e.g.* for geography and social studies. This concept puts special emphasis on the degradation of energy: energy is less valuable or is "used up" in a process or in heating up something. This view helps make the problems of energy supply and of energy saving understandable. Th. principle of energy conservation is, however, almost irreconcilable with the students' own everyday experiences. In addition to this, it brings up the question, why should we save energy, if no energy is lost. - Above all it is more than doubtful whether environmental knowledge results in the appropriate environmental behavior (LANGEHEINE, LEHMANN 1986).

C. Further Development of Environmental and Energy Education in the Federal Republic of Germany

What should be done is:

(1) More multi-disciplinary units, especially those which deal with science, technology, and the use of energy should be incorporated in the curriculum.

(2) In so far as (1) is not accepted: Environmental and energy education should be infused into existing science curricula, but without losing the social aspects.

(3) Alternative sources for future energy (*e.g.* wind energy, solar energy, hydrogen technology in chemical lessons) should be treated.

(4) The percentage of the teaching method according to Type 1 (situation and problem oriented, student centered) must be increased.

(5) Teaching the scientific concept of energy, degradation of energy (the second law of thermodynamics) must be emphasized as well as (or even more than) the conservation of energy (the first law of thermodynamics).

(6) Further research should be done about the methods to promote "environmental behavior". According to LANGEHEINE and LEHMANN (1986) environmental knowledge has little influence on this behavior. A variable called "experiences with nature (*e.g.* living beings) through childhood and adolescence" was somewhat effective.

References

EULEFELD, G., BOLSCHO D., ROST, J., SEYBOLD H.:
Die Praxis der Unwelterziehung in der Bundesrepublick Deutschland (Environmental Education in Practice in the Federal Republic of Germany). Kiel: IPN 1988.

BOLSCHO D., EULEFELD, G., ROST, J., SEYBOLD H.:
"Environmental Education in Practice in the Federal Republic of Germany: an Empirical Study". Submitted for publication in *International Journal of Science Education*, 1989.

DUIT R.:
"Science Education and the Quality of Life. The Case of Teaching Energy in German schools". Paper presented at the ICASE/CONASTA World Conference "Science Education and the Quality of Life" in Canberra, Australia, July 1988.

LANGEHEINE, R., LEHMANN, J.:
Die Bedeutung der Erziehung das Umweltbewußtsein. (The Significance of Education for Environmental Sensibility). Kiel: IPN 1986.

ABSTRACT *The Development of Environmental Science Education in Finland*
Hannu U. Kultunen, National Board of General Education, Hakaniemenkatu 2, SF - 00530 Helsinki, Finland •Environmental education has traditionally had a high status in Finnish school policy. Between the Nordic Countries (Denmark, Finland, Iceland, Norway, Sweden) there has been a common environmental education project since 1974. Environmental aspects have been planted into curricula, and practical measures to implement environmental education have been sought during this period. •The environmental aspect in education was enhanced in October 1989 when the Ministry of Education gave guidelines of implementing the recommendations made by the Finnish Commission on the Environment and Development. (This was based on the resolution of the General Conference of United Nations concerning the Brundtland commission report.) •Within the framework of UNESCO's International Network for Information in Science and Technology Education (INISTE) Finland founded a national network, FINISTE, in 1985. The main activity of FINISTE has been developing new teaching methods for science education and disseminating them to teachers. Chemistry has been well represented in this project. An important aspect of the project has been introducing teaching methods that are relevant in developing attitudes and values in environmental science education. •The Baltic Sea Project (BSP) is a common enterprise of two of UNESCO's Networks, the ASP and INISTE. It was started in 1988 as a Finnish initiative. The aim of BSP is to establish a network of schools around the Baltic Sea which observe and study the environmental state of the Sea, communicating with each other and trying to influence locally and nationwide. All 8 nations around the Baltic Sea have appointed 5 - 20 schools to this project. As a part of this project FINISTE network will develop environmental science education methods and apparatus. •In developing chemistry education, cooperation with chemical industry has played an important role in Finland. The model of Activity Based Industrial Visit was developed in cooperation with the Chemical Industry Federation, and as a follow up of this activity environmental education will have an increasing importance (*e.g.* in the summer of 1990 a symposium will take place where models of environmental science teaching will be studied). Defining the sustainable development as a starting point for environmental education gives new relevance for school-industry links.

Energy and Environment Efforts in Finland

Finland

Finland is situated between the latitudes 60° and 70° N. Finland's climate is milder than that of many other areas at the same latitudes. This is mainly due to the moderating effect of the Gulf Stream. The winters are milder since heat is stored in the waters of the 100,000 inland lakes and the Baltic Sea by which Finland is bounded in the west and the south.

Finland is a sparsely populated country (total area of 338,000 km² with 5 million inhabitants) which leads to special demands for transportation.

The Finnish National economy is exceptionally dependent on natural resources. Protecting the forest and the rest of nature from air pollution and over exploitation and preparedness for climatic changes are therefore of particular importance.

Table 1 shows how different sectors of the national economy account for the GDP in 1986:

sector	1986 share %
Primary Production	8
Industry	28
Construction	7
Services	41
Producers of Government services	16
GDP (basic value)	100

Table 2 shows how the energy consumption is estimated to be shared in Finland in 1990:

Industry	47%
Heating of the buildings	25%
Traffic	18%
Other	10%
Total energy consumption	100%

Energy Research programs

The Ministry of Trade and Industry has reorganized the energy research in Finland in 1988. The main research activities have been grouped into large goal-oriented research programs. These programs are carried out, financed and utilized by the major industrial companies, universities, research institutes, government authorities and other relevant parties.

The basic issues in energy research concern future uncertainties about energy supply and potential environmental impacts. This implies an increasing contribution by basic scientific research.

The increasing role of international energy research cooperation has made it possible for Finland to focus its national research efforts on its own area of expertise.

In Finland the priority areas are different from those in many other countries, especially larger ones. The focus is on small and medium scale technologies that have special relevance in Finnish conditions. The research is being directed at those areas where Finnish technology and know-how is at high level internationally speaking, like energy end-use technologies, use of ingenious fuel sources - peat and biomass. Special attention is being paid to combustion processes and energy use in the paper and pulp industry.

Energy research has been organized into 10 large national research programs. Five of the programs are related to efficient end use of energy, and the other five to energy production and conversion. Several of the programs have a strong environmental motivation. Most programs are closely related to the respective education and post-graduate studies.

National energy strategy 1991

Questions about energy production have recently become very popular due to the increased environmental discussion. Ministry of Trade and Industry is planning a national energy strategy that should come out in 1991. In preparing this strategy there are some documents that are of special importance. There have recently been two committees in Finland about energy and environmental economy; reports from these and some other sources have already had effects on the national energy and environment policy. A third document that will have a major stress when planning the strategy is the report of the Finnish Commission on Environment and Development.

Report of the Finn' ı Commission on Environment and Development

After the r.port from the World Commission on Environment and Development, chaired by Norwegian Gro Harlem Brundtland, was presented to the 42nd General Assembly of the UN, it passed a resolution on the Commission report on December 11. 1987. In the resolution the governments of the member nations are urged to embark upon action to ensure that the promotion of sustainable development begins to be furthered in the activities of authorities, plans of operations and budgeting.

On December 16, 1987 the Ministry of the Environment set up the Finnish Commission for the Environment and Development to deal with the proposals and recommendations of the World Commission to assess their significance from Finland's point of view. On May 31, 1988 the Finnish Council of State presented a report to Parliament on environmental policies.

The Finnish Commission proposals in the field of energy economy

In the field of energy economy, Finland should promote sustainable development by using energy more efficiently and by promoting energy saving. The environmental hazards of energy generation can also be reduced by making correct energy choices and by using environmental protection techniques. Finland should also work actively in international cooperation so as to achieve these objectives.

The Commission is urging the remodeling of the energy policy, a program proposing that the aim should be to halt Finnish consumption of primary energy at the 1989 level by the year 2000 and to cut consumption by 10 percent by the year 2010. The Commission also proposes that possible ways of totally or partially converting coal and peat fired power stations near the present and future natural gas pipeline to gas power should be pondered. In the metropolitan area in particular, heat and energy generation should be converted to gas in order to improve air quality.

In the Commission's view, use of peat as an energy source should not be further extended beyond the current peat-fired power plant requirements and once the plants included in the present outline plan for electricity supply a built.

Use of economic regulation methods should be increased in environmental policies. PPP (the Polluter pays Principle) should be applied more consistently and preventitively than at present. Economic instruments include various charges and taxes which reflect the real cost of the activity to society and the hazards to the environment.

NO_x and SO_2 programs

There are decisions to decrease the emissions as follows:

NO_x: In 1995 emissions should not be bigger than in 1987.

SO_2: In 1993 emissions should be only 50% of the level of 1980. This level has been reached already.

Pollution Taxes

The Finnish Government has proposed for the year 1990 extra taxes for environment harmful products (*e.g.*. for coal 16 FIM/t; peat 2 FIM/MWh; gasoline with lead, 0,135 FIM/litre). The Parliament has not yet approved these extra taxes.

Education and National Energy Strategy

There are links between the National Energy Strategy and Education which mainly comes from the work of the World Commission on Environment and Development. The following picture illustrates these links.

Literature

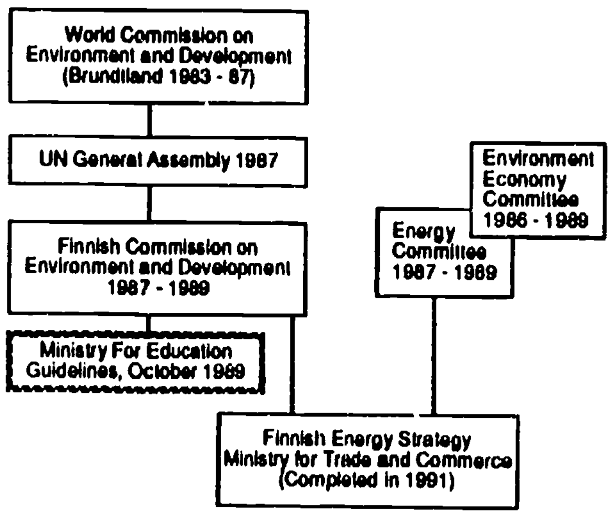
-*Efficient Energy Production and Use*. Energy Research Programmes in Finland 1988 - 1992; Ministry of Trade and Industry.

-*Environmental Protection in Finland*, National Report 1987; Ministry of the Environmental Protection Department, Series A 67/1988.

-*Report of the Finnish Commission on Environment and Development*, March 31, 1989. English Summary in: Ympäristön ja kehityksen Suomen

toimikunnan mietintö; Komiteanmieteintö 1989:9.
-*Energy Review*: Ministry of Trade and Industry. Energy Department. 1/1989 and 2/1989.

Links Between Education and National Energy Strategy in Finland



The picture at the left is simplified, however, it demonstrates well the stress laid on the work of the World Commission on Environment and Development in Finland.

ABSTRACT *Chemistry and Environment in France* **Danièle Cros, Centre International Francophone pour l'Education en Chimie, Université de Montpellier II, Place Eugène Bataillon, 34060 Montpellier Cedex, France** •Three points will be underlined in this paper: 1) The first comes within the framework of the French Chemical Society, Division of Education; one workshop on "Chemistry and Environment", has been held in the University of Montpellier (June 1989). Teachers from secondary school and from university were present. Different aspects have been treated: environment from the point of view of chemists and environment from the point of view of other people. 2) A three year course about environment is delivered at the University of Montpellier. The implications of this course will be discussed. The study subjects are related to the particularities of the region: water, aquaculture, hydrology, hydregeology, . . . 3) National Olympiads of Chemistry: this activity has been created for five years in France by the Union of Chemical Industries. The pupils of the last classroom of secondary school are concerned by this activity. The theme is different each year. Exceptionally, the theme "Chemistry and Environment" has remained two years (1988 and 19[illegible]), due to the importance of the subject. The interest of pupils has been very great, so that we have had to refuse the registration of some of them. This year, the theme "Chemistry and Health" is related to the environment, too.

Chemistry and Environment Situation in France

I Environment: Chemistry and environment teaching in secondary schools

Up to now there is no official academic courses connected to a rigorous curriculum in the field of environment. Nevertheless, for five years, the Union of Chemical Industries (Union des Industries Chimiques, U.I.C.) in relation with the Société Française de Chimie (S.F.C.) and the union of the teachers of chemistry have organized an extra school activity, *i.e.* The National Olympiads of Chemistry, in all the french regional education authorities.

The previous themes were chosen as following:

* Drinks and Chemistry
* Chemistry and the Environment (2 years)
* Chemistry and Health

This out-school activity concerns essentially voluntary pupils during their last year in secondary school (Fourteenth pupils). They are trained by voluntary teachers from secondary schools and from universities during extra courses.

1) The Main objectives are:

- to sensibilize pupils to chemistry, even and especially to the future non-chemical seniors they will be, and not to train future "genius".

- to develop the experimental teaching of chemistry in secondary schools.

FRANCE

The training does not look like a scholarly lecture; it is essentially based on experiments linked to the theme and to everyday life. The idea is to use different approaches for chemistry, either more connected to environment or more attractive or both.

In the same time, some articles from science newspapers or magazines are discussed in order to develop a critical mind. Some examples of the subject that have been studied and concerning environment are:

- Water: research of cations and anions.
- Air: Problems with anti-knocking compounds, *i.e.* lead tetraethyl and titration of lead in gasoline. Problems due to acid rains, ozone layer, corrosion.
- Earth: Analysis of a soil sample and titration of pesticide residues, sulfamides and antibiotics.
- Surfactants and their applications
- Perfumes
- Chemical disasters in the world: methylisocyanate (Bombay), dioxine (Sevesco), red muds (Mediterranean Sea).
- Elimination of radioactive waste.
- Hazards determination and localization.

2) Results

After five years it can be outlined that the results are essentially positive ones and that they can influence future education policy. In fact, we have observed the following:

a) motivation of the voluntary teachers: "After this experience I won't teach chemistry as I did till now", some of them said.

b) A motivation of the pupils who understand much better the role of chemistry and its place in the society.

c) The point that seems the most important in the sensitization of the educational authority to the importance of the developing experimental chemistry in the secondary school, in relation to the everyday life.

Already some new official regulations have been spread out to all the teachers for two years in secondary schools. This has been done in order to make use of several experiments linked to the environment and chosen from a specific list.

d) As a result of this last point, the national examination ("Baccalauréat') takes into account the experimental teaching by a written test on a procedure close by an experimental situation.

3) Conclusion

Gradually the environment plays a role more and more important at secondary school level.

II Environment: Situation at University

Some Universities in France have developed a curriculum upon

"Science and Environment" at different levels.

1) A three year course with specific items upon environment leading to the DEUST french diploma (Diploma of Scientific and Technological Graduate Studies).

2) A three year course leading to the french diploma Licence or Maitrise (Advanced Studies). After that students can continue for post graduate studies or prepare a PhD.

There are some connections between these teachings, even if they are not delivered by the same universities. The students who have been successful in DEUST can continue their studies until they get the PhD.

It should be mentioned that the DEUST has been created with the help of local industries. Each university chooses its DEUST as a function of local industry (size and number of societies) and actual openings. As an example I will talk only about the DEUST "Science and Environment" which is delivered by the university of Montpellier: the city is located in the south of France and is near the seaside. The curriculum takes into account the local situation and is strongly connected to water and sea water preservation. The students are also trained to be able to organize industrial and urban wastes treating.

The main objectives are to train technicians in order to:

- make them specialized in sea fish farming;
- make them able to treat waste water;
- make them able to treat urban and industrial waste;
- make them specialized in environment management in urban and land areas (technical and legal aspects).

The teaching is delivered in three years: the first two contain 12 moduli (50 h each)· some of them are compulsory, the others are chosen by the students themselves (Chemical Ecology, quality of water, legislation about water and waste, elimination of urban and industrial waste, analysis of air, safety, etc.).

The teaching in the third year is concerned with complementary information, *i.e.* biodegradation, calcining, control of technological risk, etc.

Each year the teaching is completed by a term of probation in industry:

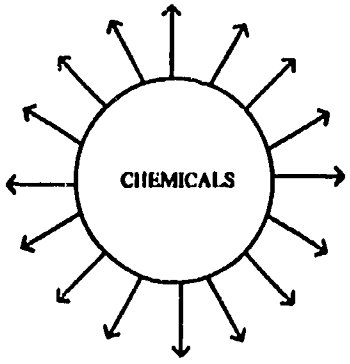
* 1 week the first year
* 1 month the second year
* 6 months the last year

The diploma are very successful among the students for it is worthwhile to get a job after the end of their studies.

III Chemistry and the Environment: A seminar organized by the S.F.C., Teaching Committee Section

The participants at this seminar came from secondary schools and from university. Some other people issued from near-by subjects such as biology and ecology were also attending the meeting.

The main discussion concerned essentially the chemicals.



If we draw a circle we can find inside the chemicals that are under the responsibility of the specialists, but outside they are spread out and the non-specialists are now in charge of them. How are they to be transformed? The future of all the chemicals has a great influence on the environment due to:

- ´ ; extra or by-products which did not react,

- the solvents which are more or less adulterated after use,

- the wastes that are to be eliminated.

These problems are of capital importance for teachers, and also for students themselves, for industry and for local authority. Two cases should be considered:

- the waste that can be treated (beneficial for the environment)

- the waste that is under the responsibility of non-trained people or sometimes incompetent ones; they cannot know an abnormal or excessive use (too important dosages with home products, pesticides, or hazardous mixing of products leading to a toxic one or at least harmful). So the roles of chemistry is very important.

The teaching of chemistry should be the best insurance and the warranty of precise information, and should initiate regulation which will allow the solutions of the most important problems of our industrial civilization.

Results of the Seminar

1) The experimental teaching of chemistry should be more related to the environment (pollution control, substitution by less harmful products, etc.). An interdisciplinary approach has to be developed at each level.

2) The teachers must be trained and more sensibilized to the problems concerned with environment.

3) The non specialists have to be educated.

4) Due to the complexity of the actual world, some educative and integrated actions should be reinforced (for example, recuperation of chemicals in waste).

5) Some booklets or notices should be elaborated that will be very worthwhile at different levels in order to get the chemists more able to understand the other sciences. For non-chemists, also this technical information should be integrated into their own disciplines.

Conclusion

1) The first conclusion that can be deducted is that the environmental sciences are well integrated at the university level. If the curriculum of the secondary level is always traditional, the feeling of the education authority is

now in accordance with the development of environment in classroom.

To be very successful, the action of integration of environment should be done with well motivated and sensitized teachers.

2) The Centre International Francophone pour l'Education on Chimie (C.I.F.E.C.) has organized several workshops on experimental chemistry related to the environment. These experiments concern teaching at first level in the university as well as secondary schools (14th class).

The C.I.F.E.C. has published four manuals upon experimental chemistry with the help of UNESCO.

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ABSTRACT *Energy and the Environment Research Efforts in Ghana: Implications for Chemistry Teaching* **Joseph M. Yakubu, Department of Science Education, University of Cape Coast, Cape Coast, Ghana** •The motive force of the integrity of human kind and the environment is not merely economics or politics, but an understanding of what energy is and how to utilize it in our communities. The environmental hazards such as the temperature rise of the atmosphere, droughts and famines may be attributed to the fact that we have not grasped sufficiently how best to utilize energy in our environment. To grasp the concept of energy, "issue-oriented" or interdisciplinary chemistry teaching methods have to be employed and science policy should aim at transformational rather than transferential development. The on going energy research projects in Ghana, however, can be described as transformation-oriented. They include the following: Improvement of charcoal production method and the efficiency of the charcoal stove; a study of rural energy utilization; Model Biogas village project; Solar Village Project; the Briquettes Project; and energy use in Agriculture and public education for efficient use of energy. •The "Science in Ghanaian Society Project" is the only educational project in Ghana addressing itself to the energy - environment problem. It is, therefore, "issue-oriented". Funding for the publication of the project books is lacking. Help is urgently sought from any generous funding agency that is willing to support us.

"Energy and the Environment" Research Efforts in Ghana: Implications for Chemistry Teaching

Ghana

I. Introduction

In 1911, Sir William Ramsay, in a Presidential address to the British Association for the Advancement of Science asserted that, "real gain, real progress consists in learning how to better employ energy - how better to effect its transformation" (1). This assertion can be interpreted to mean that while it is pertinent to be concerned about drought, desertification and agricultural productivity, it is even more pertinent to understand what bio-geo-chemical cycles in the soil are and how to maintain them; while it is pertinent to be concerned about the temperature rise of the environment, it is even more pertinent to understand chemical processes which lead to this effect. The implication of Sir William Ramsay's assertion is the need for appropriate science teaching and research methods in connection with the energy-environment equilibrium in Ghana. This is possible if we have a rational science policy.

II. "Free Energy" as an appropriate concept in "Energy and the Environment" Issues

Energy, if construed to have the same textbook meaning of "ability to do work". will not help us to use it for developmental work. Energy *per se* is a label for a property of matter and is the same as its "mass", but "Free Energy" or available energy is what makes things go; it is the "go of things"(2). This is a more useful term for our energy and environment deliberations. Fuels such as petrol, carbohydrates, charcoal and firewood can be regarded as "reservoirs" of free energy. They "pour out" or deliver their contents during combustion. The contents of fuels can be transformed into other forms of energy (free energy) and the rest is spilled as heat. Just as shallow dug-out wells need to be dug deeper to reach water, so also do forests which have been cut down for firewood and charcoal need to be replaced. Not only fuels, but also moving masses of air, water and objects put in unstable positions and have a tendency to move, have free energy. This concept suggests to us how to control and transform fuels and the forces of nature to turn the wheels of progress.

III. An Interactive Model of Energy and the Environment

The energy and environment relationship can be conceptualized in the following interactive model.

(a) Ghanaians influence the ecosystems of the earth through the ideas they have about nature as well as the techniques they employ to control it: bush burning, charcoal making, and craftwork are just a few examples. The ordinary fuels such as firewood and charcoal are termed "heat givers" (mashiw) but carbohydrates and other food stuffs are termed "strength givers" (mahordzin) in the Fante language. Fantes to do not see anything common to "heat givers" and the "strength givers". This could be a good starting point for effective chemistry teaching.

(b) The Impact that cultural ideas and techniques make on the atmosphere is very minimal. The temperature rise of the atmosphere with the consequent weather changes are noticed, but not understood. While some indigenous Ghanaians are inclined to blame this on aggrieved ancestors and spirits for a deteriorating moral behavior of their people, scientists explain that it is due to the greenhouse effect which should be seen in global terms rather than in pockets of localities. Periods of global atmospheric cooling and warming up have been observed since the 1880s (3).

(c) The bio-geo-chemical cycles in the soil are affected when the temperature rises and evaporation increases. This renders the soil dry and infertile. The atmosphere becomes more humid and increases the greenhouse effect further.

IV. Implications for Science policy: Current Energy Research Projects in Ghana

It is not clear whether there is a permanent and comprehensive rational science policy body in Ghana. The Council for Scientific and Industrial Research (CSIR), the Ministry of Science, Technology and Industry and *ad hoc* national committees have been set up from time to time to deliberate on science policy issues.

But this does not mean that no organized research activities exist. On the contrary, they exist and are functioning well, despite the obstacles they have to overcome in the process. The Environmental Protection Council, the National Energy Board and the Energy Research Group, which is made up of individual researchers from the universities, are the identifiable groups doing research in Ghana at the moment. A selection of on going research coordinated by the National Energy Board in 1989 includes the following projects:

1. Improvement on indigenous charcoal production methods.
2. Improvement on the efficiency of the indigenous charcoal stove.
3. Rural Energy Planning Studies Project which aims at gathering information on rural energy sources, consumption and conversion processes with a view to planning rural energy provision.
4. The Apolonia Model Village Biogas Project aims at lighting the village with biogas. It is intended to extend the research to other villages in the future. Energy digesters are being constructed for each household for cooking and lighting purposes.
5. Solar and Wind Energy Resources Assessment. The aim of the research is to improve solar radiation conversion instruments as well as monitoring stations. A "Solar Village" project has been started. The aim is to provide the village with solar energy for domestic and cottage industrial purposes.
6. The Sawdust Briquettes Renewable Energy Resources Project aims at producing compact bricks, with an improved calorific value, from sawdust. It is estimated that sawmills in Ghana generate over 65,000 tons of sawdust annually which are dumped around sawmills, thus posing as environmental hazards.
7. Energy use in Agriculture is a project which aims at studying the energy demand, sources and end-use devices in the agricultural sector to identify energy requirements for improved agricultural production.
8. A Public Information and Awareness Campaign is a public education program which aims at educating the public to use energy efficiently.

These projects fall within Ghana's policy goals as stated in the energy policy document "Energy and Ghana's Socio-Economic Development"(4) which can be summarized as follows: (i) To reactivate the energy operating institutions; (ii) To plan a sustained provision and security of energy supply; (iii) To ensure that energy is supplied to all sectors of the country including the rural areas.

It can be observed that the educational aspect of the "energy and environment" activities, is conspicuously absent. While it is pertinent to be concerned about energy and socio-economic development in Ghana, it is even more pertinent and fundamental to be concerned about the teaching of the relationship between "energy and environment" to our pupils.

V. Implications for chemistry teaching

What has been said so far, has unearthed teaching situations. Traditional methods of teaching chemistry will prove obsolete and impotent for teaching about "energy and the environment". The ideas expressed above as well as the research projects listed above, are "issue-centered" and therefore are best taught with interdisciplinary methods. Energy issues are cast in economic, political, cultural, sociological, educational, scientific and technological contexts. A few can be mentioned here: (a) Problem solving and decision making; (b) Simulation games; (c) Community involvement approach; (d) Project work approach; (e) Historical approach; and (f) A systems approach. These teaching methods can also be termed industry-oriented approaches. In the teaching of "energy and the environment" the chemical concepts such as the laws of thermodynamics, especially the Second Law, thermo-chemistry, oxidation and reduction, exothermic and endothermic reactions, fermentation and metabolic processes, bond energies and so on, are the core of the interdisciplinary methods. To teach these chemical concepts outside an interdisciplinary context must be ineffectual. These methods have been recommended for use with the Science in Ghanaian Society Project (SGSP) which was started by the author in 1983.

VI. The Science in Ghanaian Society Project (SGSP)

The SGSP is based in the Department of Science Education of the University of Cape Coast. It aims include a study of indigenous industries in order to identify the scientific concepts and processes embedded in them; to base science teaching on them using the industry-oriented or interdisciplinary methods; to improve young peoples' image of the world of work; and to enhance rural development programs.

Booklets have been written on a number of cottage industries. There is a Workbook to go with each booklet. There is also a teacher's guide to help the teacher use the books. In essence, the SGSP is a chemistry project presented in an interdisciplinary context. Each booklet includes the location of the industry, ecology of the raw materials, the indigenous process, the science and technology embedded in the processes; the economics of the industry, the job generating potential of the industry and the social responsibility of the industry to the environment.

The books have been trial tested in a number of schools in Ghana and are currently being rewritten for publication. The main obstacle to the project at the moment is the lack of funds to publish the books. It is hoped that funding agencies approached will be generous enough to help us get, at least, the first set of the books published very soon. The draft of the "Energy" unit: The charcoal industry of the SGSP books have been brought to the conference as exhibits. Further information can be obtained from the author.

VII. Conclusion

The threat of a deteriorating biosphere is felt by all. We can definitely do something about it, but first, we need to understand the concept of energy (or rather free energy) in order to use it as an instrument for progress. Interdisciplinary or "issue - centered" chemistry teaching methods have to be used if we have to produce rational science policy makers, scientists and technologists as well as liberate the minds of the ordinary citizens from ignorance. *A transformational development*, which emphasizes transfer of technology will have to give way to a *transformational development* strategy, which emphasizes the transformation of indigenous ideas and techniques into effectual ones. The ongoing energy research in Ghana can be described as fuelling a *transformational development*, but there is still far more to be done.

References

1. Findlay A. (1964): Chemistry in the Service of Man. Longman, Green and Co. Ltd., 72-73.
2. Ogborn, Jon: ""Energy and Fuel": The meaning of the 'go of things'". School Science Review, Vol. 68, No. 242, September 1986, 30-35.
3. Gibbin, J: "Temperatures rise in the global greenhouse". New Scientists, No. 1508, 15th May, 1986, 32-33.
4. National Energy Board (1989): 1989 Work Programme Summary.

I wish to express my thanks to Mr. Mensah and the other officials of the National Energy Board and Mr. Gyamfi Aidoo of the Environmental Protection Council who kindly spoke with me when I visited them.

ABSTRACT *Energy and Risk - A View from Hungary* George Marx, Department of Atomic Physics, Eötvös University, Puskin u. 5., Budapest H - 1088 •Restructuring the industry keeps the power demand of factories steady or decreasing, but the energy consumption of households and transport climbs as the standard of living improves. The debate about risks of energy alternatives is in the focus of public and media interest, but it is at an emotional level, demanding an absolutely safe free lunch. The Chernobyl accident, in lesser degree the acid rain and city air pollution, influence the adult opinions. We try systematically to use the high school science education as an efficient channel for transferring more quantitative knowledge to society, enabling at least the next generation to make rational decisions. The efforts of science disciplines are not yet coordinated; it deserves future attention. Our means are organizing radon and acid rain monitoring networks of schools, using interactive computer simulations and decision making games. Present poll in senior high school says that 59% of students prefer nuclear, 21% hydro, 5% fossil fuel as future development, 9% would import electric energy and only 3% is ready to restrict public energy consumption. This result differs dramatically from the adult opinions presented by the media.

Energy and its Risks
International Conference on Energy Alternatives and Risk Education in Hungary, September 1989

Hungary

The London smog in the winter of 1952, the Chernobyl nuclear accident in 1986, the Bhopal chemical accident in 1987 focused the public interest onto actual and potential disasters, demanding thousands of victims, associated with modern technology.

One may object that since the arrival of the industrial revolution the human life span has doubled. Wolves, famine, black plague do not kill people by the millions any more. The casualties of technological catastrophes are dwarfed by the number of victims of "local" wars in Asia, even by the casualties of car accidents (in the US within a year). But psychological alienation and public fear are strong facts as the laws of physics or the breakdown risks of modern technology. Our era has been already named *the age of anxiety*.

We love our children, our students. We want them to become happy people in a humanized world, not alienated refugees suffering a cruel universe. This was the motivation of science educators and international organizations, when they invited teachers, professors and other experts (from the field of physics, but also from chemistry, biology, medicine as well) to a science education conference with the goal to discuss *risk education*, using mainly *the energy alternatives* as the carrier topics. The conference opened by the messages of Bruno Straub, president of Hungary, past president of the International Commission of Scientific Unions; Frederico Mayor, director general of UNESCO; Jan Nilsson, secretary general of the International Union for Pure and Applied Physics; Morris Rosen, assistant general of the International Atomic Energy Agency. The organization work was in the hands of the Groupe International de Recherche sur l'Enseignement de la Physique, of the International Commission on Physics Education and of the Roland Eötvös University (Budapest).

Exposing the challenge, the invited lecture of Jon Ogborn (London University) discussed the concept of energy from the point of view of its actual relevance: *energy differences* serve as *motors of change*, are used as *means of comfort*, and are feared as *sources of danger*. Ed Jacobsen (UNESCO Paris) remarked that newspapers and magazines do not write about mathematical concepts like *equations* or *trigonometry* or *polynomials*, but they argue with the help of such expressions as *trend, change*, or *probability, average, error, risk*, which are missing from traditional school curricula. This is why citizens think in *black* or *white* alternatives, they expect *no* or *yes* informations. Uneducated (or traditionally educated) public opinion can be easily swayed by emotional approaches, therefore John Lewis (Committee for Teaching Science at ICSU) stressed in his keynote speech that perhaps the most important task of science teaching today should be the education for *decision making*. In order to realize these actual goals, the conference paid special interest to clarify children's concepts of energy and environment but also their concepts concerning radiations and risks. These are important to be aware of, because children's mis-concepts reflect mostly the feelings of the adult society.

Several morning sessions were devoted to the scientific presentations of the hard facts of *reactor safety* (Alvin Weinberg from Oak Ridge), *radiation damage* learned from the cases of Hiroshima and Nagasaki bombs (Sohei Kondo from Tokyo), technological-psychological-social factors of *recent disasters* in industrialized and developing countries (USSR, USA, India, Brazil, Uganda), the level of *radiation reaching the public* from *natural sources* (radon etc.) and from *medical treatment* (X-ray etc.) The risks may be balanced by *comfort*, by *luxury*, by *economy* (Nicolas Kurti from Oxford University). The alternative energy options (hydro, geothermal, wind, solar) were discussed by authentic local speakers (from Egypt, Kenya, Israel, Japan).

Participants from 36 countries (industrialized like Japan or USA or FRG, developing like Bangladesh or Uganda or Honduras) strongly argued, whether these unconventional points of view can be introduced to the public education or not. Concrete school approaches were presented in *praxis* (radon and acid rain monitoring by networked schools, nuclear experimentation, utilization of microcomputers and other high-tech equipments). The central issue was the following: Is the public ready to accept only *black-and-white* answers: "this is transparently safe" - "that is risky, therefore to be avoided"? Or can the incoming generation be educated to a more logical (even quantitative) approach to the concepts of *acceptable* and *unacceptable risk*? Will the public be ready to weigh the price of richness, to be paid to reduce risks to acceptable levels? Will people understand that there is *no free and safe lunch* and more today. It never was.

The proceedings of the conference make two volumes (energy education, risk education) in 600 pages, it is distributed in February 1990. (US $25 in case of interest contact the editor who signs this report.) The Proceedings raises questions, sets challenges, offers options, but does not give final answers. It cannot because "*the future is no longer what it used to be*" (Paul Valery).

In case of a murder or a car accident, one can point to the perpetrator with a finger. In the case of the ozone hole, acid rain, oil spill, CO_2 greenhouse effect the phenomena can be understood scientifically, but there is no direct chain from those who are guilty to those who are victims. If I exchange my big, old car to a new one with 80 km/gallon consumption of lead free gasoline, it will not affect the world. If Hungary suppresses burning coal and prefers uranium and gas for electricity production, that alone will not save Bangladesh from flood. These are not technological or economical but *moral and educational problems*. Leonard Jossem, president of the International Commission on Physics Education quoted Alfred North Whitehead in his conclusion: "*It is the business of future to be dangerous, and it is among the merits of science that it equips future for its duties*". But young people may enjoy what is unknown, even menacing: it is so great to win, to overcome the dangers! It is now the *privilege* and *moral obligation* of science teachers, to educate the new generations to accept challenge, to develop global responsibility, to enter happily the brave new world they are going to inherit from us.

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ABSTRACT *Energy and Environmental Science Studies in India* **P.S.N. Reddi and T. Navaneeth Rao, Osmania University, Hyderabad - 500007, A.P., India** •India is unique in the world as one of the few countries where thermal power, petroleum, nuclear power, hydroelectric power and non-conventional energy sources are all given equal status and importance. The emphasis of late is shifting to the development of non-conventional and renewable energy systems such as solar energy and biomass in view of: 1) the fast decline in the availability of commercial and non-commercial fuels and 2) to protect the environment from pollution effects. •A beginning is made in the environmental impact studies of all the forms of energy systems. Recently a suitable curriculum is devised for undergraduate and postgraduate students of chemistry in India to familiarize them with various aspects of energy, ecology and environmental science education. These related areas of energy are discussed in the paper which give the scenario including environmental science education related to chemistry teaching in India.

Energy and Environmental Science Studies in India

Energy is one of the most important issues today in India on par with population growth and food production. At the time of independence in 1947, the energy profile in the country was very primitive. Since then, the Government of India has been making constant efforts to improve energy production in the country by steadily increasing the emphasis on energy at the time of launching of Five Year Plans. At present, the Seventh Five Year Plan (1986-91) has allocated 30 per cent (Rs. 54,821 crores, 1$ = 16.75 Rupees) of the total plan outlay towards energy as against 8 per cent in the First Plan. Consequently, the total installed capacity of power utilities by the end of the Sixth Five Year Plan (1985) rose to 42,440 MW comprising of 27,074 MW of thermal, 1,095 MW of Nuclear and 14,4221 MW of hydroelectric (hydel) power. Thus the installed generation capacity multiplied 24.6 times since independence. However, the demand for power has always grown at a faster rate than the supply.

The energy resources used in India today are of commercial and non-commercial nature, and may be classified into four categories, *viz*. fossil fuels (coal, oil, natural gas), hydel power, nuclear fuels and biomass fuels (firewood, vegetable waste, dung). The total resource potential for each of these energy resources is indicated below:

A. Fossil Fuels:
   i) Coal: 83.74 GT
   ii) Oil: 2.06 G Brl
   iii) Natural Gas: 3.40 Cu Tft
B. Hydroenergy: 80 - 100 GW
C. Nuclear Fuels (Uranium reserves): 29.8 KT
D. Biomass Fuels:
   i) Firewood: 21.5% of the land are in India
   ii) Vegetable Waste: -
   iii) Dung: 195 million head

It is estimated that the energy requirement of the country for 2000 AD will work out to be 1,763 million tons of coal replacement for an estimated population of 1,037 million, assuming a per capita energy consumption of 1.7 million coal replacement in 2000 AD per capita per year. Projections shoe that in order to meet such an energy need, about 92 million tons of oil, 472 million tons of coal and 600 billion units of electricity will be required. Besides, at a modest estimate about 320 million tons of non-commercial fuels, such as firewood, dung, etc., will also be required. This means that the availability of oil shall have to go up 41/2 times, coal production by three times and power generation four times, all on an average basis.

This is a formidable challenge for a developing country like India with capital expenditure constraints and commercial fuels not only being scarce but also expensive. Nevertheless, India is making vigorous efforts to meet this challenge by exploring for oil and gas through offshore drilling operations, developing fast breeder reactor technology, improving hydro power development, and by initiating vigorous R & D efforts in developing new technologies in non-conventional energy production and renewable energy sources, thus putting India in a unique position in the world as one of the few countries where thermal power, petroleum, nuclear power, hydroelectric power and non-conventional energy are all given equal importance and status.

India

But the oil crisis in 1973 and the fast decline in the availability of commercial and non-commercial sources of energy, particularly fuelwood which would be in short supply in developing countries by approximately 25 per cent of the projected needs by 1994, has profoundly influenced the energy planners in India to recognize the urgent need to develop renewable energy systems. The natural environment and ecological balance stood threatened in many parts of the country, leading to increased pollution and drought situations. Also, there is now greater awareness that excessive burning of commercial fuels increase the concentration of green house gases in the atmosphere leading to global warming which will accelerate the present sea-level rise leading to far reaching cataclysmic effects on ecosystems and society. All these factors have influenced the Indian Government in favour of increasing reliance on non-conventional and renewable sources of energy. The government of India has established recently a few specialized centers to undertake R & D work for developing prototype and systems for alternate non-conventional sources of energy such as solar cells, wind mills, biogas, etc.

A break-up of energy topics covered during the past nine years of R & D efforts in India in the areas of non-conventional energy shows that almost 53% of the literature was devoted to biomass and solar energy. Other subjects, such as hydrogen, synthetic fuels, geothermal energy, tidal and wave power, wind energy and energy and environment, seemed to have received negligible focus. In the biomass area, energy pollution/social forestry has contributed the maximum (35.46%). The other categories which received significant contributions were biomass resources, microbial conversion, anaerobic digestion (mainly biogas production and related aspects) and thermochemical conversion contributing 16.42%, 10.62%, 18.71% and 7.06% respectively. Significant amongst the solar energy studies are photovoltaic conversion, space heating and cooling, water heating, solar collectors and concentrators. Studies showed that biogas production by anaerobic digestion of animal wastes has a tremendous potential in India, and that it is less polluting and uses low energy technology for processing. The same is true of solar energy.

While the R & D efforts continue in the areas of commercial and non-conventional energy resources, Indian scientists have undertaken the environmental impact studies on these projects. The studies led to various measures for protecting the environment from pollution. Pollution Boards have been established for monitoring the level of pollution and to suggest methods of pollution control. Highly efficient methods for monitoring air pollution, soil pollution and water pollution have been developed and further work is in progress. For example, the influence of sewage water and sewage soil on photosynthesis, nitrate reductase activity and biomass accumulation is a topic of current interest.

Chemical education can contribute to the measures described by educating people about all the aspects of pollution - preventive and corrective. As a first step, the University Grants Commission has recently developed curriculum in environmental chemistry to be taught as an Undergraduate Elective Course. The students of chemistry will be exposed to various facets of environmental chemistry such as physical and chemistry environment, chemistry of soil environment, toxic chemicals in the environment and methods of environmental evaluation, analytical methods of environmental evaluation and chemical control of waste products. A beginning is now made in this direction, and hopefully 'non conventional energy and environment' will be a subject of study for all the undergraduate and post graduate students of chemistry in India.

ABSTRACT *Some Activities on Environmental Education in Italy* **A. Bargellini, P. Riani, Dipartimento di Chimica e Chimica Industriale dell' Università, Via Risorgimento, 35 - 56100 - Pisa, Italy** •In accordance with the following UNESCO aim in environmental education "to design and evaluate new methods, materials and programmes in environmental education", many activities are going on in this field in Italy, at different scholastic levels. •One of the most important of these activities is the "Acid Rain Project" realized with the technical assistance of the Institute of Atmospheric Pollution of the National Researches Council (CNR). •The main objective of this project, proposed to students and teachers of middle and high school, is to get information on the entire national territory, on the acid rain problem, and to sensibilize youngsters on this relevant problem. •Concerning the activities developed in Pisa in this field, our group, in recent years, has studied the problem of the relationships between the integrated science teaching and the environmental education. •The group has furthermore planned and experimented with the following activities: •a) At middle school level (pupils 11 -14 years old): examination of several chemical parameters of a fresh-water environment, using autonomous, low cost materials. •b) During the first two years of upper secondary school (pupils 14 - 16 years old): Study of an Etruscan environment.

Some Activities on Environmental Education in Italy

The recent fact concerning the proliferation of seaweed in the Adriatic sea, and the question on the Acna factory in Cengio, accused of polluting the River Bormida valley with its toxic wastes, together with the not-so-recent facts concerning Chernobyl, have contributed to a notable increase in the sensibility of Italian public opinion towards environmental problems. In 1982 a work group was created by the Ministry for Scientific and Technological Research with the aim of setting up the National Environmental Research Program; this group terminated its activities in June 1984 (1).

The group selected the following twelve areas of environmental problems to be subjects for research:

1) Ecosystem
2) Air: atmospheric problems
3) Water: management and protection of water resources
4) Soil: exploitation and conservation of soil resources
5) Population and community: knowledge and management of biological resources
6) Study of chosen individual environmental systems
7) Management of the National Territory
8) Management of waste products and residues
9) Reorganization of institutional structures and management of the environment
10) Scientific foundations for subsequent legislation
11) Professional training of researchers and technicians for the environment and of interface problems experts
12) Environmental Education

The following content concerns the last research area (n. 12).

Some activities of environmental education in Italy

In accordance with the following UNESCO aim in environmental education "to design and evaluate new methods, materials and programs in environmental education" many activities are going on in this field in Italy, at different scholastic levels.

One of the most important of these activities is the "Acid rain project" realized with the technical assistance of the Institute of atmospheric pollution of the National Research Council (C.N.R.) (2).

Concerning the activities developed in Pisa in this field, our group, in recent years, have studied the problem of relationships between integrated science teaching and environmental Education. The group has furthermore planned and experimented with activities at the middle school level and in the first two years of upper secondary school.

The Acid Rain Project

Italy

The Acid Rain Project (called the Rainbow Project) was directed by Prof. Arnaldo Liberti of Rome University under the auspices of Italian Society for the Advancement of Science (SIPS); the first phase was carried out by Ecological research groups with the technical assistance of the Institute of atmospheric pollution of the National Research Council (C.N.R.), and produced a meaningful evaluation of the extent of this phenomenon.

The experiment to which the data here reported refers, was realized in the period 13/2 - 28/2 in 1988, dividing the entire national territory into 151 quadrants each with sides of 52 km. In order to obtain homogeneous distribution, a certain number of places in which there were middle and high schools or other institutions interested in taking part to the project, were selected. Following this criterion, the experiment over the whole national territory was carried out through the collection of data from 900 sampling points.

In order to measure pH values by colorimetric methods, all the schools and groups were able to use rain collecting apparatus and a kit specially developed for this project.

In this way, the following data were collected:

- average pH values of the precipitations;
- range of pH;
- entity of acid deposits expressed in grams of H^+ per surface unit.

The data obtained underlined the fact that in Italy the phenomenon of Acid Rains is extremely wide spread and that in most of the quadrants, apart from the average value, rain with a remarkable degree of acidity occurred, both in industrial zones and in remote areas.

Activities developed by the chemistry didactics research group of the University of Pisa at the first two years of the upper secondary school (pupils: 14 - 16 years old)

Study of an Etruscan Environment

In view of the proposed reform of the Italian upper secondary school and of the extension of compulsory schooling to the age of 16 (present limit is 14), our research group is planning to develop a series of didactic units for teaching of integrated sciences in the first two years of upper secondary school. The most important characteristic of these didactic units lies in their "Motivation", each unit being based on a subject fundamentally connected with natural resources, history, economics, technology and industry in the Tuscany Region.

The first of these units, has as its underlying theme, the study of an Etruscan Environment. The following material is all part of an experimental activity which has involved teachers and students in a Scientific High School in Pisa.

Prerequisites for the chemistry aspect:

Concepts: element, compound, chemical reaction, oxidation and reduction, energy

Procedures: to observe, classify, separate variables, infer, hypothesize, deduce

Learning cycle and content

1) Motivational phase
Students starting from the analysis of historical documents, discussed and broadened their knowledge of the most important aspects of the Etruscan civilization.
2) Exploration phase
With the help of maps provided in the above mentioned documents, students were able to recognize some of the environments in Tuscany, rich in sulphurous minerals (pyrite and chalcopyrite) and other iron minerals, such as haematite and limonite. The students subsequently explored the chosen environment, gathering various types of materials: minerals, samples of scoria, living organisms.
3) Development phase
The students worked in pairs in the laboratory, carrying out chemical analysis of minerals and scoria.
4) Reinforcement phase
Numerous examples of oxido - reduction reactions were observed.
5) Synthesis phase
This phase represented the conclusion of the whole activity; it was also the most complex one. The problems faced related to the process of interaction between man and environment relative to the exploitation of environmental resources by the Etruscans and that of those carried out today.

We can outline the following main integration areas:

I Environmental chemistry and technology. The smelting of minerals with wood gave rise to the destruction of all trees in the region.

II Chemistry and technology. Copper technology is easier than an iron one. The product of a primitive iron furnace is either non carburated (too tender) or carburated (hard, but very brittle). Etruscan people did not know steel technology.

III Chemistry, technology, history and economics. The primitive iron technology produced scoria with a large iron content. From 1900 to 1960 the exploitation of Etruscan was considered profitable.

6) Evaluation
On conclusion of the activity the students presented a written report and answered written and oral questions with regard to the initial objectives.

References

1) Il piano Nazionale di Ricerca sull' ambiente in "Ricerca scientifica e tecnologica", a cura del Ministro per il coordinamento delle iniziative per la ricerca scientifica e technologica n. 1, gennaio 1989, p.6.
2) A. Liberti, Progetto piogge acide in "Scienza e Tecnica" a cura della Società Italiana per il progresso delle Scienze, nn. 215-216 luglio-agosto 1988, Roma 1988.

ABSTRACT *Teaching of Environmental Science at the University of the West Indies* **Tara P. Dasgupta Department of Chemistry, University of the West Indies, Mona, Kingston 7, Jamaica** •During the last decade environmental education has been presented in Jamaica mostly at an informal basis.' Informal education was initiated by government resource management agencies through seminar and workshop in order to reach the wider public within a short time. However, financial constraints restricted this programme. In recent years to promote the understanding of ecological principals the University of the West Indies has started a programme which leads to a B. Sc. degree in Environmental Sciences. The programme is an interdepartmental on and constitutes courses offered by the departments of Botany, Chemistry, Geography, Geology and Zoology. The details of this teaching programme and the future plan of expanding environmental education in the Chemistry Department will be discussed.

Teaching of Environmental Science at the University of the West Indies

The development of environmental education in Jamaica received major impetus by the international community. The International Conference on Environmental Education organized by UNESCO in cooperation with the United Nation Environmental Programme (UNEP) during the period of October 14 to October 26, at Tbiliso, USSR reinforced the initiatives taken by the Jamaican Government to promote environmental education after the Stockholm Conference in 1972. During the late seventies, a number of Caribbean regional training activities under the auspices of the UNESCO-UNEP were organized. These activities emphasized curriculum development in the educational institutions and teachers training in environmental education. As a result of these formal environmental education existed in Jamaica today evolved.

Jamaica

In general Jamaicans are 'environmentally conscious'. This stems out from the important role played by the resources exploitation in the economic development of the country, *e.g.* agriculture bauxite industry and tourism, which includes beaches, forests and wild life. Environmental education in Jamaica has possibly grown out of the need to protect a resource base which was deteriorating rapidly for various reasons.

Environmental education is comprised of two components - informal and formal. The informal system consists of a group of people in both the private and public sectors, who have used instruments such as exhibitions, workshops, posters, pamphlets, talk shows, articles and television programs to promote environmental themes. They are quite often supported by the government and international agencies. The formal system, on the other hand, is comprised of a network that includes school systems at the primary, secondary and tertiary institutions. These institutions have responsibilities to include environmental related courses in the curriculum.

The informal system of environmental education got priorities in Jamaica in the late seventies mainly due to generous financial help by the international agencies. This approach was in keeping with the need to reach the wider public within a short time. However, due to financial constraints, this informal education has been restricted heavily. On the other hand, the educational institutions took initiatives to start formal education. The Ministry of Education has also been encouraging the primary and secondary institutions to include environmental aspects in their curriculum. At the primary level, students are exposed to a general awareness of the environment and the development of the proper attitudes to their surroundings. In the secondary schools, the Caribbean Examination Council (CXC) has heavily introduced main aspects of environments in the curriculum of grades 8 - 10. The CXC with its emphasis on subjects of regional relevance, is an excellent vehicle to educate and increase the environmental awareness of the upcoming generation.

At the tertiary level there are five major institutions which presently carry out aspects of environmental education - University of the West Indies (U.W.I.), the West Indies School of Public Health (WISPH), the College of Arts, Science and Technology (CAST), Teacher's Colleges and the College of Agriculture. Among these institutions, the College of Arts, Science and Technology offers a course in Environmental Chemistry, which introduces the student to the causes and effects of and the solutions to the different types pollutions. The course involves 30 lecture hour for an academic year and requires the completion of a research paper.

The University of the West Indies offers formal courses on aspects of the environment at the Faculties of Natural Sciences, Social Sciences, Medicine and Arts and General Studies. The Faculty of Natural Sciences has started its formal degree course on Environmental Sciences leading to a B.S. degree in Environmental Sciences. This new option aims to broaden the scope and competence of graduates in Botany, Geography, Geology, and Zoology, who may wish to work in the field of Environmental Science. The students registered for this course will automatically be registered for one unit of Environmental Chemistry. Presently the Chemistry Department offers no separate environmental course, however the Applied Chemistry course offered by the Department covers a significant range of environmental related topics. The Department will, however, offer a new, one unit course on Environmental Chemistry from 1990.

As mentioned previously a significant amount of environmental research on topics such as environmental pollution by industries, trace metals in water, pesticides in soil and water, are being carried out by the Department of Chemistry. Thus, a formal graduate program is already established at the University of the West Indies and the graduates will form part of a pool of Scientists whose skills are vital to the problem solving aspects of environmental management of the island.

These are some of the key issues and problems related to the development of environmental education in Jamaica. There are as follows:

(a) Lack of Financial Resources
(b) Shortage of Environmental Educators
(c) Lack of adequate media involvement
(d) Lack of coordinated Arrangements
(e) Lack of Socio-cultural approaches in Environmental Education
(f) Lack of reciprocal approach to Environmental Education
(g) Inadequate involvement of private sector in public environmental education

ABSTRACT *Laboratory Waste Treatment and Environmental Education in Japanese Universities* **Yutaka Tamaura and Mitsuo Abe, •Department of Chemistry, Tokyo Institute of Technology, Ookayama, Meguro-ku, Tokyo 152, Japan** •In Japan, the environmental education in universities is becoming more important to preserve the global environment and to solve the global environmental problems. The environmental education in the university should be given to students to understand the environmental problems from the view point of chemistry and science. The waste waters from the laboratories in the universities in Japan are treated at treatment facilities in their own campuses. The students in the Japanese universities are educated and trained to stock the laboratory wastes in their laboratories, and to treat them at the facilities. This training is recognized as an important and most effective approach to the environmental education in the university, since students can learn in practice how to protect the environment from pollution with the hazardous chemicals and with what chemical reactions the hazardous chemicals are treated. In the universities in Japan, where the laboratory waste waters are treated by the "Ferrite Process", the students can learn the practical process for the reuse of the waste, since the ferrite-sludge can be reused as useful magnetic materials.

Laboratory and Waste Water Treatment and Environmental Education in Japanese Universities

Japan

In Japan, the effluents from research laboratories in the universities have been regulated under the law (the Water Pollution Control Law) for about one decade. Table 1 (follows) shows the regulated items and the permissible limits in the law. These items and limits are the same as those applied to industry effluents. Under the law, the universities in Japan are regarded as the factories which will discharge an effluent causing water pollution. Thus, the students and the researchers in the research laboratories in the universities in Japan, are regulated not to discharge the research laboratory waste waters directly into the environment.

Almost all of the national universities in Japan have the treatment facilities in their own campuses, and they treat the research laboratory waste waters at the facilities. Figure 1 shows the flow chart showing how the research laboratory waste waters in the universities are treated. In the research laboratory, two kinds of waste waters are generated, that is, waste waters containing heavy metal ions and those containing waste organic solvents.

In almost all of the universities in Japan, the waste organic solvents are treated using the incinerator in the treatment facility in the campus. On the other hand, the waste waters containing heavy metal ions are treated by the neutralization precipitation method or a very unique treatment system of the 'ferrite process'. The students and the researchers in the research laboratories in the universities stock waste waters, and carry the bottle to the treatment facility, when the bottle is filled. The carried waste waters are treated by the treatment systems in the facility.

Table 1 shows the classification of the research laboratory waste waters for the stock of waste waters. This classification is very important for the complete treatment of the hazardous chemicals in the waste waters. If the hazardous chemicals given in Table 2 are mixed together, their treatment will become impossible.

Since the Hg ions are severely regulated by law in Japan, we have to treat the Hg ion by a different method from those applied to other heavy metal ions. Since, by the neutralization precipitation method, we can not precipitate the Cr(VI), we have to apply a different method, say the reduction step using Fe(II) ion. Thus, we have to stock the waste waters in different bottles depending on the treatment method applied according to Table 2.

The very hazardous chemical, CN^-, should be stocked separately. If the CN^- is once mixed with heavy metals ions, such as iron(II), the treatment will become very difficult. Moreover, if someone accidentally put a strong acid solution in the bottle, where all the waste waters are stocked together, a serious accident concerning the human life could take place. Thus, a classification of the waste waters for stock in the research laboratory is very important not only from the view point of the complete treatment, but also that of the occurrence of a serious accident.

Therefore, in the universities in Japan, we teach and train the students to stock the research laboratory waste waters according to this classification. We believe that this teaching and training is very important chemical education, since this training is required for us to recycle the wastes generated in daily life in human society. If every waste is mixed together and disposed, recycling will become very difficult. Moreover, by stocking the research laboratory wastes, we can preserve the environment. In this sense, we can say that this education is environmental education.

Figure 2 (follows) shows the treatment process of the 'ferrite process' for the treatment of the waste waters containing heavy metal ions. We add the $FeSO_4 \cdot 7H_2O$ into the waste waters and adjust the reaction pH to 10.5 - 11, and heat to around 65 °C. When we pass air through the reaction suspension, the Fe(II) ions are oxidized, and ferrites with the spinal structure are formed. During the formation of the spinel structure, the heavy metal ions in the waste waters are incorporated into the lattice points of the spinel structure. Since the heavy metal ions are situated into the lattice points, they are not so readily dissolved, that is, the ferrite sludge is chemically very stable. Therefore, we can reuse the ferrite sludge as useful magnetic materials, such as a magnetic marker and a microwave absorber, etc.

In some factories, the carrying automobile is guided by a land of magnetic markers, formed with ferrite sludges. Thus, the ferrite treatment system for waste waters of heavy metal ions is a very useful teaching subject to learn how the hazardous heavy metal ions are chemically stabilized and how we have to consider the treatment and the recycling of resources.

In some universities in Japan, a lecture concerning the treatment of waste water is given to students in the general chemistry laboratory. This lecture includes visiting the treatment facility, where the students can learn practically how the waste water is treated and how the treated water is analyzed. In some universities, students are treating the waste waters at the facility themselves. This is recognized as good training for environmental education. Thus, in the universities in Japan, we can use the treatment facility as an environmental education facility.

Items	Permissible Limits
Cadmium and its compounds	0.1 mg/l
Cyanide compounds	1.0 mg/l
Organic phosphorous compounds	1.0 mg/l
Lead and its compounds	1.0 mg/l
Hexavalene chromo compounds	0.5 mg/l
Arsenic and its compounds	0.5 mg/l
Total mercury	0.05 mg/l
Alkyl mercury compounds	not detectable
PCB	0.03 mg/l
pH	5.8 ~ 8.6
BOD, COD	160 mg/l
SS	200
N-hexane extracts	5 (mineral oil) 30 (animal fat and vegetable oil)
Phenols	5.0 mg/l
Copper	3.0 mg/l
Zinc	5.0 mg/l
Dissolved iron	10.0 mg/l
Dissolved manganese	10.0 mg/l
Chrome	2.0 mg/l
Flourine	15.0 mg/l
Nitrogen	120.0 mg/l
Phosphorus	16.0 mg/l

Table 1: Permissible limits in the Water Pollution Control Law in Japan

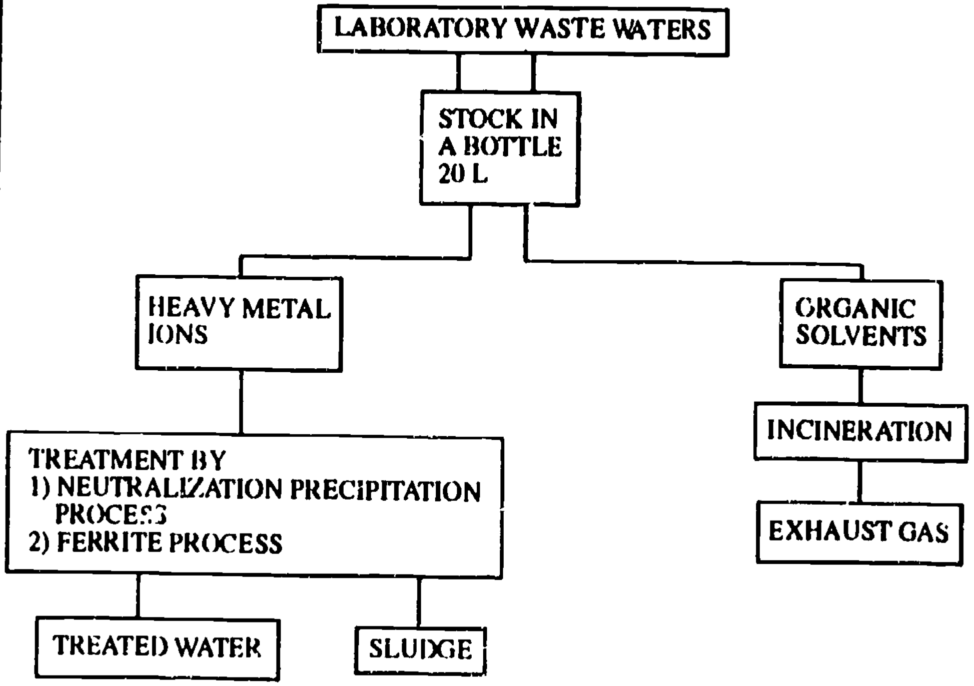


Fig. 1: Flow chart of the research laboratory waste waters in the universities in Japan

Table 2 Classification of research laboratory waste waters

Class	Compounds	Treatment Process	
Chromium (IV)	Chromic acid	Reduction/neutralization precipitation	Ferrite process
Arsenic		Hydroxide coprecipitation	
Heavy metal ions	Cd, Pb, Cu Fe, Zn, Mn others	1. Neutralization precipitation 2. Hydroxide coprecipitation 3. Sulfide coprecipitation	
Mercury	Inorganic mercury except metal mercury	1. Sulfur coprecipitation 2. Chelate regin	
Organic mercury	Methyl mercury Ethyl mercury	The same method as that of Mercury after oxidation.	
Cyanide		1. Oxidation method 2. Prussian blue method	
Fluorine	Hydrofluoric acid	Calcium coprecipitation method	
Acid or alkali		Neutralization	
Active Chemicals	Oxidizing or reducing reagents		
Photograph waste water		1. Incineration (Developing solution) 2 Incineration after silver recovery. (Fixing)	

ABSTRACT *Energy and the Environment as related to Chemistry Teaching in Jordan* **Musa Z. Nazer •Department of Chemistry, University of Jordan, Amman, Jordan** •The educational system, especially at the undergraduate level, has been slow in accommodating basic knowledge about the environment and energy. Chemical aspects are scattered through traditional courses and do not form a useful whole. Difficulties in developing modern instrumentation-based analytical chemistry programs and the lack of educators trained in environmental chemistry handicap efforts to implement necessary curriculum changes. In contrast, stronger activity exists at the graduate and research levels where work is done on air, water and industrial pollution and on pesticide residues. On the national level several government and nongovernment institutions, societies, and departments have been set up to cater for environmental and, to a lesser extent, energy issues. Efforts tend to spread in superficial breadth without sufficient basic understanding of what goes on in the environment.

Energy and the Environment as related to Chemistry Teaching in Jordan

Jordan

Introduction:

No need to build up a case for the role of chemistry in most aspects of the environment and energy. Sound chemical knowledge is, therefore, mandatory.

Issues related to energy and the environment are of such a nature that they concern everybody; from the highly specialized scientist to the layman. Public concern and enlightened awareness are very important in facing these issues. Such a wide knowledgeable public involvement would not be possible without careful education. Relevant knowledge, whose core is chemistry, needs to be transmitted and propagated through our educational system at all levels. Presently advanced and sophisticated scientific knowledge is available to the specialist, but what arrives to the public is often insufficient and misrepresented. Only through teaching, suitable knowledge and understanding could be acquired. Without proper perception of problems of energy and environment, which comes as a consequence of education, positive attitudes and constructive actions would not be expected.

Research, technology and applications have advance quite a bit in the fields of energy and environment, but systematic organized knowledge has not found its way easily into curricula. It is understandable that curriculum changes are usualy slow and lag behind scientific discoveries, but the lost time so far and the importance of the fields should put sufficient pressure for serious considerations of curriculum changes.

Energy and Environment in the Educational System in Jordan:

The educational system in Jordan, as might be the case in many other places, has been slow in accommodating basic scientific knowledge about energy and environment, although interest and concern of educators, educational institutions and the public have been rapidly growing for the last ten years, with environmental issues gaining more than energy issues.

The following synopsis of the main activities and programs would reflect the extent and the level of involvement of educational institutions in environment (mainly) and energy.

1) At the pre-college level

As an outcome of a national conference on education held in 1987, work is going on to introduce new curricula for all pre-college grades (grades 1-12). Special attention has been given to a science curriculum in which energy and environment have been at the core in all grades. Chemical aspects of these subjects, however, cannot take a major share except at a later stage through this level of education, but attention and interest is built up gradually to give sufficient basis to later development.

2) At intermediate college education (Two year community colleges)

In Jordan, this sector of higher education is sizable. About 50% of successful high school graduates enroll in these colleges (49 colleges), whereas 25% go to local universities (four universities). This year, the Ministry of Higher Education introduced new curricula for all programs and specializations (90 specializations). Although there is no one specialization devoted wholly to environment or energy, courses and topics in these areas have taken up a larger portion of the various curricula.

3) At Teacher's College

A teacher's college, established this year, works on qualifying about 20,000 school teachers holding a two year to a four year bachelor degree level over the coming few years. As teachers, expected to help in spreading and intensifying public awareness, their qualifying curriculum exposes them to current environmental and energy issues.

4) At Universities

a) Bachelor degree level: The traditional departments at Jordanian Universities gave some room in their curricula for scattered topics and courses which are related mainly to conservation and environmental pollution but rarely to energy. These scattered courses lack coordination and do not form an effective network. Environmental chemistry, for example, has not even grown to a single course in most chemistry departments. On the other hand, one university initiated a department of earth sciences and environment and another a department of applied chemistry. Curricula in both places list few courses related to environment and energy, but the content does not reflect sufficient depth in basic ideas.

One major factor that retards the progress and the spread of environmental chemistry at the undergraduate level is the difficulties that universities face in upgrading and modernizing their expensive instrument-based analytical chemistry teaching.

b) Graduate and research level: The environment has a good share of M.Sc. research projects and other research activities. Survey and monitoring analytical-based work is performed in several departments on water pollutants, pesticide residues, heavy metal poisoning, and industrial air pollutants. Several regional and local seminars on environmental chemistry have been sponsored by the universities. At the University of Jordan, the biggest and oldest of all, there is a Water Research and Study Center and a Program of Environmental Studies. In spite of this reasonable research activity, there is a notable lack of suitable course work to go along with it. Thus a basic understanding of the environment and a proper evaluation of research results remains unsatisfactory.

Energy and Environment in other Institutions and Centers:

Since the time the Jordanian government started on its three- and five-year development plans in early 1970's a number of government and non-government agencies, departments and societies have been set up to deal with energy and environmental issues. The establishment of some was catalyzed by crisis and health and environmental problems. The following lists of these main establishments:

- Ministry of Energy and Natural Resources, Department of Standards and measures at the Ministry of Industry, Water Authority, Community Health and Environment at the Ministry of Health, Department of Environmental at the Ministry of Municipal Affairs, Occupational Safety and Health Institute at the Ministry of Labor, Pesticide Residue Laboratory at the Ministry of Agriculture, Royal Society for the Conservation of Nature, Royal Scientific Society (RSS) and the Higher Council on Science and Technology (HCST).

Although much of the functions of the above could be predicted from their names, the last two merit some comment. Both, RSS and HCST, enjoy strong government support. They are headed by His Royal Highness Crown Prince Hasan. Their staff includes people of high qualifications. RSS, established in 1971, has an Environment Research Center which is active in work on air and water pollution and industrial waste. The center is rich in equipment and information resources. RSS has also a department of energy which focuses on non-fossil energy sources, in particular, solar and wind.

HCST is a body, set up in 1988, to draw and help implement a national strategy for science and technology. It has a sector devoted to "environment" and another devoted to "energy". Its role is mainly in planning and coordination and support of programs and research projects that relate to the needs of the society.

ABSTRACT *Energy and Environment in College Chemistry Curricula* Carlos M. Castro-Acuña Depto. Fisicoquímica/Investigación Educativa, Fac. Química, Universidad Nacional Autónoma de México, 04510 México, D.F. México •Although energy and environment topics are daily covered by the Mexican media, and there has been a considerable social concern about pollution and waste of natural resources for many years, it is just recently that this situation is leading to some changes in the chemistry curricula at college level. At the National Autonomous University, we are starting with new curricula in five careers: Chemical Engineering, Metallurgical Chemical Engineering, Pharmaceutical Biological Chemistry (PBChem), Food Chemistry and Chemistry. In the Chemistry program there are two optional "energy and environment" oriented courses: Natural Resources and Ecology Balance. For the chemical engineers there is one compulsory course (Environmental Engineering) and two optionals on energy resources and conservation. In PBChem there is a traditional Toxicology course and in Food Chemistry we have Food Toxicology and Water Treatment courses. At the National Polytechnic Institute there is an optional course of Environmental Engineering for chemical engineers and, in many other universities there is not a single course in these topics. An analysis of the courses mentioned above, and of the "energy - environment - education" guidelines of the National Plan for Development (1989 - 1994) will be presented.

Energy and Environment in College Chemistry Curricula

Energy and environment topics are daily covered by the Mexican media, and there has been considerable social concern about pollution and waste of natural resources for many years. The problem of Mexico city, with its nearly 23 million people, is perhaps the most known outside the country; while three years ago the major pollutant was lead, now the government owned oil company has changed the gasoline and, as a direct consequence, ozone is the principal contaminant. Starting November 20 there will be a program named: One Day Without a Car" and the city government expects to reduce the vehicle circulation to around 300,000 units. The weekday that one is not allowed to drive a car depends on the plate number.

Although this program is generally accepted as a positive measure to reduce air pollution, there are many drawbacks: there is not sufficient public transportation, many people have their cars for working purposes and not just for traveling and, besides, wealthy people who have more than one car will not be affected at all.

Besides, there is a program of compulsory tune-up once a year for every vehicle, but unfortunately some people cheat and buy the emission certificate without having their cars fixed. This situation clearly show that a major factor in our pollution crisis is a lack of proper education.

The government, through SEDUE (Department for Urban Planning and Ecology) has taken many actions to improve the air and water quality in the whole country. However, due to the same lack of education and social commitment, many programs fail when they affect personal interests. It is very common to find very intricate situations: an industry is closed down because is is contaminating the only river of some town, and the majority of the people are now unemployed because that industry was the main support for the regional economy. Besides, the resources to treat the effluents are not available. Another typical situation is that an industry, where owners are conscious of the risk factors involved in its operation, is built in a place far away from the town; as time goes by, the population grow and people start to settle illegally in the land that surrounds the industry. Finally, when the company complex is in 'midtown', people start asking for the industry to shut down because it is polluting the neighborhood. On the other hand, due to ignorance or lack of scruples, some people hide small factories and disguise them as houses to avoid paying taxes and emission control.

Perhaps the most controversial topic is the installation and starting up of the nuclear plant at Laguna Verde. Concerning this project, there has been more than one thousand conferences, newspaper articles and editorials in the last two years. Many groups of ecologists are fighting fiercely against the plant, while the nuclear experts state that there is no risk involved and that the nuclear generation of electricity is essential for the country's development. The last word is still to be said.

Mexico

The aim of this article is not only to summarize the main energy and ecology problems in the country and the efforts to solve them, but also to establish that almost everybody is talking about pollution and energy crisis, but few are doing anything about it.

Although there is a general agreement on the urgency of taking strong actions, there is no commitment in our society. It seems that pollution is always "somebody else's problem" and we are expecting that this "somebody else" will perform all the work. We wrongly believe that the government is the only entity responsible for all our troubles and so it has the obligation to fix everything. As we can see, the absence of a strong "social oriented" education is a much more dangerous pollutant than ozone or sulfur dioxide.

Chemical education in Mexico has not been excluded by the situation mentioned above. In the new chemistry curricula at the college level, we find more "ecology oriented" courses, but Nuclear Chemistry and Nuclear Engineering have disappeared as optional courses. It seems that the national campaign against nuclear power is paying off and we are forgetting the many useful applications of this energy source. Moreover, the bad public image of the chemistry industry as a major source of pollution, is one of the many factors leading to a lower enrollment in chemistry related careers and we, as a society, are forgetting that we *need* to know chemistry to detect and identify contamination sources and to propose solutions.

At the National Autonomous University, we are initiating new curricula in five careers: Chemical Engineering, Metallurgical Chemical Engineering, Pharmaceutical Biological Chemistry (BPChem), Food Chemistry and Chemistry. In the Chemistry program there are two optional "energy and environment" oriented courses: Natural Resources and Ecology Balance. For the chemical engineers there is one compulsory course (Environmental Engineering) and two optional on energy resources and conservation. In PBChem there is a traditional Toxicology course and in the Food Chemistry we have Food Toxicology and Water treatment courses. At the National Polytechnic Institute there is an optional course of Environmental Engineering for chemical engineers. However, in many other universities there is not a single course on these topics. As usual, one of our main problems will be the lack of enough human resources with experience as well as the time to involve them in educational programs.

In the National Plan for Development (1989-1994), there are several guidelines to follow in energy, ecology and education:

"We need to involve everybody in the educational structure. We have to increase the appreciation of science and technology among the people".

"This plan has, as a major priority, the protection and restoration of the environment. The main goal is to harmonize economic and industrial growth with the preservation of the ecology balance. We call for a national and international crusade to save the capital".

"We will invest in water treatment plants and we will ban industries with high water consumption in many regions. We have to stop immediately the irrational destruction of our forests". "In the universities, we will support research projects oriented to environment protection. We will promote a strong link between academic programs and the energy and ecology needs of our country".

Our government is taking many actions. Fortunately, more and more people are getting involved in community programs for environment protection. However, for this plan to succeed, we still require an enormous improvement on basic education as well as on Chemical education at every level.

ABSTRACT *The Environment Inside the Chemistry Curriculum: The Mexican High School Situation* **Jose A. Chamizo Facultad de Quimica, Universidad Nacional Autonoma de Mexico and Colegio Madrid, Cuidad Universitaria, 04510, Mexico, D.F. Mexico** •The high school education in Mexico is divided in two, three year levels. The first one, secondary or junior high school (ages from 12 to 15) has basically the same curriculum all around the country. It has a population of 4.3 million which represents 40% of the people at that age. The second one, with students from 15 to 18 years old is divided between twosectors: Federal and State. It has two main objectives: to prepare for undergraduate university education (preparatory) or to train for technical jobs (terminal). The population at this level is around 2 million which represents 20% of the people at that age. For 90% of all the students enrolled in the six years high school system, the education is free. The environment inside the chemistry curriculum is practically absent in one of the more polluted countries of the world: only 4% of the study space at the junior level and 2% of at the higher one. The problem and ideas toward a solution will be discussed.

The Environment Inside the Chemistry Curriculum - The Mexican High School Situation

I Introduction

Mexico, as other Third World countries, can be characterized by two parameters: contrast and growth. With 85 million people and a per capita income of US$2300, Mexico has suffered in the last years an enormous population increase, while trying to attain the economic growth, with the corresponding pollution problem, that might equalize the social justice balance. In spite of the increasing population, the country has been able to enlarge its social justice balance. In spite of the increasing population, the country has been able to enlarge its educational capacities even faster in terms of schools, teachers and students. However, since 1982 when the economic crisis and the external debt dominates all the political decisions of the country, the education budget was reduced dramatically from 5.5% of the Gross National Product, to 3.6% in 1987. The result in the education system (characterized in Table 1) is that we have to teach more students with less money each year, year after year.

Table 1: Mexican Education System 1987-1988

Level	Schools	Teachers	Students
Day care	41,438	93,423	2,625,678
Elementary	79,677	463,117	14,768,008
Secondary(Junior)	17,640	230,785	4,347,257
Baccalaureate	3,850	101,064	1,586,098
College	1,453	107,492	1,112,788
Others	5,209	69,145	1,004,818
Total	149,267	1,065,026	25,444,647

As can be observed in Table 2, in the near future the population growth will be particularly significant at the high school level (secondary and baccalaureate), the population that is the subject of this report.

Table 2: Population at school (million)

Level	1970	1980	1990	2000
Elementary	9.25	14.60	14.50	11.20
Secondary	1.10	3.03	4.45	4.26
Baccalaureate	0.31	1.18	2.28	2.80
College	0.26	0.79	1.40	1.40

The high school education in Mexico, almost free for approximately 90% of all the students enrolled, is divided in two, three year levels. The first one, secondary, or junior high school for people between 12 to 15 years old, has basically the same curriculum all around the country, and the second one, baccalaureate, with students from 15 to 18 years old, divided, in terms of curricula, in two equally sized administrations:

i) Federal. A system of education centralized by the Secretary of Public Education.
ii) States. This system can be represented by the National Preparatory School of the National University of Mexico created in 1868, and complemented in 1971 with the so called "Science and Humanities School".

II Secondary

There are two alternative approaches to science education at this level: a) Isolated science approach, physics, chemistry and biology courses each one with a different teacher. b) Integrated science approach, at least in the name one integrated course, with only one teacher. In both approaches, chemistry has been incorporated through the three years. The discussion here will be related only to the chemistry curriculum in the first approach, however the main points are valid for the second one.

The space dedicated to study subjects explicitly related with the environment is only one unit (Pollution) of a total of 24. Also there are three short sections in the units dedicated to water, air and carbon. That means about 3% of the total, in one of the more polluted countries of the world. Here as in other education situations, the facts and theories that we do not teach are more important than the ones we do.

A few concepts from two of the bestseller chemistry textbooks, classified in four categories (Table 3) will show the magnitude of the problem.

Table 3: **Few Textbook concepts related with the environment introduced in the secondary school***

Category	Example	Comment
1. What we understand by environment.	"The always wise Nature. . ." (RMV, 3-85)	That can resolve by itself(Without human responsibility) all the pollution problems.
2. Origin and development of the evironmental problem.	"The industry in the First World countries increases in their cities the allowed levels of pollution" (RR, 3-89)	Only in the cities of First World countries?
3. Environmental education.	"The use through history of metals is an example of Nature mastered by means of science." (RR, 3-66)	Nature, as water, air and soil appears alien, passive and static, which is used and polluted by the active man.
4. Curriculum aspects.	Only one experiment related with pollution. (RR, 3-95)	Chemistry in the textbooks and in the curriculum is "chemically pure", outside students world.

* They are the same two approaches earlier described.

** RR = ABC de Quimica
Alvaro Rincon y Alonso Rocha
Editorial Herrero, Septima Edicion, 1985
135,000 copies

RMV = Quimica
Xavier Rodriguez, Olga Magaña y Maria Velasco
Editorial Esfinge, Sexta Edicion, 1982
10,000 copies.

III Baccalaureate

With one compulsory year dedicated to chemistry, the last one for the vast majority of the students, the magnitude of the education problem at this level is important. In a country with a powerful petrochemical industry identified as the 15th economy of the world, the proportion of baccalaureate students that choose to study a professional career related to chemistry has been going down from 10% (of a total of 271,000) in 1970 to 6% (of a total of 1,100,000) in 1986. One of the reasons for this situation (identified and discussed by hundreds of teachers around the country through specially designed training courses) corresponds to the way we have been teaching our discipline - a lot of "chemical principles" (Table 4) and too little of exciting, useful, everyday chemistry. The environment does not exist in the current curriculum. How can the students understand their world?

Table 4: Current Chemistry curriculum in Mexican baccalaureate

Federal	States
Matter	Scientific Method
Atomic Structure	Atomic Structure
Periodic Table	Periodic Table
Chemical bond	Reactivity
Stoichiometry	Stoichiometry
Equilibrium	Hydrogen, Oxygen, Halogens, Sulphur
Inorganic nomenclature	Metals
Functional Groups	Electrochemistry

The incorporation of environment topics, however, must be realized under the consideration of the four categories briefly identified in Table 3. Environmental education is an attitude, a way to see ourselves as part of Nature.

ABSTRACT *About What Happens in Environmental Education in the Netherlands*
Wout Davids and Hans Hoekman Institute for Curriculum Development, Postbus 2041, 7500 CA Enschede, The Netherlands •**General**: During the last years there has been a growing interest from both the Government and different private organizations for the environment. In a report, "Concerns for Tomorrow" which appeared in 1988, The Netherlands were presented as the most polluted country in the world. Employers and the labor unions decided to give top priority to the environment in the coming decennium. •The Government was interested as well Environmental education appeared to be important for the future. In that way a well - informed society could give the needed support for measures to be taken in the future by politics. Important changes in production and consumption patterns will be necessary and therefore support from the majority of the population is needed. •**Organization**: A "National Support Center" for nature and environmental education was created, which has a coordinating task for different activities in the environmental education. Not only private organizations but the Government as well participate in this "Support Center". •With regard to education, a lot of work has been done by private organizations in making contributions for lessons in biology, physics, chemistry and geography, especially for the lower secondary level. However, the implementation in schools was not very good, although the quality of work they did was very good. Their problem was: no experience in the educational field. •Since 1986, the University of Utrecht, together with the National Institute for Curriculum Development, came into the picture. Implementation is much better now. •The subject "Energy" is introduced by a series of lessons about "Fuels", developed by the University. Besides it can be said that some "single lesson topics" were made about chloro-bleaching products, ozone, smog and the greenhouse effect. •For upper-secondary level preparations have been made and an introduction into education will start soon. In the actual programme for chemistry in the upper secondary, there are several topics which may be easily connected and extended with environmental education.

Country Report of the Netherlands

Science education in Holland (The Netherlands) for 12 - 16 year, general level.

We have no tradition in environmental education at the secondary level. Accidentally it happens that a teacher is doing something about the environment. Maybe about 20 school are doing this, but up until now it is not in the regular curriculum.

As we pointed out in the abstract of the 1988 governmental report "Concerns for Tomorrow", politics and some parts of society are more involved in taking measures concerning the environment. Of course, it takes time to introduce "environment" as a structural part of education.

For this introduction, a national support center for the environment was created. The center got financial support from the ministries of Education, Economic Affairs, Agriculture and Environment. For next year, the support will be $5.10⁶.

In the meantime, for lower secondary level up to 15 year old students (education for everyone) teaching units are being developed for biology/ chemistry in a thematic approach by the Institute for Curriculum Development at Enschede in co-operation with the University of Utrecht.

These teaching units have been tested in a small number of schools. A revision is now introduced in a bigger number of schools.

Environment and Energy in the Chemistry Program for 16 - 18 year, of the highest level of secondary education in Holland. Three years of chemistry education, lasting 3-4 hours weekly. Our program will be changed as a new project for the upper secondary will start January 1, 1990.

Besides a general modernization, special attention will be paid to computers and to the environment. Existing subjects will be emphasized from other points of view. In the actual program there are several topics that are easily connected with environmental aspects.

The Netherlands - Chemistry Program up to year 15

Topics Related to Environment / Energy	
- Meat: Environmental Effects and alternatives	All levels
- Pesticides: Environmental effects and alternatives	Low levels
- Fuel: Local Contribution to solve the energy problem	High level
- Waste Management: Comparison of different methods of waste disposal	High level

The Netherlands - Chemistry Program up to year 18

The Netherlands

Topics related to environmental education:

- Aspects of energy and entropy
- Handling substance: Small Scale/Big Scale
- Heavy Metals
- Waste problems related to production and purification
- Recycling
- Corrosion

Programma Central Examination Chemistry Education Highest Level

1. Analysis
2. Atomic Structure, Chemical Bond
3. Energy, Entropy, Equilibrium
4. Industrial Chemistry
5. Carbon Compounds
6. Rate, Mechanism of Reactions
7. Reductors, oxidators
8. Calculations
9. Stereo Isomerism
10. Acids, Bases

ABSTRACT *Environmental Science Education in Norway* Vivi Ringes University of Oslo, Box 1033 Blindern, 0315 Oslo 3, Norway •The Ministry of Education appointed in 1988 a project leader responsible for implementation in schools of the World Commission's recommendations. Contact groups for initiating school projects on aspects of energy and environmental science are also established in the 19 countries. The present policy is to let environmental issues gradually permeate every school subject. Environmental issues are already included in the courses of 80% of chemistry classes, grades 11 - 12. Some of the present school projects on environmental science are: •Water Data project. 150 schools monitor one lake each. •Coast Watch Europe. 450 schools monitor water quality and report on solid pollutants. •Ozone Project. A pilot project on the effects of air pollution (ozone) on growth of tobacco plants. In 1990 schools from other nations will participate in the project. •Acid Rain Project. 800 schools measure *ph* in rain and take meteorological observations. •Teaching material comprises 91 units of the Environmental Science Project and video programs such as "Chemistry of the Car" and Mega - the Energy Magazine. Efforts are made to start upgrading all teachers in environmental science Both in-service courses and qualifying courses will be offered.

Energy and Environmental Efforts in Norway

In 1972, Norway established a Ministry of Environment and two years later a State Pollution Control Authority. Acts of control of chemical products (1976) and pollution (1981) have been put into legislation. The work of the World Commission on Environment and Development - sometimes called the Brundtland commission after Norway's former prime minister - has given environmental issues increased attention. A 1988-89 White Paper shows how to implement the recommendations of the World Commission. In three years the budget of the Ministry of Environment has doubled. The sum of environmental efforts in the budgets of all ministries mounts to 2.3% of the total expenses in the 1990 Budget. The Norwegian Council for Scientific and Industrial Research has launched a R&D program on environmental technology and alternative energy sources. Contours of an expanding industry for construction of purification plants is now visible.

Norway

Every county administration has a division of environment working on a more local base. Some districts have received national support for solving their specific problems such as hazardous wastes, eutrophication in lakes, and noise exposures. Efforts are made to indulge local trade and industry as well as schools and the general public in handling the local problem.

Energy

Compared to most European countries, Norway is extremely rich in power supply: oil, gas and water power. Our energy consumption is among the largest in the world based on consumption per capita (figure 1). The consumption is equally divided between hydro-electric power and oil; solid fuels constituting some 10%. Concerning electricity, practically all production is derived from hydro-electric power. Of the exploitable, non-preserved water power, just a small percentage is left for future utilization. At present production level we have, however, oil reserves in the North Sea for almost 40 years and gas reserves for more than 100 years. Future increase in power production should, according to an Energy White Paper, mainly be based on gas power.

There are various reasons for Norway's high energy consumption per capita. Winters are rather cold and long, electrochemical industry is a dominant export industry, and energy prices have been kept low.

On a world scale the principal cause of acid rain and possible changes in global climate is combustion of fossil fuels such as oil and gas. As a consequence, the expressed policy of Norwegian government is to contribute to a sustainable development on earth by levelling out the energy consumption by the turn of the century. To achieve this goal energy economizing (Enec) will play an essential role. By the term Enec is meant economically profitable use of existing technology. Enec projects for industrial plants and various buildings will be subsidized. Prices of energy will gradually be increased because less energy is consumed with higher cost per unit. Investigations have shown that an increase of 1% in oil prices is followed by a decrease in demand of 0.5%.

Environment

Air pollution is a global concern and several international agreements are concluded. G.H. Brundtland of Norway has, in cooperation with the prime ministers of France and the Netherlands initiated a declaration accepted in March 1989 by 24 countries. It addresses conservation of the atmosphere. In Norway, ozone measurements have been conducted on a regular basis since the first atmospheric measurement ever in 1934. A national research program on climate and ozone has recently been started.

Norway has signed the Helsinki protocol of a 30% reduction of SO_2 emissions by 1993, as compared to 1985. The aim is already accomplished as a result of lowering sulfur content of fuel oils, introducing strict cleaning treatment legislation, and the closing down of an old mining plant. However, 90% of the sulfur dioxide ever Norway is imported pollution.

Whereas Norway's SO_2 emission per capita is low, the NO_x emissions are high due to sizable domestic shipping and fishing fleet. The emissions of NO_x have in the last decade increased by a yearly average of 3.9% along with a rise in the purchase and use of private cars. From 1989, legal demands on cleanliness of exhaust gases from new cars have been met by installment of catalysts. In order to stabilize the total NO_x emissions by 1994 as compared to

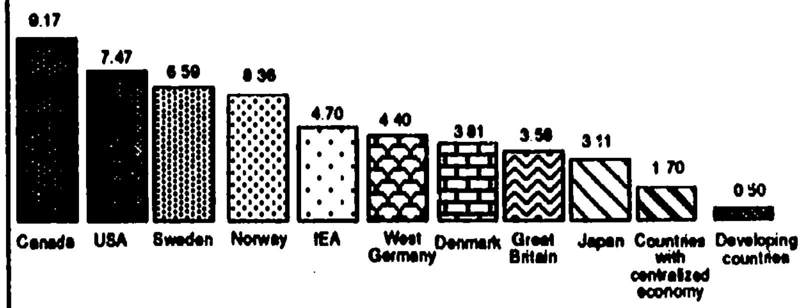
1987 (the Sofia protocol) further demands an older private cars, on trucks, and on diesel-powered vehicles will be carried into effect in the near future. Alternatives to catalysts such as recycling of exhaust gases are being reviewed. Speed limit will be maintained at 55 mph. Requirements as to purifying maritime traffic will be put forward.

The 1988 algae growth in fjord waters of the North Sea was a dramatic evidence of too high concentration of ionic nutrients. Poisonous algae did exert a threat to nature as well as to commercial salmon breeding. Efforts are now being made to half the emissions of ionic nutrients by 1995. 100 new sewage treatment plants will be constructed on the south coast of Norway and existing municipal sewers repaired. Agriculture is one of the main sources for nutrients in watercourses. Thus, farmers get 30% grants of the cost to different actions, *e.g.* repairing manure and silo store houses and planting vegetation nearby watercourses. Special requirements to periods for spreading manure and fertilizers, and to the ratio of cattle to area of farmland are set. Use of phosphates in detergents is from 1989 prohibited.

The State Pollution Control Authority has elucidated the extent and effects of toxic wastes. Priority has now been given to reduction of (compounds of) the following 13 toxic chemical substance: fluorine, lead, cadmium, copper, chromium, mercury, zinc, chlorinated alkyl benzenes and alkyl styrenes, dioxines, chlorinated phenols, PAH and PCB. The substances originate from industry and reduction will be made possible by changing production technology and imposing better purification works.

ENERGY CONSUMPTION

Figure 1: Total energy consumption per capita, 1985 tonnes oil units per capita



Adapted from IEA and BP Statistical Review of World Energy

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ABSTRACT *Chemistry Teaching in Connection with Country Environment in China* Junying Yang and Tongwen Hua **Department of Chemistry, Peking University, Beijing, 100871, China** •China is facing more and more environmental pollution problems. In order to solve these problems, the Chinese government began to draft laws for environmental protection and established many organizations, such as the National Environmental Protection Bureau, environmental monitoring stations, environmental sciences research institutes since the seventies. In the mean time, the environmental science education system has been established. Environmental science departments or specialities have been set up in many universities and colleges. More than a hundred BS and about thirty MA and PhD candidates graduate from such universities or colleges each year. Some knowledge about environmental problems have been introduced to the courses of "Nature" and "Chemistry" in primary and secondary schools, respectively. For general chemistry courses, we are considering the possibility of linking chemical principles with popularly known environmental problems such as the greenhouse effect, photochemical reaction, destruction of the ozone layer, photo-chemical smogs and heavy metal contamination.

Chemistry Teaching in Connection with Country Environment in China

As the industry is developing, China faces more and more environmental pollution problems. Because 70% of the energy sources in China depend upon coal, the air is contaminated by waste gases and floating dusts. It has been reported that there were almost no clean rivers around the water shortage area north to the Yellow River and even in the so called water area south to the Yangzi River. After investigating nearly one hundred cities, varying quantities of toxic pollutants were detected in underground water supplies. The recently developing township industrial enterprises further aggravate the pollution of the environment and critically damage the eco-environment.

People's Republic of China

The Chinese Central Government has paid close attention to environmental pollution problems and promulgated some laws for environmental protection. The National Environmental Protection Bureau was established in 1978. Under this Bureau are the National Environmental Monitoring Head Station and the Chinese Environmental Sciences Academy. Each province also set up its corresponding organizations. Under the Chinese Natural Sciences Academy there is the Eco-biological Environmental Research Center with 530 staff members, of which 230 are research fellows.

The Chinese environmental science education system was formed during the seventies. A special college for environmental sciences was established in Suzhou, Jaingsu Province. Departments of environmental science, environmental engineering, environmental protection, environmental monitoring, etc. were set up in many universities. Specialities of environmental chemistry under the departments of chemistry or applied chemistry were established in other universities. Elective courses in environmental sciences or chemistry are offered at other universities. Even art students at Peking University study these subjects. More than one hundred BS and about thirty MA and PhD graduate students were accepted by the departments of environmental sciences last year. In most provinces and municipalities over the past years, a large number of competent technicians have been trained in junior colleges. More knowledge of this field will be introduced in the courses "Nature" and "Chem" in primary and secondary schools, respectively. In Shanghai and Beijing, courses of environmental chemistry and environmental management have been offered particularly for middle school chemistry teachers.

In general chemistry courses, we are considering the possibility of linking principles with the popularly known environmental problems such as the greenhouse effect, photo-chemical reaction, destruction of the ozone layer, photo-chemical smogs, acid rain and heavy metal contamination.

In the lecture concerning the relationship between the molecular structure and its spectra, we will mention that the non-polar diatomic molecules N_2 and O_2, main components of the atmosphere, cannot absorb infrared radiation, while the triatomic molecules CO_2, due to their asymmetric vibration, do absorb it. Since fossil fuels are used much more than previously and the amount of CO_2 in the atmosphere has increased, the infrared radiation reflected by the earth's surface to outer space will decrease. This will lead to the so called "greenhouse effect".

Talking about the interaction between photons and molecules, we can relate the formation or decomposition of ozone in the stratosphere to the photo-chemical reactions of ultraviolet light. The so formed ozone can absorb ultraviolet radiation and thus protects all creatures on the earth from the harm of excess radiation. But the ozone in the stratosphere can be destroyed by reactions with some pollutant molecules such as nitro-oxides in the polluted atmosphere, for example NO_x, HO free radicals, freon, etc, and this threatens human health.

In discussing the reaction mechanism, we can also introduce the chain reactions of free radicals in the polluted atmosphere. When the atmosphere containing NOx and hydrocarbon compounds is illuminated by ultraviolet light from the sun, photochemical reactions, involving free radical and chain reactions occur.

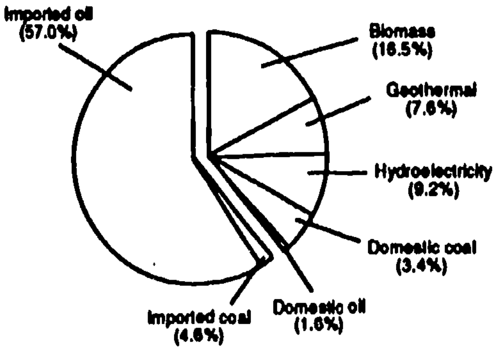
When teaching elementary chemistry and elemental analysis, we will point out that heavy metals such as Hg, Cd, Cr and Pb are the main pollutants. It will be more practical to properly connect the heavy metal pollution problems in polluted water with their chemical properties and chemical equilibria.

For human health, chemistry teachers should pay more attention to environmental chemistry education.

ABSTRACT *Environmental Science Education: A Tool for Sustainable Development*
Merle C. Tan Institute for Science and Mathematics Education Development, Diliman, Quezon City, 1101, Philippines
•Environmental Science Education (ESE) is viewed as one of the tools that could reverse alarming trends now seen in the Philippine environment. A strategy for action in ESE for sustainable development will soon be adopted. Hopefully this will optimize the contributions of people in making environmental education systems more valuable, efficient and effective and, ultimately, redound to environmental rehabilitation and upli. ment. It includes the preparation of a scope and sequence for ESE, development of instructional modules on priority concerns not discussed in existing materials, and incorporation of environmentally - related courses in the technical and vocational field. An on-going in-service program to expose teachers on the various teaching approaches to ESE compliments the curriculum development activities. This will also provide them with a comprehensive understanding of basic scientific concepts and techniques to enable them to do investigatory work about the environment, and to educate students for the environment. Networking between government and industries, and other agencies working on environmental protection and improvement will be strengthened with the setting up of the Philippine Science and Technology Centrum. The Environmental Pavilion will feature energy-saving and pollution free devices. Hands-on experiences will enable the public to appreciate the cause-effect relationship of environmental problems and better equip them to participate in decision making.

Energy and Environment Efforts Related to Chemistry Teaching: Philippine Experience

Energy use accounts for most environmental problems. With the government's move to accelerate development of domestic energy resources (PNOC, 1988 Report) in order to meet rising prices of crude oil and increasing consumption, there has to be a corresponding education campaign to ensure that economic gains do not come at the price of a damaged environment.



Present Primary Sources (Source: AsiaWeek Sept. Issue)

Philippines

What is going on

Education about and for energy and the environment focus on the following concerns: (1) All people are users of energy. (2) Energy is crucial to people's lifestyles. (3) A large amount of energy is wasted when it is poorly managed and used. (4) The extraction and use of energy led to some environmental problems. (5) Effective education will bring about positive action for environmental protection, and at the same time promote economic development.

These concerns are integrated into the science curriculum to increase awareness among students. In the UPISMED study entitled "An Analysis of Environmental Enhancement Concepts in Science Instructional Materials for Elementary to Tertiary Level", a number of energy related environmental issues were identified: sources and kinds of energy, energy transformation, law of energy conservation, pollution problems associated with use of fossil fuels and other energy sources, alternative sources available in the country, and management techniques. The study revealed, however, that at the tertiary level, even non-science students are required to take one environmental science related subject.

Energy - Environmental Concepts in the Chemistry Curriculum

In the chemistry core textbook for secondary schools (*Science and Technology 3*, DECS, 1986) abstract concepts are related to student's life by citing familiar technological applications or environmental phenomena. The list that follows is not exhaustive, although illustrative of the energy-based environmental concerns integrated into the curriculum. Many of these concepts are value - laden.

Chemistry Topic: Diffusion/Gases in the Atmosphere
Application: Air Pollution
Energy - Environment Enhancement Concepts

*A pollutant once released from its source undergoes three things:
a. travel through air, scattered by temperature differences and the wind.
b. react with itself or other substance both chemically and physically
c. reach a sink such as oceans, or soils, or a receptor such as a person or a plant.

*The degree of harmfulness of an air pollutant is determined by its quantity, residence time, interaction with other pollutants, and tolerance level.
*Some meteorological and topographical factors favor rapid spreading and transformation of pollutants in the air.
*Carbon Monoxide from exhaust of motor vehicles due to incomplete combustion is harmful even in small amounts.
*An increase in atmospheric CO_2 can increase atmospheric temperature. This may cause the melting of ice caps and inundation of coastal areas.
*Prevention of air pollution should occur at the source, *e.g.* use of a cleaner energy source and change in industrial process. Greater effort should be

upon prevention rather than controlling air pollution.

*There is equipment that prevents or controls air pollution, *e.g.* a Cottrell precipitator for the electro-deposition of smoke and dust in factories.

*Air quality standards are legal limits placed on levels of pollutants in ambient air.

*There are laws passed to protect the environment from degradation and pollution.

*Every individual has the responsibility of improving the air quality of the community.

Chemistry Topic: Carbon Compounds
Application: Plastics/Pesticides/CFC's
Energy - Environment Enhancement Concepts

*Plastics do not decompose. Their improper disposal clog waterways which cause urban flooding, provide breeding grounds for pests, and degrade the landscape.

*Biodegradable plastics should be developed.

*Burning of plastics produce air pollutants, such as toxic HCl from polyvinylchloride (PVC). Waste plastics can be recycled to reduce consumption of fossil fuels.

*The use of fertilizers and pesticides has increased crop yield. Pesticides contain toxic substances that affect living organisms. Increased fertilizer run-off has caused eutrophication.

*CFC's are believed to destroy the ozone layer, increasing exposure to ultraviolet rays of life forms on earth causing genetic defects, skin cancers, low agricultural yield, etc.

Chemistry Topic: Energy and Change
Application: Energy Crisis
Energy - Environment Enhancement Concepts

*Any energy crisis that we face is not a shortage of energy on the view that energy can never be destroyed. It is, more accurately, a shortage of useful forms of energy.

*Fossil fuel formation is a slow geologic process, and these materials are non-renewable or are not recyclable.

*Whenever we attempt to order a part of nature, the disorder created in out environment exceeds the order created in the system.

*A steam generator power plant creates disorder by producing air pollution and emitting heat.

*Exploring, processing and transporting large amounts of fuel have undesirable impact on the environment.

Chemistry Topic: Solutions/Solubility of Gases
Application: Acid Rain/ Water Pollution
Energy - Environment Enhancement Concepts

*Rain dissolves the different oxides (particularly of sulfur and nitrogen from the burning of fossil fuels) in air, forming "acid rain" which eventually affect the soil water and the life forms in them.

*Thermal pollution of bodies of water is caused by the discharge of hot water from industrial and power plants.

*Less oxygen is dissolved in bodies of water with higher than normal temperatures.

Not all topics related to an environmental problem can be discussed in the core textbook. They may be irrelevant to the science concept being developed. To overcome this limitation and to give an interested reader a holistic view of the environmental phenomenon, self-contained supplementary materials have been developed. Relevant science is developed from these.

Some energy related supplementary materials include:

1. Environmental Series: Air, Water and Soil
2. Potable Water from Sea Water by Solar Distillation
3. Geothermal Energy: Its Chemical and Thermal Effects
4. Which Energy Source for Your Community
5. Plastics in Our Lives
6. Laundry Soap from Used Oil
7. Global Warming
8. Charcoal Making with Less Air Pollution
9. Waste Not, Want Not
10. Natural Pesticides: An Alternative to Synthetics

Many supplementary materials expose students to activities and work experiences that are useful, productive and relevant to any setting - urban or rural. They may not substitute for formal training on marketable skills but they develop in students a positive and healthy attitude towards productive work. They also serve to orient them in process skills development including problem - solving and decision - making in real life situations - essential characteristics of environmentalists.

Short and Long Term Programs

Energy - environmental education involves complex issues. It does not allow for easy and quick solutions, but must be an on-going process.

There is a need to conduct researches to determine student's attitude towards energy issues and how changes in behavior may be effectively made. Classroom interaction reveals that many students are enthusiastic concerning energy conservation, but have difficulty grasping the consequent need for modification of lifestyle.

There is a need to link systematically with nongovernment institutions towards environmental conservation even under exigencies of economic development. The setting up of the proposed Science and Technology Centrum - Environmental Pavillion where government and industry will work together towards developing scientific and technological manpower, will also promote education for energy and the environment. Exhibits on energy-saving and pollution control devices will be displayed. Hands-on activities will stimulate minds.

There is a need to adopt a national framework on energy/environmental education to guide organizers of energy/environmental programs and to reduce overlapping of activities which fritter away limited funds.

There is a need to develop more chemistry - based learning materials in Filipino to reach more people not only in schools but also out-of-school. In-service training of teachers should complement curriculum development efforts.

Better ways have to be found to implement policies/laws related to energy - environment.

People Power has to be organized once again to influence more individuals, organizations and industries to do their share in economic development as well as environmental protection.

ABSTRACT *Environmental Science Education in Portugal*; **Elisa M. Pestana and Mauricia Oliveira; Faculdade de Ciencias, Universidade de Lisboa, Bloco C1, Campo Grande, 1700 Lisboa, Portugal** •Although no formal curriculum on environmental education exists in secondary education in Portugal, there is some governmental concern on this subject. This concern is revealed in the existence of a State Department of the Environment, and in some actions carried out in schools or for the general population, in TV and other media. •On the other hand, many science teachers, in particular in the physics chemistry interface, introduce energy and environment topics in their everyday teaching and stimulate work in this field in science clubs and/or develop projects involving students of their schools at different levels. As a result of their work, several Portuguese schools are now linked to the international network of "Caretakers of the Environment". •At the tertiary level some new universities offer courses related to the environment, for example, Environmental Engineering. In chemistry teacher training, several universities include topics related to energy and the environment. During the final year of the course (5th) the teacher trainees, besides giving their classes, get involved in projects developed with their students. One favorite topic is environment as related to chemistry. Some of these projects, which are important not only for the education of the pupils but also for teacher trainees, will be presented and discussed.

Environmental Science Education in Portugal

Environmental education may be considered at two different levels: one, formal, which is carried out integrated in a specific curriculum, and another, a non-formal one, outside a defined curricular content. We also may consider two kinds of actions - those aimed at schools and those for the general public.

Although only some notions about environment and environmental protection are introduced in the curriculum of primary school and no formal curriculum on environmental education exists in Portugal in secondary school, there is some governmental concern on this subject. Since 1975, there is a State Department of the Environment, and after a report produced by the government in 1979, a set of laws to protect the environment has been approved by the Parliament. A National Institute for the Environment has been created in order to develop projects in this area and in spite of small funds awarded, some actions have been carried out in schools or for the general population, in TV and other media.

PORTUGAL

The year 1987 was considered the "European Year of the Environment" and the slogan "ambiente mais puro, melhor futuro" (cleaner environment, better future) constituted the "lietmotiv" for essays of students of all levels all around the country, and for actions aimed at making the population aware of the importance of the environment. Publicity campaigns have been developed to maintain cities clean, or to clean up beaches and protect forests and rivers. An important role is also being played by local administration in the sensibilization of the population for pollution problems and waste management.

On the other hand, a more specific work has been undertaken by many teachers who have developed projects involving students of their schools at different levels in classes and in science clubs. This interest seems more widespread among science teachers, in particular in the physics - chemistry interface. Even when they do not get involved in project work they often introduce energy and environment topics in their everyday teaching, and so environmental science education has become a teaching practice related to everyday life, although without an explicit content structure.

In fact, often only pollution topics are focused, and many projects are limited to the quality of water and air. This approach may contribute to present pupils negative image of science/industry (in particular chemistry) if teachers do not take enough care of showing how these problems can be overcome by the correct use of scientific knowledge. Nevertheless the work of the teachers in this area is very important in the change of mentality of the population towards the environment, on a long term basis.

It is worth mentioning that several teachers have developed innovative projects either on energy topics - solar energy, biogas, etc. - or on environmental topics - acid rain, waste management, etc. - integrating them in their physics - chemistry teaching. As a result of their work, several Portuguese schools are now linked to the international network of the "Caretakers of the Environment". This organization was born in 1986 in the Netherlands and links students and teachers of many countries, concerned with the care of Earth's resources.

At the tertiary level, some new universities offer degrees in environmental sciences, for example, Environmental Engineering. Others offer courses related to the environment, in particular in chemistry degrees. In chemistry and in physics - chemistry teacher training several universities include topics related to energy and the environment. During the final year of the course (5th) the teacher trainees, besides giving their classes in a secondary school, supervised by a secondary school teacher and university teachers, get involved in projects in the area of chemistry related to the environment.

The involvement of teacher trainees in this sort of project is important for their pupils, as well as for them, as they have the opportunity of developing project work under guidance of a group of supervisors of education and scientific areas.

In 1987/88, in the Faculty of Sciences of Lisbon, the five groups of teacher trainees and their supervisors decided to work up a common project around the theme "Preservation of the Environment". This project was developed during the whole academic year and aimed at making the secondary school students aware of the problems of the environment, through the achievement of an extra-curricular project closely related to their daily life. The project was sub-divided into three sub-projects:

- Treatment and quality of water
- Identification of sources and forms of pollution
- Recovery of residua (recycling of paper and re-conversion of fruit residua).

This project was very successful with pupils. It also interested so many teacher trainees that the following year, after their graduation, some of them extended the project to the schools where they were placed. They are now collaborating with new groups of teacher trainees in projects in energy and waste management as related to chemistry teaching.

Another project, in which the author is involved in centered in toxicological and environmental aspects of pesticides. For the moment, it is concerned both at university level, in teacher training, and with primary and pre-primary teachers and children.

Obviously, the chemical content which can be explored at university level is only mentioned with primary and pre-primary teachers. For children, only information and publicity, mainly as related to safety and environment are focused. It is intended to extend this project, that is now in a pilot phase, to the whole population, by the construction of teaching units for teachers and primary school children.

This project, as well as the previous one, are examples of projects that, although making students aware of the problems of pollution, are aimed at showing how chemistry / science are important in helping to solve some of the main actual problems of our world.

ABSTRACT *A Comprehensive Outlook on Energy and the Environment in Puerto Rico* **Ram S. Lamba Department of Chemistry, Inter American University of Puerto Rico, P.O. Box 1293, Hato Rey, Puerto Rico, 00919** •Like any developing country, particularly in the Western Hemisphere, Puerto Rico is playing an important role in its renewable sources of energy and the environment. Several initiatives at the teaching and research level have been taken. •At the pre-college level, in the elementary to high school, emphasis is placed in science courses to the teaching of energy and the environment. In the university, the students have the opportunity to take special courses in this area. In addition, almost all science courses place emphasis on this topic. •Taking into consideration the utmost importance of the alternate energy sources and the environment, in 1976 a Center for Energy and Environment Research (CEER) was created. To help solve Puerto Rico's energy and environment problems, several projects have been undertaken. Some of the important ones are: Renewable Energy Alternatives, Tropical Energy Studies, Tropical Marine Studies, Chemistry for a Better Society, Science and Technology Development, and others. •Funding for these projects have come from several governmental (local and federal), educational and industrial sources.

A Comprehensive Outlook at the Energy and the Environment in Puerto Rico

INTRODUCTION:

Energy is not only the lifeblood of the ecosphere but also of society all over the world. The amount and type of energy shape our lifestyles and the economic system of all countries. About one third of our energy in the world comes from petroleum, although the dependency on petroleum is much greater in the industrialized nations. For example, while more than 90% of the consumption in the USA is in oil, third world countries, in general, depend more on coal and natural gas.

At present, there are four main sources of energy: petroleum, coal, natural gas and nuclear energy. Graph I (second following page) illustrates the distribution in quads (quadrillion BTU's) among there four energy sources since 1850 and their projected distribution until 2000.

Puerto Rico

Puerto Rico (PR) being part of the western hemisphere and becoming an industrialized country (island) is no less different in terms of its consumption. It has a population of more than 3.5 million inhabitants within about 8,000 square kilometers of area. It is, in other words, a densely populated island. On the other hand, it has the highest concentration of pharmaceutical and chemical industries in the world. moreover, there are more than 60,000 registered vehicles within such a small area.

PUERTO RICO:

Since 1898 Puerto Rico has been a US territory, with the official name being the Commonwealth of Puerto Rico. The energy consumption in Puerto Rico is basically due to petroleum and natural gas. Since it is a tropical island with mild winters, coal consumption is almost negligible. Puerto Rico has not discovered any fossil fuels within its boundaries, that is, every drop of oil that is needed to generate energy is imported. In the 1960's, a nuclear power plant was envisaged as one of the sources of energy. However, due to several socio-political problems its implementation has not materialized.

During **"Operation Bootstrap"**, in the early 1950's, the economic base of the island shifted from agricultural to industrial production. The shift had a drastic social impact, particularly in lifestyles of the population when people began moving to urban centers. As a result, the need for energy in transportation, manufacturing, and production of electricity for residential and industrial applications increased significantly. Within a decade, Puerto Rico became one of the first 25 nations in the world in its per capita consumption of world oil supplies.

With this picture of heavy oil consumption of which 100% is imported, no alternative was left but to loom into alternate renewable energy sources. It was about the same time when the price of oil increased worldwide, creating disastrous effects on the world economy and that of PR.

During that period, education reforms in the Commonwealth Department of Education were also going on. One of the principal changes was to put a major emphasis on the area of teaching sciences at all levels, including elementary, junior and high school levels. Concepts related to energy and the environment were introduced as well. A similar approach was taken by colleges and universities.

In 1957, the Puerto Rico Nuclear Center (PRNC) was established as a technology transfer laboratory. After almost two decades, in 1976, the scope and focus of PRNC were changed and a **Center for Energy and Env Research** (CEER) was created. The primary purpose of CEER was to study the development of renewable energy sources for Puerto Rico and the environmental aspects of these new energy technologies. This infrastructure was developed with help from the Energy Research and Development Administration (ERDA) and the U.S. Department of Energy (DOE).

Thus, a two prong approach was taken: one at the educational level and the other in the area of research and development.

The Present Situation:

There are about 700,000 students at the school level and more than

170,000 in colleges and universities of which about 20,000 have opted to study science. In addition, Puerto Rico has more than 100 small and large scale industries, the majority of which are pharmaceutical and chemical industries, resulting in the highest concentration of these industries in the world.

In the schools, emphasis is being placed on basic concepts related to energy and the environmental. In many colleges and universities special courses have been designed with a focus on energy production, new technologies, and their economic and environmental implications. Moreover, concepts on energy conversion, demands costs, population, and optimization of energy systems are discussed as well. However, only very recently practical approaches to solve our energy and environmental problems were being emphasized in the classrooms.

Due to its location, its consistent temperatures, high isolation and climatic variations, Puerto Rico has undertaken several alternate energy projects. This factor, combined with the interest in R&D, a large industrial base, and its political ties witn the USA, have made it relatively easy to initiate research in this area.

To help solve Puerto Rico's energy and environmental problems, several projects have been undertaken through CEER. Some of the more important ones are briefly described below:

a) **Renewable Energy Alternatives**

In order to alleviate the almost complete dependency on imported oil, several research programs are being carried out or planned at this time to develop renewable tropical energy sources. Specific ones are: biomass conversion, tropical grasses and trees, biofuel cells, ocean thermal energy conversion (OTEC), wind energy assessment, energy conservation, and waste energy conversion.

b) **Tropical Ecology Studies**

Due to high population density, unplanned and uncontrolled development, the environmental situation in Puerto Rico is deteriorating. The enfr.cement of federal regulations have achieved the following: program for water treatment, solid waste management, hazardous and toxic waste disposal.

c) **Tropical Marine Studies**

Because of tropical conditions, and the Atlantic Ocean and Caribbean Sea surrounding it, Puerto Rico is an ideal place for marine studies. Projects on lagoon management, its system structure, total metabolism, nutrient chemistry, and environmental conditions with its impact on human activities are some of the major components of this program.

d) **Chemistry for a Better Society**

Puerto Rico has the highest concentration of pharmaceutical industries in the world. In addition, the biggest plant of rum in the Caribbean is located in Cataño, near San Juan. Since these technologies are closely related to chemistry, the electro - chemistry research program has provided synthesis of organic sensitizers, their photochemistry, photogalvanic behavior, efficiency, and mediation action in biofuel cells.

e) **Science and Technology Development**

Since Puerto Rico is becoming an industrialized country, it must develop and implement technology transfer activities to adapt to the local needs. Studies on Caribbean resources management and energy resources use and demand, residential energy consumption have been conducted.

The total budget for these efforts for CEER has been up to $3.5 million. This includes help from the local and federal governments (DOE, NSF, NASA and others), university (UPR), and industry.

Problems:

Although initiatives have been taken at both the teaching and research level to develop the concepts of energy and the environment, there are lots of problems that Puerto Rico is facing and the future may be even dimmer. As indicated earlier, changes were made in the educational system. However, teaching concepts and internalizing these so that they can form part of one's life do not necessarily go hand in hand. Several laws have been passed in order to control the energy consumption and to avoid ecological crises. however, none are enforced, even by the government itself. This lack of enforcement is in part due to the political status of Puerto Rico and also due to problems with the government's efficacy. For example, most of the police cars, when received, have their catalytic converters removed, thereby contributing to the air pollution problem.

Power blackouts are common in PR, in part due to high energy demand and in part due to politics so that the electric rates can be increased. There are more than 600,000 registered vehicles in Puerto Rico and the number is increasing every da. There are many reasons for this. It is extremely easy to get car loans. No mand.tory car insurance is required in terms of responsibility towards public property. Although more than half of the Puerto Rican population is below poverty level by federal standards, most of them can afford a car and housing. On other words, the government's attitude has been to promote federal funds for the "poor" without asking for anything in return. This has resulted in an attitude of inertia on the part of the public which is reflected in every sphere of life. The only responsible decision to get public awareness taken by the government has been to give tax incentives, for example for the installation of a solar water heater.

Recommendations:

The following recommendations should be taken into consideration:

1) **Deciding political status:** Although it may sound absurd, it is true that if we want to enforce laws and policies in Puerto Rico towards energy and the environment, we must decide our political status first. This will bring "security" to the people and possibly less dependence on federal funds.

2) **Effective management of research and its resources:** It is of utmost impor-

tance to effectively manage and conduct different research and development programs geared towards energy and the environment in order to relieve part of Puerto Rico's burden of its sole dependency on imported oil.

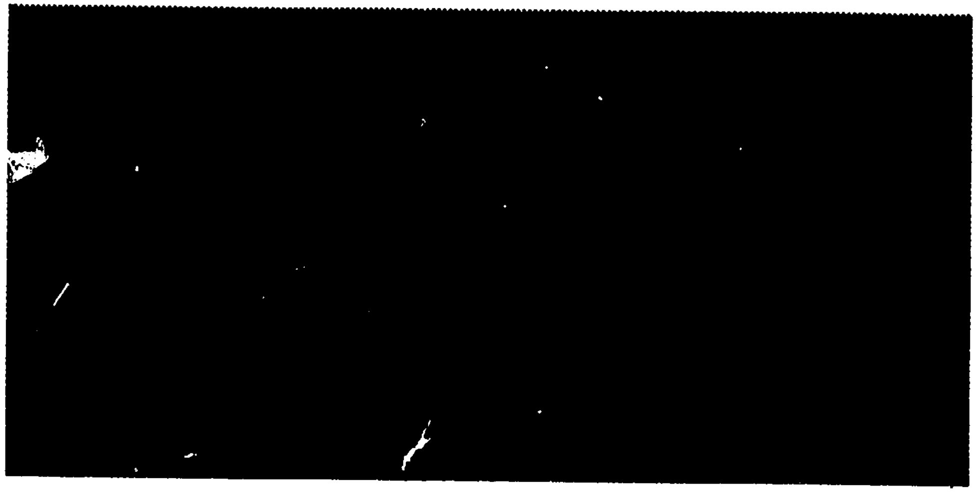
3) **Better public understanding:** Radio programs, newspapers, TV programs, forums and other media should emphasize the applications of energy and the environment, so that the public develops a better understanding of these concepts in everyday life.

4) **Enforcement of laws and policies:** In order to have a sound political atmosphere pf mutual respect, we must enforce various local and federal laws and policies so that energy consumption may be reduced and environmental conditions improved.

As has been shown in this article, **Puerto Rico has an urgent need to respond to the challenges it faces because of its high energy consumption and its total dependency on imported oil. We believe that this can be successfully achieved through changes in the political scenario, public awareness and government efficiency.**

Bibliography:

1. Regina R. Axelrod, (editor) *Environment, Energy, Public Policy: Toward a Rational Future*, Lexington Books, 1981.
2. G. Taylor Miller, Jr., *Energies & Environment: The Form Energy Crises*, Second Edition, Wadsworth Publishing Co, 1980.
3. Annual Reports, CEER, 1952 - 1987.
4. *National Geographic*, Special Report on Energy, February 1989.



ABSTRACT *Education on Energy and Environment: The Singapore Situation*
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•The Singapore environment has undergone rapid and tremendous physical transformation in recent years. Provisions for the formal education and training of adequate manpower in environmental planning and control has been established so as to ensure an orderly and pleasant environment. Various aspects of energy and environment are presently taught to students at the primary and secondary school level. While at the tertiary level, both energy and environmental considerations have been included in the curricula of some faculties at the National University of Singapore, the Engineering Faculty at the National Technological Institute, Ngee Ann Polytechnic and Singapore Polytechnic. •Non-formal environmental education has also been provided by a number of government and quasi-government organizations and statutory boards. These organizations either provide physical facilities or are actively engaged in the promotion of energy conservation, environmental education and training.

Education on Energy and Environment: The Singapore Situation

Singapore

Introduction:

The Republic of Singapore, consisting of the island of Singapore and some 58 islets surrounding it, it situate approximately 137 km north of the Equator. The main island is 573 sqkm in area; about 42 km in length and 23 km in breadth. Due to the serious constraints of limited land and water in Singapore, careful and coordinated planning of energy and the environmental has been , and continues to be essential.

In this paper, the education and training on energy and environment in Singapore will be described and discussed under two main sections: Formal and non-formal education.

1 Formal Education

1.1 Primary And Secondary Level

At the primary and secondary school level, simple concepts of energy and environment are taught in different subjects, including Chemistry. The integrated science curriculum, which begins formally from Primary 3 onwards, includes some Chemistry teaching.

Chemistry at the lower secondary level is an integrated part of General Science, which is taken by all students. At upper secondary level, Chemistry is an elective subject offered either as a single subject, or combined with other sciences.

1.2 Tertiary Level

At the National University of Singapore (NUS), some courses in various disciplines provide training on environmental aspects: The course available at the *Faculty of Science*, in particular the Biology and Chemistry units, provide much training on the natural environment, energy and economic aspects of local industries, sources for chemical energy, environmental pollution and its control. The Department of Chemical Engineering of the *Faculty of Engineering* equips graduates with a comprehensive understanding of energy and environmental aspects associated with chemical process industries in Singapore. In the *Faculty of Arts and Sciences*, a combination of environmental course are available in the Geography Department. These courses provide tertiary students with a wide understanding of topics such as: urban land use in Singapore, urban transportation, pollution and environmental quality. At the *Faculty of Architecture and Building*, the special environmental problems of the hot, humid climate of Singapore are given close attention.

While there are no specialized environmental courses at the Nanyang Technological Institute (NTI), Ngee Ann Polytechnic and Singapore Polytechnic, there is some training provided during the teaching of environmental chemistry topics in some course.

2 Non-Formal Education

A number of government and quasi-government organizations and statutory boards provide non-formal environmental education in Singapore. Some of these organizations are described below.

The Science Council of Singapore has organized a number of public seminars on water resources, environment and energy, which give a comprehensive and integrated treatment to selected technological topics. It has published many reports on Singapore including "A Handbook on Environmental Protection in Singapore" in 1988.

The Public Affairs Department of the Ministry of Health organizes environmental public health education programs to raise public awareness of and concern about environmental public health and pollution problems.

The Singapore Science Center is a contemporary science museum which plays an increasingly important role in disseminating information on science and technology to the public through its exhibitions, publications, and educational and promotional programs. The center complements the teaching in schools. Among its school-based promotional activities are the biennial Ecoweek (Ecology Week) and Energy Week, which highlight the importance of conserving environment and energy. Professional organizations also organize their own seminars, talks and conferences to inform their members about current developments and technology, and to provide a forum for the exchange of ideas.

Plans for the Future

As industrialization continues to progress in Singapore, plans are being made for new types of environmental training, education and research. There is a constant push towards a more aesthetic and pleasant physical and social environment.

References

Chia LHL & Boo HK (1989), "Trends in Chemistry Education", in *Proceedings of the Seminar on Trends in Science Education*, pp 14-24, Singapore National Academy of Science.

National University of Singapore (1989), Faculty handbooks for academic year 1989 - 1990.

Pakiam JE (1982), *Environmental Education and Research in Singapore*, Regional Institute of Higher Education and Development Occasional Paper No. 5, Maruzen, Asia, 1982.

Singapore: Facts and Figures 1989, Published by the Information Division, Ministry of Communications and Information, Singapore.

Singapore 1988, Published by the Information Division, Ministry of Communications and Information, Singapore.

ABSTRACT *Chemistry in the New Curriculum 12/16* **Medir Magda Department d'Enginyeria Química i Bioquímica, Plaça Imperial Tarraco 1, Universitat de Barcelona, 43005 Tarragona, Catalunya, Spain** •The primary and secondary education is going through a reform in Spain. The primary education, which is the compulsory one, includes now 6 to 14 grades, and the secondary education 14 to 18. The reform brings compulsory education up to grade 16, and introduces the 6/12 and 16/18 cycles. •The Ministry of Education of the Central Government as well as the different Ministries of Education of seven autonomous regions are working on their own curriculum projects at the first and second level of concretion. The third level of concretion is being developed and experimented by trial schools in collaboration with the Department of Education of the corresponding Minister. This third level is where each school will be free to choose its credits and develop the contents according to its social reality and emplacement. •At the cycle 12/16 a first approach to science will analyze chemistry in relation to physics, geology and biology. In the cycle 16/18 chemistry is considered as a separate subject. •At the first and second level of concretion, attitudes and values are oriented towards the study of science as related to energy and environment, and at the third level of concretion, the different credits developed may approach a chemistry or a science credit as related to energy and evironment. Many groups around the country are working ib the development of materials for these credits. This groups may be associated to Secondary Schools, Institutes of Education (ICEs), University Departments, Secondary Teacher's School Seminars, and Private Institutes of Education. •Technology is another areas considered in the new curriculum for the 12/16 cycle where some as ts of chemistry, as related to technology and society, may be studied. The cycle concern is again a function of the particular credits developed.

Chemistry in the New Curriculum 12/16

Spain

Introduction

In recent years an attempt is being made in Spain to make a general reform of the Secondary School System.

Program planners are developing and implementing new curricula that reflect the nature of science as well as what we know about society. Societal issues are incorporated into the new Science Programs for Secondary Compulsory Education 12/16. The goal is that of creating scientifically literate citizens as well as to prepare students for everyday life. The renewal of the science curriculum stresses the role of chemistry in everyday life at the same time that it integrates it within the science syllabus.

The Ministry of Education and Science (MEC) of the Central Government as well as the different Ministries of Education of seven autonomous regions are working on their own curriculum projects at the first and second level of concretion. The third level of concretion is being developed and experimented by the trial schools in collaboration with the Department of Education of the corresponding Ministry. This third level is where each school will be free to choose its credits and develop the contents according to its social reality and location.

At the cycle 12/16 a first approach to science will analyze chemistry in relation to physics, geology and biology. In the cycle 16/18 chemistry is considered as a separate subject.

At present, the general reform is under development and no materials are published, but internal reports are available. The trial teaching is almost finished and implementation will start in 1990 in some schools with no compulsory character.

The Science Curriculum in Catalonia

The structure of the curriculum in Catalonia is presented as a sample of the curricula being developed in Spain. The objectives include concepts, process-concepts, and values and attitudes. The three aspects are considered equally important.

A summarized description of the general trends about concepts includes the following items:

- matter and materials; structure, diversity and chemical change,
- energy: electricity and magnetism; waves in nature,
- forces and movement,
- the world and the universe,
- water and air,
- organisms,
- interactions among biotics and antibiotics components of the environment,
- changes in the natural environment. Human being as a changing agent,
- health as related to human equilibrium

Process-concepts include observation, testing, investigating, designing, analyzing qualitative and quantitative problems and drawing conclusions to solve issues related to questions, curiosities and needs of the students.

Values and attitudes are concerned with the rules regarding the development of a conscience about the use of the social and natural environment, including

- safety,
- environmental protection,
- raw materials conservation.

Environment as related to Chemistry teaching

Research on developing units for the teaching of chemistry as related to environment is being conducted by several groups around the country, which are associated to University Departments of Chemistry, Chemical Engineering, Didactics of Science; and Institutes of Education (ICE), Private Institutions of Education and Secondary school Teacher's Seminars. Each project carried out by a group has either public or private financial support.

Units recently developed include, not pretending to be an exhaustive list, the following subjects:

Soil as a resource. Different materials are studied, looking at aspects such as composition, amount, and consequences for social life.

Waste water treatment in a coastal area where tourism is an important economical resource. Water composition is studied.

Manufacturing cosmetics: natural versus synthetic products.

Urban and industrial wastes. The way to dispose and to recycle them. Uses.

Food Industry. Are additives necessary?

Student perceptions towards chemical industry. Different aspects are consideredsuch as: raw materials and products, energy sources, security, waste, environmental impact and protection, products storage.

Air pollution. Pollutants are analyzed and the effects as well as solutions to pollution are discussed.

Plastics: Are they biodegradable?

How many trees do we need in order to make paper every year.

Buying packed products. Pollution, energy cost, raw materials consumed, waste production and recycling as related to the packing.

What is in a garbage bag? Products and materials are classified. Other uses are considered.

Toxic materials. Different methods of disposal are studied.

Salinization of the water resources. Corrosion problems developed by salty water are studied and water reclamation explored.

Acid rain. What happens when we burn coal? Desulphurization techniques are considered as well as air pollution treatments.

Oil exploration in the sea. Environmental impact. Transport of crude. Hazard of oil spills.

Fire in the woods. Combustion processes and deforestation. Actions for prevention.

Here is where each of the groups may focus attention on diverse aspects and consider different ways in which these subjects can be programmed. Whereas some relate the chemical principles to professional issues, others are more societal-issue oriented. Some challenge students to look for real solutions whereas others work on simulated situations. Similarly, some expect students to participate actively in the class work and decision-making process, while others give them more guided lectures. Also, some will favor situations for students to ask questions, obtain evidence and use it to take decisions whereas others will give them answers.

Conclusions

The Spanish Educational System is adapting its curricula to much European standards and orientations. The contribution of many groups in the design of instructional materials is in the direction of relating the teaching of chemistry to environment issues.

ABSTRACT *Energy and Environment in Vocational Education* **K Yngve Lindberg National Board of Education, S 106 42 Stockholm, Sweden** •Sweden is reforming the vocational education in the upper secondary school. Pilot projects are organized with 3 year lines for different branches. The studies are based on modules with specified aims and contents. One module, which is compulsory for all students, is "Energy and Environment". Important topics in this module are: •Ecology •Carbon, nitrogen and sulphur cycle •Greenhouse effect •Ozone Layer •Climate Changes •Information will be given on Swedish work for protection of the environment, methods and results, mainly based on facts published by the Board for Protection of Nature.

Sweden

Energy and Environment in Sweden

The energy consumption in Sweden is highly based on oil products. The total consumption of 455 TWh (1988) was distributed in the following way.

Source	Energy/TWh	%
Oil and natural gas	157	35
Electric energy	119	26
Domestic fuel	54	12
Losses	42	9
District heating (mostly oil)	39	9
Shipping	29	6
Coal	15	3

The electric energy is mainly water power and nuclear power, 50% of each. Most of the streams are used but four rivers in the north of Sweden are protected by law. There are 12 nuclear power stations now in use but a referendum in 1980 showed that a majority of people were against use of nuclear power. A decision was taken by the parliament to close all stations before the year 2010.

Locally, there are efforts made to use biomass as fuels. As the prices both of oil products and electric energy are low, these efforts have not been very successful.

Use of Energy in Industry

The following table show the use of different energy sources in the industry during some years with a prognosis for 1977. All values are in TWh.

Fuel	1970	1980	1987	1997
Oil Products	74	55	27	30
Natural gas	0	0	2	6
Electric energy	33	40	50	51
Domestic fuels	33	35	42	45
Coal	14	15	15	20
Total	154	148	141	157

The industry stands for roughly 35% of the total energy consumption. Earlier, the energy consumption was increased at the same rate as consumption and the GNP. But, in spite of the fact that GNP has continued to increase, the use of energy after 1970 had remained almost constant. This is due to the fact that wee now use energy more effectively and that the industry has changed its production. The following shows some actions to decrease the use of energy in the industry.

- economizing, *e.g.* by installing thermostats and regulating of engines and furnaces
- recovery of energy, *e.g.* by use of wasted heat and energy from used, but warm water
- new ways to make products
- change of structure, old products replace by new, less energy consuming ones

In principle the government has taken decisions to

- close all nuclear power stations
- to reduce the outlet of carbon dioxide
- not use more rivers for production of electric energy

If this should be possible to realize, most people think that the living standard in our country must be strongly reduced, but nobody assumes this is possible.

Education on Energy and Environment

In order to teach people basic knowledge, a great project has been carried through. A material, "The Natural Step", has been produced in 5 million copies and distributed to all families in Sweden. A tape was also distributed together with the printed material. A program was broadcast at the same time on TV. Unfortunately, inquiries have shown that rather few people have read the material and listened to the tape.

In schools, science is compulsory on senior level (grades 7-9). But it is up to the planning in the local school if there will be any teaching on energy and environment.

In the upper secondary school, integrated science is taught on social, economics and humanistic lines. Normally teaching on energy and environment is important and the teachers spend rather much time on the concepts.

On the natural science line and the technology line, environmental studies are important, especially in biology. On natural science line, there is an option, "Protection of the environment". The subject is given 3 periods a week in the 11th grade and 5 periods a week in the 12th grade. The studies are often organized in projects and laboratory work is common.

The vocational education in Sweden is going to be changed. Now it is a 2 year education, but in the future it will be changed into a 3 year program. A decision is taken that in all vocational lines, a module, "Environment and Health" should be taught. This is certainly a remarkable change. However, there will be problems with the teachers qualifications. A team of teachers with different backgrounds, must take care of the teaching and all experiences have shown the difficulties with such arrangements.

Finally, there are problems with the environment in Sweden, partly depending on the great amounts of sulphur dioxide coming from the DDR and Poland in the east and the UK in the west. The water in the Baltic sea is strongly polluted. From an initiative of UNESCO a project was started based on cooperation between the Baltic countries. In Sweden, about 50 schools in different levels have announced interest in the "Baltic Sea Project". The aim of the projects is, among other things, exchange of students between countries on both sides of the sea.

ABSTRACT *Energy, Environment and Chemistry, a Thai Picture*

Pirawan Bhanthumnavin Department of Chemistry, Faculty of Science, Chulalongkorn University, Phaya Thai Road, Bangkok 10330, Thailand
•Energy and environment play minor roles in chemistry teaching. Energy released from bond breaking and forming in combustion is not clearly linked with chemical energy present in fossil fuels. A similar situation exists in the case of nuclear fuels. Chemical hazards are mentioned in one chapter only in school texts and are only starting to appear in college laboratory texts. Chemical waste management has not been touched upon. The time seems ripe to remedy all this with the establishment of the Eastern Sea Board to reap maximum benefit from the natural gas from the Gulf. Chemists have been in great demand in the past year. Petrochemistry as well as polymer chemistry are offered in the local vocational school. Public demonstrations through the mass media could be a starting point and details could follow in the classroom or popular science journals. This would also help with the fading image of chemistry. Specific and relevant examples need to be brought into the class, details of which will be discussed.

Energy, Environment, and Chemistry, A Thai Picture

Thailand

This paper will try to present efforts in Thailand to use chemistry teaching to promote the relationship between chemistry and energy and environment. It will be in four parts: 1) Educational background, 2) Energy and Chemistry, 3) Chemistry and environment, and 4) The efforts in various sectors.

1) Educational Background. The educational system in Thailand is a six-three-three system and only the first six is mandatory. Chemistry becomes a separate subject at the senior high school level. It is taken at the university entrance examination by a majority of science students which constitute some sixty-five percent of school leaving population. A number of these students opt for social science faculties and will never read chemistry texts again. Thus, school population should be the prime target for campaigning to emphasize the role of chemistry in relation to energy and environment.

2) Energy and Chemistry. There are six volumes for the school chemistry texts with energy being prominently treated under bonding, rate, electrochemistry and solubility. The energy present in bonding tends to project itself as thermal rather than chemical energy. Every time a graph is presented for a chemical reaction, the ordinate will represent potential energy. It is felt that various forms of chemical energy should be clearly stated, or its connection shown and not assumed, in the text.

Nuclear binding energy and nuclear fuels are hardly mentioned for the reason that they will appear in the physics text. It is not certain whether those students, after leaving school, will be able to make decisions on matters related to nuclear power stations, for example. Here it is felt that supplementary reading could be presented in the form of case studies on the story of, for example, Chernobyl, as well as the pros and cons of other nuclear power stations.

3) Chemistry and Environment. Chapter eighteen, the last one contained in volume six of the school chemistry text, deals exclusively with environment and their effects, but examples cited are not indigenous. Numerous local incidents prevail and school children should be made conscious of relevant findings. For example, in an effort to increase short term agricultural production, farmland in many areas is cultivated improperly, resulting in extreme erosion that threatens its very existence. One such crop is cassava. Chemistry of the soil and proper use of fertilizer would be well received here.

One village, not far from Bangkok, has been known to use large amounts of discarded accumulators to fill a swamp to make up a road, resulting in cases of lead poisoning. Although symptoms and consequences of lead and other heavy metal poisoning are mentioned in the text, it is felt that case studies of real situations would be more meaningful to school populations.

Work at university level seems to concentrate in small places as the social trend is to encourage the offering of degrees in applied subjects in order to supply the work force toward the development of the country. A contrary view is to train personnel in the basic science so that they can develop any skill as needed later or at that particular time of their graduation. These two views will have to come to term somewhere. The consequence felt here is that chemists tend to neglect to find out what is going on in the applied fields. Although students in other disciplines attend basic chemistry courses we chemist tend to give them what we want to do with our own chemists and not how chemistry is related to those applied disciplines. Hence important links are missing and only we chemist can remedy this.

There are also a number of environmental degrees at the master's level and there are a number of people doing active research in the field but concerted effort is still needed to disseminate that information to the public. It is felt that parts related to chemistry could be simplified and presented.

However, to tackle environmental problems needs interdisciplinary approach and chemists need to educate themselves first before they are fit to impart the role of chemistry on the environment. Training programs and workshops come in useful at this point. It cannot be denied that many of the environmental problems are caused by human activities involving chemicals in one form or another. We chemists have to admit that less desirable consequences of the use of chemicals were often observed bu people other than us. In order for chemistry to make a maximum contribution to the solution of environmental problems, the chemists must also work toward an understanding of the nature, reaction and transport of chemical species on the environment and then emphasize that in our teaching.

4) **Efforts in various sectors.** As a nation, Thai people are not overly conscious of energy and environmental problems and actions are usually taken at governmental levels without much cooperation. For example, the campaign to save electricity, which includes prohibiting television transmission between six and eight in the evening was interpreted as a move to minimize advertising and the period was replaced by an educational program so that it could be aired again. Some lecturers are trying to use this period to present the useful and relevant picture of chemistry to the public. It could be shown that air pollution may arise by burning most things that they want to throw away, and water pollution by sheer neglect. Official effort to combat this exists in the form of agencies to monitor energy and environment (see table). It is felt that information could be obtained therefrom to enhance the classroom activities.

Private organizations also join in, such as the Magic Eye campaign against littering which is appealing to school children and has won a prize. An important international conference to mark Her Majesty the Queen's sixtieth birthday, to be held in Bangkok in 1992 will be based on the theme of environment. The Thai Chemical Society is currently holding a national conference on the theme "Chemistry for Life Year". The organizer found that a number of private companies are afraid to participate for fear of being linked with the not-so-clean image of chemistry after it was reported that chemical wastes were found unclaimed at Bangkok port and no suitable means could be found to dispose of them. It is clear that chemistry teaching must include chemical hazards as a topic.

From what has been described above it may be said that efforts are being made in all available channels to use chemistry teaching as a means to improve the image of chemistry in relation to energy and environment. Although factual information may be contained in the text, local and relevant examples could be added as lasting impressions are better receive through active class participation while still at school.

Table 1. Government Agencies and educational institutions responsible for monitoring energy and environment matters

	Agency	Unit Responsible
1.	Min stry of Defense	Defense Energy Department
2.	Ministry of Public Health	Environmental Health Division, Department of Health
3.	Ministry of Industry	Mineral Fuels Division, Department of Mineral Resources
4.	Ministry of Science, Technology and Energy	Office of the National Environment Board; The National Energy Administration Office of the Atomic Energy for Peace
5.	Universities	Faculty of Science, Departments of Chemistry, Physics, Chemical Technology (Fuel), General Science (Environmental Science), Marine Science (Heavy metals in the estuaries) Faculty of Environment and Resource Studies Operation for Environmental Toxicology Institute for Environmental Research Center for Energy Research and Training
6.	Private enterprises and private sectors	Petroleum Authority of Thailand Electricity Generating Authority of Thailand Chulabhorn Research Foundation The Magic Eye The Chemical Society

ABSTRACT *Energy and Environmental Education in Thailand* **Thongchai Chewprecha Institute for the Promotion of Teaching Science and Technology (IPST), 924 Sukhumvit Rd. Bangkok 10110, Thailand** •Energy and environmental problems in Thailand have been increasing dramatically during the past two decades. Air pollution and acid rain in Bangkok is becoming a severe problem. Siam Gulf and rivers in big cities and industrial zones become more and more pollute. The increasing of hazardous and solid wastes and the use of chemicals in agriculture are among the other important problems. A large-scale deforestation in Thailand has lead to several environmental crises. Many attempts have been made to tackle with the problems. One of the efforts has been made to provide basic environmental education for inculcating environmental awareness through both formal and non-formal education systems. Environmental education in schools in Thailand has been initiated for more than seventeen years by IPST. Teaching activities and concepts related to energy and environmental issues were integrated into existing subject areas, mostly science, at all education levels. However, this approach may not be enough for the present situation. The IPST has now been engaging in the development of the environmental education curriculum as separated courses for secondary school students and will be implemented in 1990 as elective courses. It is expected that these courses will be required for all students in the future. The environmental concepts and teaching and learning activities to be developed will not only focus on local and national problems, but also on global problems. Problems related to the depletion of ozone, the greenhouse effect and ocean dumping of wastes will be included in the curriculum. These curriculum materials, with little modification, can also be used with students outside the formal school system.

Energy and Environmental Education in Thailand

Energy and environmental problems in Thailand have been increasing dramatically during the past two decades. The expansion of the human population and the progress of socio-economics of the country in both basic services and industries, demands a massive use of energy, and that has a great impact on the current status of the environmental. The increasing demand for electric power that almost exceeds the electric production capacity in recent years, causes the government to make a campaign on national energy saving. One of the measures used was cancelling the daily TV broadcasting programs between 6:30 pm - 8:00 pm. This measure has just been alleviated earlier this year.

Most of the electric power production in Thailand uses fossil fuels. Hydroelectric power production is also available with a small share. Sometimes, particularly in summer, the production in reduced because the amount of water in reservoirs is inadequate to produce electric power. The thought of utilizing nuclear fuel in the production of electricity is not currently accepted by most people. They are anxious about safeguarding the environment and the dependency on self-help activities regarding nuclear technology. The expansion of hydroelectricity production, by constructing more reservoirs, is nor possible due to strong resistance from a mass of people who are aware of its disastrous consequences upon the environment. The proposed hydroelectric scheme, the Nam Joan Project, has to indefinitely postponed due to the lack of popular support.

Mass transportation in most urban communities and industrial zones, uses dirty fuels that are the product of fossil fuels. These fuels not only have a great impact on the environment, but also on the economy of the country since they have to be imported from other countries.

At the present time, air pollution and acid rain in Bangkok is becoming a severe problem. The quality of air in some particular areas in Bangkok is lower than standard measure. It is reaching a dangerous point. In addition, several rivers, *e.g.* Chao Pha Ya, Mae Klong, Tha Gean, Bang Pa Kong, that pass overcrowded dwellings in big cities or industrial zones, become more and more polluted. It is increasingly apparent that water pollution from untreated wastewater disposed of by factories and industries located along the east coast of the Siam Gulf, if not properly managed, can be disastrous for the economy of the whole country, particularly in the areas of tourism and fisheries. In addition to the water pollution problem, the increasing amount of hazardous wastes and solid wastes in big cities and industrial zones is another problem that has great consequences on environmental degradation.

In rural communities, there is also an increasing demand for energy consumption pertaining to domestic use and agricultural production. The use of wood as a domestic fuel is another reason for destroying the forests. The massive clearing of forests in the past considerably reduced forest lands. The distinct danger that all accessible forests will be eliminated forced the government to enact a law that cutting the forest trees is absolutely prohibited. At the present time, all timbers used in building materials or furniture are those imported from neighboring countries. Large-scale deforestation has led to several environmental crises, especially to an acute shortage of natural water resources for agriculture, domestic and industrial uses. It is anticipated that, without proper management of water resources, there may not be enough water supply for the population of Bangkok within the next decade. Currently, the government has paid much attention to this matter; essential mechanisms and implementation management have been developed to conserve and protect forest land resources of the country with emphases on reforestation and aforestation.

Pollutants, caused by the use of chemical products in various forms, *e.g.*, fertilizers, pesticides, preservatives, is another important environmental problem. Besides being harmful to the environment, such chemical products can frequently pose hazards to consumer health. Excessive amounts of chemical contamination in food or agriculture products are cases in point.

Many may agree that the increasing demand for energy needs and the degradation of the environmental situation are consequences of the population explosion and the economic expansion of the country. The problems are hard to solve. However, the solutions to these problems may be obtained by seeking answers to these questions:
(a) the extent to which most people understand about the energy and environment situation is adequate or not, (b) the extent to which most people consume energy and natural resources is effective or not, (c) the extent to which most people protect and conserve natural resources and the environment is satisfactory or not. The answers to these questions clearly illustrate how energy and natural resources can be used economically and efficiently without harming the environmental situation.

The Thai government has realized the importance of environmental problems. Many attempts have been made to tackle the problems. More budget has been allocated to make the implementation possible in addition to outside supports obtained from international organizations that include technical assistance, equipment and funds. Responsible agencies were established to deal with environmental matters. These agencies are: The National Energy Authority, The Office of the National Environment Board and the National Commission of National Resources and Environment Conservation.

Efforts have been made to carry out research and development in the areas of alternate energy resources, effective consumption of energy and natural resources, and remediation for disastrous environment. Moreover, the government has further intensified her efforts to provide basic environmental education for inculcating environmental awareness, particularly in young people, through both formal and informal education. It is among the young that the ethic should be fostered to regard natural resources as a precious heritage which must be protected and, where possible, enhanced.

Coupled with the environmental education program, mass communication campaigns have also been carried out to heighten public awareness of the importance of energy, natural resources and environment conservation.

Environmental education in schools has been initiated by the Institute for the Promotion of Teaching Science and Technology (IPST) and the Department of Educational Technique, Ministry of Education for more than seventeen years. Teaching activities and concepts related to energy and environmental issues were integrated into existing subject areas, mostly science, at all education levels: Life experience at the primary level; General Science at the lower secondary level; and Chemistry, Biology, Physic and Physical and Biological Science at the upper secondary level. This approach may not be suitable in that students' involvement with teaching and learning activities has to depend on teachers who do not actually pay much attention to those integrated energy and environmental activities. Therefore, only these integrated activities are not sufficient for students to realize the importance of environmental problems.

The IPST has been now actively engaging in the development of the environmental education curriculum as separated sources for secondary school students. The curriculum will be implemented in 1990 as elective courses. It is expected that these environmental courses will be required of all students in the future.

The environmental concepts and teaching and learning activities to be developed by IPST will not only focus on local and national problems, but also on global problems. Problems related to the depletion of ozone, the greenhouse effect and ocean waste dumping will be included in the curriculum. These curriculum materials, with little modification. can be used with students outside the formal school system as well.

ABSTRACT *Energy and the Environment in the National Curriculum in England and Wales* **Anthony D. Ashmore, Royal Society of Chemistry, Burlington House, London, W1V OBN United Kingdom** •A national curriculum for students aged 5-16 is being introduced in England and Wales over the period 1989 - 1994. Science will be a compulsory subject throughout the age range leading to more science in primary school and all pupils studying some chemistry right up to age 16, although most students will study science rather than discrete chemistry. •The science curriculum is divided into a number of Attainment Targets", two of which are "Human Influences on the Earth" and "Energy". In addition, the applications and implications of science pervade the whole curriculum.

United Kingdom

To the Secretaries of Education Division Regions,
Industrial Division Regions,
Local Sections

Joint Education Division/Industrial Division Program for 1991

The Councils of the Education Division and Industrial Division have agreed upon a major programme of joint activity during the Society's 150th Anniversary year to bring together schools and the chemical industry. The overall aim will be to highlight the contributions chemistry has made and will continue to make to improve the quality of life. It is intended that the activities described below should take place in each of the Regions of the two Divisions and in as many Local Sections as possible.

There will be two main interconnected aspects to the programme.

1. **Chemistry at Work 1991**

   These will be modeled on the successful "Physics at work" exhibitions run by the Institute of Physics and a pioneering "Chemistry at Work" event organized by the mid-Anglia Section of the RSC (*Royal Society of Chemistry*) earlier this year

   The purpose of the events will be to teach pupils in the 14-16 age range something about the application of the chemistry they are doing in school to the chemical industry or chemistry based employment in their area. At each event local employers would be invited to have a stand and to put on a 20 minute lecture/demonstration on an aspect of their work that relates to the curriculum. Schools would be invited to send class size groups for half a day during which they will attend six lecture/demonstrations. It is envisaged that the events would probably be held between April and June 1991. It has been suggested that colleges running RSC examined courses ma be suitable venues.

   The Society has agreed to provide funding for a half-time national coordinator and to assist local organizers of the events.

2. **Bringing the Chemical Industry into the Classroom**

   Through the Regions of the Industrial Division, members in companies will be asked to make contact with their local schools to explore and then agree ways in which they can contribute to chemistry in schools through a regional and national competition. This may be via project work arising from industry or a case study of a particular process or job. It is hoped that there would be an outcome to the collaboration such as a demonstrated experiment, project or artifact, perhaps backed by a poster display or report. The Chemistry at work event would provide an opportunity to display work and prizes would be given for outstanding achievement. The best work at each even would be brought together nationally. The main purpose would be to give pupils a better insight into the workings of the chemical industry and to establish relationships between schools and companies.

   This activity would start in September 1990 and conclude with the Chemistry at Work events.

Having agreed the above programmes, the councils of the Divisions expect that each of their Regions will participate and we hope that as many Local Sections as possible will do so in order that there may be more than one centre of activity in each Region. The Historical Group of the Society has pledged its support for appropriate aspects of the programme.

At this stage we would like to invite expressions of interest from Local Sections. From Regions of the Division we should like to have invited reactions about where the events could be held and the names of members who would be willing to form the nucleus of the local organizations.

We expected that similar programmes of activity will continue beyond 1991 so that the investment of effort required locally would have a lasting effect. We hope, therefore, that you and your Committee will become actively involved in this important venture.

A paper outlining the envisaged programme of activity is enclosed.

Yours sincerely,

D G Chisman	T F McCombie	P H Ogden
President	Chairman	President
Education Division	Local Affairs Board	Industrial Division

Energy and the Environment in the National Curric::um in England and Wales

Education in the U.K. is compulsory for children aged between 5 and 16. For the first time, a national curriculum is being introduced in England and Wales over a five-year period which specifies the subjects to be studied and the nature of subject matter within subjects. Control over the curriculum is being achieved via the specification of statements of attainment (*i.e.* students should be able to . . . .) and a complex system of internal and external assessment.

Major changes from previous practice are:

- compulsory science in primary schools (age-11) leading to a significant increase in provision
- broadly based science courses to age 16 for those is secondary schools with chemistry as a component but with most schools teaching a form of integrated or combined science and not single subject chemistry, physics and biology

The science component of the national curriculum is described in terms of 17 Attainment Targets, each of which is subdivided into statements of attainment at up to 10 levels. The Attainment Targets*, which are not all of equal importance are:

1. Exploration of Science
2. The variety of life
3. Processes of life
4. Genetics and evolution
5. Human influences on the Earth
6. Types and uses of material
7. Making new materials
8. Explaining how materials behave
9. Earth and atmosphere
10. Forces
11. Electricity and magnetism
12. The scientific aspects of information technology including microelectronics
13. Energy
14. Sound and Music
15. Using light and electromagnetic radiation
16. The Earth in space
17. The nature of science

Applications and implications of science pervade the c ·ılum. Attainment Targets, "Human Influences on the Earth" is entirely .cerned with environmental issues although environmental concerns appear in most Attainment Targets. For example, pupils aged 11-14, in studying the Variety of Life (Attainment Target 2), students should "be able to support their view about environmental issues concerned with the use of fertilizers in agriculture and horticulture, based on their practical experience". Able students aged 16 would be required to "be able to relate differences of scientific opinion to the uncertain nature of scientific evidence, for example 'what is responsible for the death of trees in European forests?'".

The study of Energy (Attainment Target 13) mixes the scientific study of concepts with a consideration of energy use and conservation and the environmental effects of energy exploitation.

For many teachers at the secondary level the new national curriculum provides as much of a challenge in terms of assessment as in course content. Much supporting material al:eady exists, but needs identifying and tailoring to new needs.

* Some pupils in the age range 14-16 will be permitted to take a reduced versions of the science curriculum and will omit study of Attainment Targets 2, 5, 7, 12, 15, 16, 17.

ABSTRACT *Energy and Environmental Topics in Chemical Eduction in the USA* **Stanley Kirschner Department of Chemistry, Wayne State University, Detroit, Michigan 48202, USA** •Topics dealing with energy and the environment are taught in the United States at almost all levels of instruction involving chemistry. For example, in the Kindergarten through elementary and middle school levels, topics in these areas included in the science courses taken by children between the ages of 5 and 15. One of the main problems is to help teachers at these levels overcome a "fear" of teaching science topics in general, and chemistry topics, in particular. Summer institutes and workshops for teachers at these levels, sponsored by the U.S. National Science Foundation and other organizations, are helping to solve this problem. Certain high school (ages 16 - 18) chemistry courses (*e.g.*, CHEMCOM) have entire units that are devoted to topics in these areas, with excellent instruction in them now being offered. At the undergraduate level, these topics are well-included in courses for non-science majors, but are often omitted (or treated lightly) in courses designed for science (especially chemistry) majors. This is a serious problem which has now begun to be addressed by textbook authors for these courses. The newest textbooks now include material dealing with energy and the environment, so this problem is on the way to being solved. Much too little in these areas is being included in advanced courses in chemistry (except for environmental chemistry specialists), and hardly any material on these topics is included in graduate courses in chemistry (again, except for environmental chemistry specialists). Societies in the USA that offer significant assistance in educating both students and the lay public in these areas include the American Chemical Society (ACS), the American Association for the Advancement of Science (AAAS), and the National Science Teachers Association (NSTA). Some of their programs will be discussed.

Energy and Environmental Topics in Chemical Education in the USA

The United States of America

Introduction

Both energy and the environment are widely recognized by science educators in the USA as being appropriate and important topics for inclusion in chemical and science education curricula at many educational levels. In addition, organizations other than educational institutions have taken a strong interest in facilitating the inclusion of these topics in both formal and informal education in the USA. Professional organizations such as the American Chemical Society (ACS), the American Association for the Advancement of Science (AAAS), and the National Science Teachers Association (NSTA) have programs and publications that are designed to help educational institutions, museums, news media, and others put effective programs into place that deal with energy and the environment.

The United States government, as well as state and local governments, are also involved in facilitating and improving instruction in energy and the environment at many educational institutions - especially through the activities of agencies such as the National Science Foundation, the Department of Energy, the Department of Education, the Department of Health and Human Services, and the Environmental Protection Agency. In addition, the media (newspapers, magazines, publishers, television stations) have recently become quite interested in providing information on energy and environmental topics through Tuesday supplements devoted to scientific topics, special TV programs (*e.g.*, NOVA), science - oriented magazines (*e.g.*, DISCOVER) - all directed at non-scientists at almost every age level. Further, museums, particularly science museums, provide a major part of the informal education in energy and environmental topics - both for children and adults. Still further, private industrial companies have become active in providing materials for educational purposes that deal with energy and the environment - all of this indicating widespread and increasing interest in improving the education of both students and the general population with regard to these important topics.

The Educational Levels

A. **Pre- Kindergarten** (ages below 5)

At this level, almost all of the education relating to energy and the environment is informal - involving particularly television, museums, nursery school activities, and some children's books. This is one area in which much more could be done than is now being done. Far too little in terms of time and space in the aforementioned media are devoted to interest young children in science topics, in general, not to mention energy and the environment, in particular. A major, concerted effort in this area would be well-advised, in the opinion of this author.

B. **Kindergarten & Elementary School**, Grades k-6 (ages 5-11)

The ACS Committee on Chemical Education devoted its 1982 Invitational Education Workshop to the topic "Chemistry in the Kindergarten - through - Ninth Grade Curricula" and issued a report edited by H. Heikkinen.[1] The report contains a series of recommendations for the improvement of science (including chemistry) instruction in grades k-9. The report has met with considerable acceptance, and, since then, curricula have been introduced that emphasize science, chemistry, energy and the environment in the lower grades. For example, one is called "Toxics in My Home? - The You Bet Curricula on Household Toxics for Grades K-3, 4-6, 7-8 and 9-12."[2] This curriculum, designed for several age levels, shows relationships among science, the environment, common substances found in the home and the dangers associated with many of these substances.

In recent years, several governmental agencies and school systems have taken a strong interest in increasing the amount and degree of sophistication of science instruction at these age levels, feeling that interest in science - even to the extent of possible early career decisions - begins and is important at these early ages. The U.S. National Science Foundation is a strong supporter of such programs in the USA.

C. **Middle School** Grades 7-9 (Ages 12-14)

In the report on Chemistry in grades K-9 mentioned above, science activities (including chemistry, energy, and the environment) are targeted for much-increasing emphasis at these grade levels. There seems to be little doubt now that intellectual and social developments at these ages play a crucial role in interest in science, career decisions, and attitudes towards science and scientists. As a result, activity in enhancing and improving science instruction, both formal and informal. at these levels has increased more for these age levels than for any other. The National Science Foundation now supports many programs in formal and informal science education that are directed towards students at this age range. Two of the most important science topics taught to children at the age levels in both formal and informal educational settings are energy and the environment.

Further, many universities, state and local education boards, and other groups, including museums, news media, television stations, etc. have developed and put into place programs directed toward children at these age levels, which are designed specifically to increase the quantity and improve the quality of the science education they receive. Still further, there is instruction for children at the age levels by improving the education in science of middle school teachers - especially through the use of summer and in-service institutes - devoted specifically to helping middle school teachers with science instruction and to alleviate fears they may have that are associated with their becoming more heavily involved in science instruction than they are now.

D. **High School** Grades 10-12 (ages 15-17)

In the USA, these have traditionally been the ages at which science has been emphasized in the school curriculum. Chemistry, physics, and biology are still taught in high schools across the USA - but traditional courses are undergoing change now, and courses other than the traditional ones are also taking hold. Particular mention should be made of the new CHEMCOM ("Chemistry in the Community") course[3] developed by the American Chemical Society. It is a one year secondary school course that is designed around eight units or general topics, including energy and the environment, which is targeted primarily (but not exclusively) towards non-science students. It is enjoying outstanding acceptance and is undoubtedly one of the most successful new programs in science education ever developed in the USA. It has been so successful, in fact, that a similar type of course is now being developed by the American Chemical Society.

E. **College & University Undergraduate** (ages 18-21)

At this level, energy and the environment are well-included in courses and textbooks[4] designed for non-science majors, but are often omitted (or treated lightly) in courses and texts designed for science (especially chemistry) majors. The newest beginning textbooks[5] for students who will become science majors now include material on energy and the environment, and many people feel that this problem is on the way to being solved - at the level of beginning chemistry courses in colleges and universities. However, at the advanced levels of undergraduate university instruction in chemistry, very little material is offered in formal chemistry courses in the areas of energy and the environment - with the exception of courses designed for students who will major in environmental science. This is a problem that needs to be addressed in the USA, because these are students who already have some technical expertise and who will have much more in the near future. In short, they will be the persons most likely to develop the skills necessary to solve critical problems in the energ and environmental fields. However, they are still exposed to far too little in the way of topics in energy and the environment - unless they happen to be specialists in these areas.

F. **University Graduate and Post-Doctoral**

Again, at the graduate school (pre-Ph.D.) and post-doctoral levels, very little formal instruction in topics directly related to energy and the environment is available - except to specialists in the field - and, again, this is a problem that needs to be addressed in the USA, because these are the very people who possess the technical expertise required to make significant contributions to solving problems in these areas.

The Professional Societies

A. **The American Chemical Society**

This organization is a major player in the area of providing assistance in placing the topics of energy and the environment before students and the general public. It publishes a "Catalog of Teaching Resources"[6] that is available free of charge, which lists the many curriculum and career materials that are available from the Society, as well as other items, such as the magazines published by the Society for high school[7] and elementary school[8] students.

B. **The American Association for the Advancement of Science**

This organization is an important one in the area of providing assistance in placing the topics of energy and the environment before students and the general public. It also publishes a catalog of its publications,[9] which deal with issues in science and science education, which is also available free of charge.

C. **The National Science Teachers Association**

This is yet another organization that is heavily involved in the area of providing assistance in placing the topics of energy and the environment before students and the general public. It also publishes a catalog of its publications,[10] many of which deal with issues in science and science education, which is also available free of charge.

The Governmental Bodies, National, State, and Local

The major agencies of the US federal government that deals with placing issues of energy and the environment before students and the public include the National Science Foundation, the Department of Energy, the Department of Education, the Environmental Protection Agency, and the Department of Health and Human Services, including the National Institutes of Health. The agencies generally provide information about matters relating to energy and the environment to interested persons and groups, and they will also entertain requests for grant funds to support research and instructional projects related to energy and the environment in US education.

The Media

The media, including newspapers, magazines, book publishers and television and radio producers have become increasingly interested in producing and distributing information related to energy and the environment, ever since major problems in these areas arose in the early seventies. This has been most helpful for practitioners who are involved professionally in teaching these topics to students and to the lay public.

Private Industry and Foundations

Private science related industries in the USA, such as DuPont, Dow, Monsato, Union Carbide and others have had a tradition of providing information on scientific topics, including energy and the environment, to educational and non-profit organizations and to students. This information has usually been in the print format, or in the form of movies - and much of it has been extremely helpful to schools. Recently, considerable assistance has been forthcoming in the form of computer aided instructional materials, as well, from corporations having an interest in this type of instrumentation.

Private foundations have also been quite helpful in these areas. One that should be cited here is the Annenberg Foundation,[11] which has just produced a course in the form of a series of films on videotape aimed at the non-science majors in colleges and universities. Others include the Ford Foundation, the Rockefeller Foundation, the Dreyfus Foundation (and others) - which make grants for worthy educational projects - including those that have energy and environment topics - in school and university curricula.

Museums and the Institute of Chemical Education

Museums have long been centers of informal instruction in science, in general, and in energy and environmental issues, in particular. The Lawrence Hall of Science of the University of California is an excellent example of how museums can greatly improve education, both formal and informal, , in areas such as energy and the environment, and how they can help with the improvement of educational delivery by running workshops and other programs to improve teacher's and students' abilities in science.

The Institute for Chemical Educ (ICE) at the University of Wisconsin also runs both summer and in-service institutes and workshops for teachers and for students - many of which involve energy and the environment. This organization is supported by funding from several federal and state sources, as well as from private philanthropic and industrial sources.

Reference

[1]. H. Heikkinen, Ed., "Chemistry in the Kindergarten - through - Ninth Grade Curricula: Report with Recommendations," American Chemical Society, 1155 Sixteenth St. NW, Washington, DC 20036 USA (1983).

[2]. Purin, Gina, et al., "Toxics in My Home? - The You Bet Curricula on Household Toxics," Golden Empire Health Planning Center, 2100 21st Street, Sacremento, CA 95818 USA.

[3] S. Ware, CHEMCOM "Chemistry in the Community," American Chemical Society, 1155 Sixteenth St. NW, Washington, DC 20036 USA (1987).

[4]. M. Jones, "Chemistry and Society," Saunders Publishing Company, New York, NY USA (1988).

[5]. D. Ebbing, "General Chemistry," Third edition, Houghton-Mifflin Publishing Co., New York, NY USA (1990).

[6]. "Catalog of Teaching Resources," American Chemical Society, 1155 Sixteenth Street, NW, Washington, DC 20036, USA.

[7]. "CHEMMATTERS" - A Magazine for High School Students of Chemistry, American Chemical Society, 1155 Sixteenth Street, NW, Washington, DC 20036, USA.

[8]. "Wonder Science" - A Magazine of Physical Science Activities for Young Children and their Parents, American Chemical Society, 1155 Sixteenth Street, NW, Washington, DC 20036, USA.

[9]. "AAAS Publications", American Association for the Advancement of Science, 1333 H Street, Room 815, Washington, DC 20005 USA.

[10]. "National Science Teachers Association Publications and Membership Catalog", National Science Teachers Association , 1742 Connecticut Avenue, NW, Washington, DC 20009 USA.

[11]. "The World of Chemistry" - A New Television-Based Course for Non-Science Majors at the College Level, The Annenberg/CPB Project, c/o Intellimation, P.O. Box 1922, Santa Barbara, CA 93116 USA.

ABSTRACT *Environmental, Social and Technological Emphasis of the Future Chemistry Curriculum in Venezuelan Secondary School* **Rafael R. Pujol CENAMEC, Coordination de Quimica, Apartado 75055, El Marques, Caraca 1020, Venezuela** •In Venezuela, the emphasis of chemistry courses, which have been taught since 1972 in secondary school, is centered on discipline. These courses have too many strong theoretical topics which seem to not be relevant to most of the students. •Since 1983, in the Centro Nacional para el Mejoramiento de la Enseñanza de la Ciencia (CENAMEC) new curricula for natural sciences and mathematics in t :: secondary level re being developed. This project is based on the necessity to produce curricula that present a balance between the concepts, principles and laws of the disciplines and its environmental, social and technological applications and implications. •In the two chemistry courses, topics related to the environment and energy play an important role. Among the contents can be mentioned: chemical composition of the atmosphere, rivers, seas and soils; chemical changes in the environment; chemistry of water, air and soil pollution; social, political and economical implications of the environmental issues. •The chemical changes are classified by the type of energy involved: thermochemical reactions, electrochemical reactions, photochemical reactions and nuclear reactions. •Courses and instructional materials must be designed to prepare highly competent teachers so they can be ready to implement the new chemistry curriculum for ' secondary level.

Environmental, Social and Technological Emphasis of the Future Chemistry Curriculum in Venezuelan Secondary School

Venezuela

In Venezuela, the chemistry courses for the Secondary school are highly influenced by the projects: "Chemical Bond Approach (CBA)" USA, 1959 and "Chemical Education Material Study (CHEM Study)" USA, 1960. These two projects are centered in the discipline (UNESCO, 1984). As a result of this, the chemistry courses which have been taught since 1972 in our country at the secondary level, have too many strong theoretical topics. As a consequence, chemistry seems to be not relevant to most of the students. It is urgent for us to change the emphasis of the chemistry curriculum (CENAMEC, 1987).

There is an international consensus that chemistry should be taught, at least the basic courses, with an environmental, social and technological approach. Therefore, the future chemistry curriculum for the Venezuelan Secondary School has to deliver to the students the message that the concepts, principles and laws of this discipline allow them to understand the phenomena which occur in their environment and to know better the products and materials used in everyday life.

It is necessary to develop a balanced curriculum between the basic theoretical topics in chemistry that all students must handle at the secondary level, the properties and reactions of the more important chemical substance and the applications and implications of chemistry in our society and in our environment. As a consequence, since 1983, new curricula for Natural Sciences and Mathematics for this educational level are being designed in CENAMEC (Centro Nacional para el Mejoramiento de la Enseñza de la Ciencia).

In Venezuela, there are two chemistry courses for the science students in Secondary School. The contents proposed for the future curriculum are organized by units as follows:

FIRST COURSE		SECOND COURSE	
UNIT I:	Chemical Substances	UNIT I:	Chemical Elements
UNIT II:	Chemical Mixtures	UNIT II:	Inorganic Compounds
UNIT III:	Chemical Changes	UNIT III:	Organic Compounds
UNIT IV:	Atoms and Molecules	UNIT IV:	Products of the Chemical Technology
UNIT V:	Introduction to Research Methodology	Unit V:	Introduction to Research Methodology

Topics related to the environmental and energy play an important role in these courses (CENAMEC, 1989).

The CENAMEC has emphasized for many years the necessity of teaching chemistry with an environmental approach. From 1976 to 1984, our Center implemented the project "The Environment: a Resource for Chemistry Learning" (CENAMEC, 1976). 685 secondary school teachers participated in 27 workshops of this project. The workshops were based mainly in laboratory activities and teachers had the opportunity to design learning units in which the chemical principles were presented in relationship to the environmental phenomena.

Many of the environmental topics for the future chemistry courses will be based on this experience. Among these topics can be mentioned:

- Chemical changes in the environment.
- Chemistry of water, air and soil pollution.
- Chemical methods to eliminate pollution.
- Social, political and economical implications of the environmental issues.

The students will have the opportunity to study topics like: the use of chemical additives to fight water pollution, acid rain, thermal pollution, oil pollution, mercury pollution, origin of the elements in the stars, pH of mass water and soil, environmental impact of pesticides and fertilizers, etc.

In Unit III of the first course, the chemical changes are classified by the type of energy involved: Thermochemical reactions, electrochemical reactions, photochemical reactions and nuclear reactions.

Among the topics to be developed in this unit can be mentioned: technological and environmental impact of the combustion reactions, production of electrical energy from chemical reactions, the photosynthetic process, electromagnetic reaction and the ozone cycle, pacific uses of nuclear energy.

These curricular changes imply that courses and instructional materials must be designed to prepare highly competent teachers, so they can be ready to implement the new chemistry course for the secondary level. In order to cope with this situation at the Pedagogical Institute of Caracas some chemistry courses with the environmental, social and technological emphasis have been taught during the last three semesters. One of these courses: "Environmental Chemistry" is organized in four units:

Unit I: The Cosmic Origin and Distribution of the Chemical Elements
Unit II: Chemistry of the Hydrosphere
Unit III: Chemistry of Soils and Rocks
Unit IV: Chemistry of the Atmosphere

Throughout this course, the future chemistry teachers have the opportunity to apply the chemical principles that they have already studied (IPC, 1988).

Finally, we should say that in our country this new approach to chemistry teaching is just beginning, and therefore, there are many things to be done in the near future.

Bibliography

CENAMEC (1976) Proyecto QUIM-LAB-O2: "El Ambiente: un Recurso para el Aprendiaje de la Quimica". Caracas (Doc. Mimeo.)

CENAMEC (1987) "Analysis de los Programs de Biologia, Ciencias de la Tierra, Fisica, Matematica y Quimica. Ciclo Diversificado. Mención Ciencas". Caracas (Doc. Mimeo.)

CENAMEC (1989) "Una Proposición de Alcances de Contenidos en Quimica para la Educacion Media Diversificada y Profesional". Caracas (Doc. Mimeo.)

Instituto Pedagogico de Caracas (1988) *Programa de Quimica Ambiental.* Caracas. (Doc. Mimeo.)

UNESCO (1984) *Teaching School Chemistry.* Paris.

ABSTRACT *Energy for Recycling Energy from Waste* **Aleksandra Kornhauser, Sasa A. Glazar and Radojka Olbina International Centre for Chemical Studies, Ljubljana, Yugoslavia** •An awareness of the dangers of pollution and the need for introducing clean technologies and products is established in most countries, generally through school education and communication of science to the general public. Much less has been done for a more efficient waste management and its minimization. Th recycling of energy from waste is a challenging filed, not only for industry but for schools as well. •In many countries, the main reason for the absence of waste processing topics in the curricula is the lack of knowledge by teachers. This field is very demanding for the teacher for several reasons, *e.g.* 1) the interdisciplinary approaches; 2) the "know-how" character of knowledge; 3) the quick development of technologies; 4) the lack of teaching examples. •A Waste Management Information System has, therefor, been built at ICCS, with the partial support of UNESCO and UNDP, aimed at providing bibliographic and factual information on waste generation, characteristics, processing and disposal. The use of this information system has catalyzed several ideas for recycling energy from waste, *e.g.* biogas production from municipal waste and incineration of hazardous waste in cement kilns. The modules of the information system were produced by collecting research, educational and industrial information, as well as by attracting experts into cooperation. It now offers support to research and developmental projects, governmental decision making and teaching.

EDUCATION FOR RECYCLING ENERGY FROM WASTE

Yugoslavia

Creating awareness of local and global environmental pollution and of its consequences is found increasingly among the major goals of science curricula worldwide. Another common effort is the presentation of opportunities to avoid pollution by better use of renewable energy sources. In the past, much less attention has been paid to efforts to save energy, to introduce cleaner technologies and products, and, in particular, to recycling materials and energy from waste. Millions of tons of waste end up in sanitary landfills, most of them having a calorific value of about one third that of good quality coal (C.A.C.Haley, 1985).

Waste management offers a number of exciting teaching and learning opportunities in chemistry. The scheme about main phases of municipal solid waste processing shows that at least three possibilities for recycling energy could be discussed: (1) controlled waste incineration and energy recovery; (2) production of refuse-derived fuel (RDF); (3) production of landfill gas (methane). Recycling of materials, e.g. glass, metals, plastics and paper, also involve energy savings.

Municipal waste management has a number of additional advantages: it begins in the home kitchen and garden, continues into the home surroundings, the community, the national level, and, finally, reaches global dimensions. It offers many possibilities for low-cost teaching experiments involving hard chemistry. It can be considered in a "core" approach, as well as extended by individual student's work and research projects. It enables education for decision making on better use of materials and energy, and it creates an awareness of the need to introduce cleaner processes in homes and communities.

Processing of industrial waste is very demanding in both, the solving of chemical problems and communication with the general public. Only a few highly developed countries have satisfactorily solved the problem of chemical (including hazardous) waste minimization and processing, mainly by burning it in specially-designed incinerators. In other countries, industrial waste is still deposited in landfills, and hazardous chemical waste usually in steel drums. The number of the latter, in many areas, goes into the hundreds of thousands. Many of these drums have been deposited for several years and have started to leak. Urgent action is necessary!

Most communities cannot afford the installment of specialized waste incinerators, demanding an investment of several tens of millions of US$. A promise is the incineration of both municipal and industrial chemical waste in cement kilns, developed in the eighties in the USA, the UK, Norway (R.E. Mourninghan, 1985; C.A.C. Haley, 1985; K. Trovaag, 1983) and some other countries. The positive characteristics of this technology are, in particular: (1) low investment cost (less than 10% in comparison with a special incinerator); (2) wide distribution of the cement industry in most countries; (3) high incineration temperature and long waste retention time in the kiln, enabling efficient destruction of toxic chemicals; (4) alkaline clinker neutralizes acid components and incorporates ash; (5) the kiln is already fitted with an efficient waste gas dedusting plant, (6) a considerable primary energy saving can be achieved in the cement industry, which is a significant energy consumer (energy, mainly from coal, represents about 40% of production costs).

However, special care has to be paid to: (1) the selection of chemical waste to be incinerated; (2) the waste blending process; (3) the control of combustion; (4) the analysis and control of emissions; (5) the control of raw materials for clinker, as well as of cement quality.

These prospects and problems of the process, are considered in a research-educational approach at the International Centre for Chemical Studies, University of Ljubljana, Yugoslavia. Undergraduate and postgraduate chemistry and biochemistry students are members of the research/developmental team carrying out the pilot project on safe incineration of selected chemical wastes in cement kilns. The expert team is composed of university teachers, researchers from specialized research institutions, chemical and cement enterprises, and visiting consultants/advisors from leading international groups in the field. The consultants are partially supported by national (e.g. U.S.Environmental Protection Agency) and international organizations (Unesco, UNDP, The World Bank).

Whatever promising results this R&D project might achieve, they could not be implemented without mobilizing the general public to both clean up the accumulated waste and to introduce cleaner technologies and products. The development of a research-educational approach for the tertiary level, and a teaching module for upper secondary schools, combined with special informational materials for the mass media, is, therefore, an essential task of this project.

A Waste Management Information System has been developed first. It consists of:

- a relational database (built on IBM-PC with dBASE III PLUS and Clipper softwares) with factual information on waste generation firms and their technologies; waste physical, chemical and toxicological properties; waste on-site processing and disposal; waste legislation and regulations; experts in waste management; producers of waste processing equipment;
- a bibliographic database (IBM-PC, Unesco CDS/ISIS software) on waste generating and waste processing technologies; analytical procedures and standards; regulations and security measures; developments of clean(er) technologies.

Students are encouraged to use these databases, to process international databases in their search for new data, and to complete and update the above databases. They learn to organize data and search for patterns of knowledge.

A segment of the factual database is given in Table 1 (follows report).

A simple example of organizing data according to the needs of the incineration process is given in Tables 2 and 3 (follow report).

Students participate in discussions of waste analyses, decision making on waste to be incinerated, experiments on waste compatibility, discussions of raw materials for cement production, combustion process, emission control and quality control for the cement. They take part in economic analyses considering costs for investments, running costs, energy savings, costs for standard and "fingerprint" analyses, etc.

Students are also involved in the preparation of the teaching module for secondary schools. The preparatory studies cover waste incineration, biodetoxification, solidification and safe disposal.

The preparation of materials for the general public seems to be most difficult. The phenomenon described in the USA as "Nimby" (Not In My Backyard) exists everywhere. Local communities rapidly absorb information on pollution and hazardous waste, but they react vigorously, often emotionally, against attempts to clean up this waste by technological processes. Trust in industrial and political institutions has been lost.

A systematic education for a careful use of materials and energy, for waste minimization, as well as for efficient waste processing and safe disposal, has not only become one of society's main needs, but also a promising field of science education, combining good basic and applied knowledge with mobilization for action and decision making. The latter involves key questions of ethics and social responsibility. It is also an opportunity to re-establish trust in education and teachers.

References

Abert, J.G.: Municipal Waste Processing in Europe: A Status Report on Selected Materials and Energy Recovery Projects, 1985, (Integrated Resource Recovery), World Bank Technical Paper, No.37, Washington, 137 pp.

Alter, H.: Processing and Reuse of Municipal Waste for Energy Production, 1986, Resources and Conservation, No. 7, 327-335.

Black, M.W.; Swanson, J.R.: Destruction of PCB's in Cement Kilns, 1983, Pollution Engineering, 15 (6), 50-3.

Brocco, D.; Cecinato, A.; Liberti, A.; Rotatori, M.: Solid Urban Wastes as Alternative Fuel in Cement Kiln: Trace Organic Pollutants in the Emissions, 1983, Riv. Combust., 37 (9-10), 243-9.

carrera, R.; Dunin, S.: Energy Recovery from Municipal Solid Waste, 1983, Sorain Cecchini, Rome, Italy, 62 pp.

Chadbourne, J.F.: Cement Kilns, 1989, (Standard Book of Hazardous Waste Treatment and Disposal, edited by H.M. Freeman), McGraw-Hill, New York, 8.57-8.75.

Fiumara, A.; Odobez, G.; Rigantti, V.: Analysis of the Use of a Rotary Kiln Employing Nonconventional Fuels, 1981, Riv. Combust., 35 (5), 247-52.

Gunnerson, C.G.; Stuckey, D.C.: Anaerobic Digestion, Principles and Practices from Biogas Systems, 1986, (Integrated Resource Recovery), World Bank Technical Paper No. 49, Washington, 17-29.

Haley, C.A.C.; Chatterton, M.H.: Solid Wastes as a Fuel in the Cement Industry in the UK, Energy Progress, June 1985, 5 (2), 84-88.

Lohmann, J.H.: Converting Biogas Sewage Sludge Digester to Gas with Natural Gas Quality, 1984, Waste Management & Research, (2), 325-337.

Mourninghan, R.E. et al.: Proceedings of the International Conference on New Frontiers for Hazardous Waste Management, 1985, EPA-600/9-85/025, U.S. Environmental Protection Agency, Washington, 533-549.

Siddhartha Bhatt, M.: Biogasification of Urban Wastes and Sewage in Centralized Reactors, October 1985, Journal of Scientific and Industrial Research, (44), 548-559.

Systech Corporation: Solution for Recovering Resources form Waste Materials, 1987, commercial publication, 10 pp.

Tchobanoglous, G.; Theisen, H.; Eliassen, R: Solid Waste Engineering Principles and Management Issues, 1977, McGraw-Hill, New York, 621 pp.

Trovaag, K.: Hazardous Waste Incineration in a Cement Kiln, World Cement, March 1983, (59), 61-62.

Tweedale, A.: RDF Pellet Burning - R&D Trails, 21-24 June 1988, (Energy Recovery through Waste Combustion, Proceedings of a Seminar on Recovery of Energy from Municipal and Industrial Waste through Combustion), Churchill College, Cambridge, UK, 123-33.

TABLE 1

CHARACTERISTICS OF CHEMICAL COMPOUNDS FOR CEMENT KILN INCINERATION
(DATA ORGANIZED ACCORDING TO CLASSIFICATION OF CHEMICAL COMPOUNDS)

CHEMICAL CLASS	COMMON NAME	MOLECULAR WEIGHT	BOILING POINT [°C]	HEAT OF COMBUSTION [kJ/kg]	VISCOSITY (cps)
ETHERS	DICHLOROETHYL ETHER,2,2'-	143.0	178.5		
	DIETHYLENE DIOXIDE,1,4- (DIOXANE,p)	88.1	101.1		
	DIMETHYL-1,1'-DICHLOROETHER	115.0	105.0		
	METHOXYETHANOL,2- (METHYL CELLOSOLVE)	76.1	124.5		
	METHYL CHLOROMETHYL ETHER	80.5			
HYDRAZINES	DIMETHYLHYDRAZINE,1,1-	121.2	193.1		
	METHYLHYDRAZINE,1-	40.1	87.8		
HYDRINS	EPICHLOROHYDRIN	92.5	116.0		
HYDROCARBONS	BENZENE	78.1	80.1	41,854	0.652
	DIMETHYLBENZENE,1,2- (XYLENE,o-)	106.2	144.4	43,022	0.810
	DIMETHYLBENZENE,1,3- (XYLENE,m-)	106.2	139.1	42,904	0.620
	DIMETHYLBENZENE,1,4- (XYLENE,p-)	106.2	138.3	42,943	0.648
	ETHYLBENZENE	106.2	136.2	43,022	
	HEPTANE	100.2	98.4	48,070	0.409
	HEXANE	86.2	69.0	48,361	0.326
	METHYLBENZENE (TOLUENE)	92.2	110.6	49,832	0.590
	METHYLPENTANE,3-	86.2	63.3		
	NAPHTHALENE	128.2	218.9	40,233	0.967
	TRIMETHYLBENZENE,1,2,4-	120.2	168.9		
	VINYLBENZENE (STYRENE)	104.2	145.2	42,081	
IMINES	ETHYLENE IMINE				
ISOCYANATES	DIISOCYANATO-1-METHYLBENZENE,2,4-	174.2	257.0		
	DIISOCYANATODIPHENYLMETHANE,4,4'-	250.3	196.5		
	METHYLISOCYANATE	57.0	59.6	19,727	
KETONES	BUTANONE,2-	72.1	79.6		

Scheme 1

MAIN PHASES OF MUNICIPAL SOLID WASTE PROCESSING

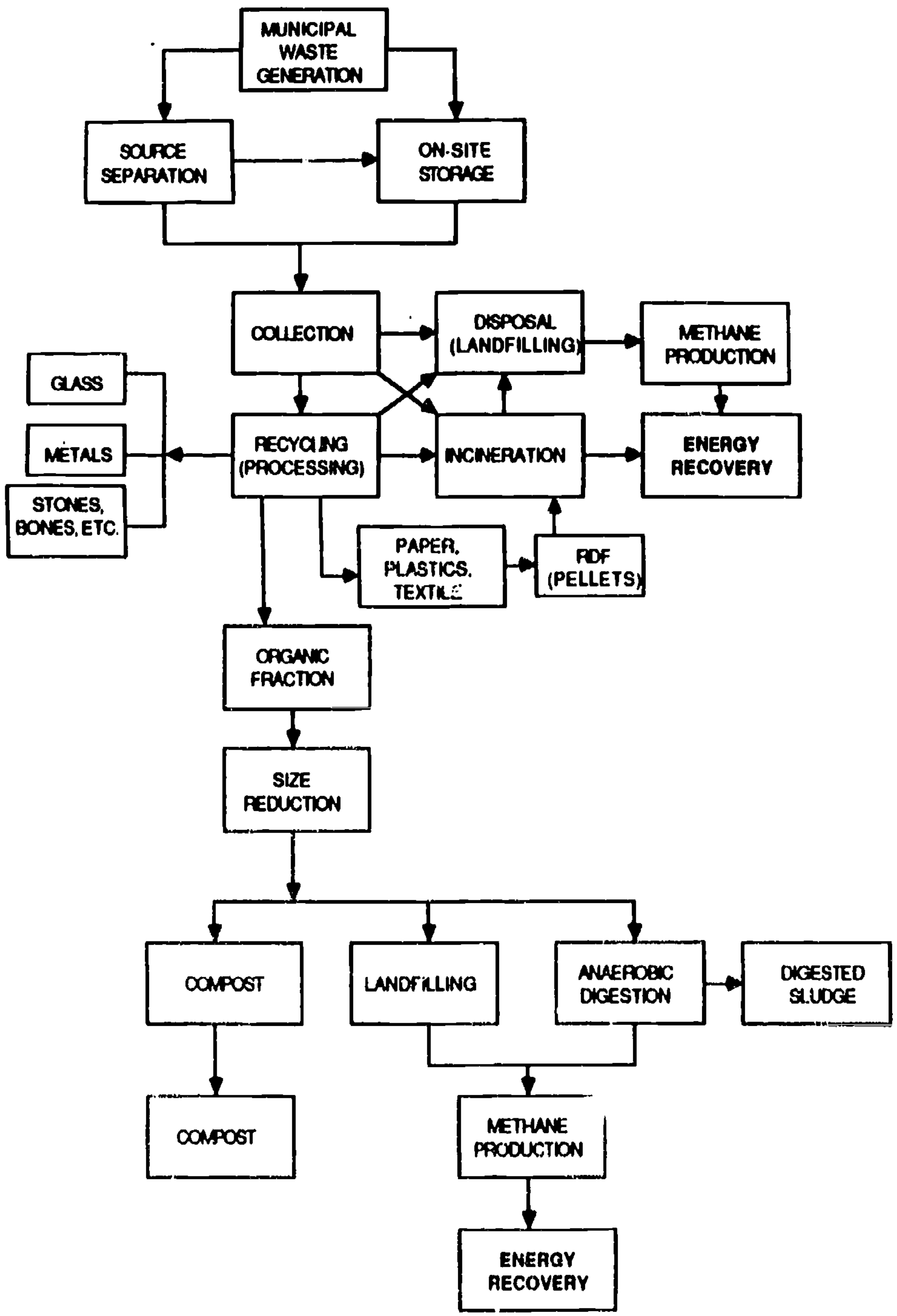


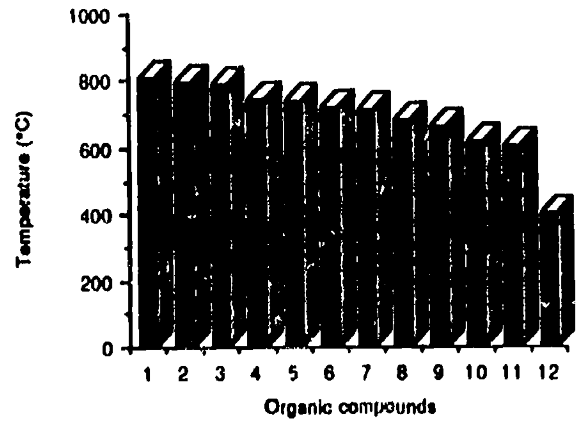
TABLE 2

TEMPERATURE NEEDED FOR 99.99% DESTRUCTION OF ORGANICS IN WASTE

No.	Organic compounds	Temperature (^{o}C)
1.	PHENOL	807
2.	METHYLENE CHLORIDE	797
3.	PYRIDINE	791
4.	VINYL CHLORIDE	746
5.	BENZENE	737
6.	TOLUENE	720
7.	TRICHLOROBENZENE, 1,2,3-	716
8.	TRICHLOROETHANE, 1,1,1-	683
9.	NAPHTHALENE	661
10.	EPICHLOROHYDRINE	618
11.	CHLOROMETHYL ETHER, bis-	602
12.	CARBON DISULFIDE	400

TABLE 3

TEMPERATURE NEEDED FOR 99.99% DESTRUCTION OF ORGANICS IN WASTE



Commission and Other Reports

ABSTRACT *Energy and the Environment as Presented in Chemistry Curricula Developed by the American Chemical Society* **Sylvia A. Ware American Chemical Society, 1155 16th Street, NW, Washington, DC 20036** •The American Chemical Society strongly supports the inclusion of societal topics in chemistry courses at all levels for all students. The Society has developed an alternative year - long, high school chemistry course Chemistry in the Community (ChemCom) which introduces chemistry through societal issues involving chemistry. Two of the eight chapters of ChemCom cover energy related topics, and three focus on the environment. The course is now being taken by more than 62,000 students across the United States and is supported by teacher training. •The Society is also developing a similar course for college students who are non-science majors. The college text will be substantially completed by summer 1990 with full field trials of the text scheduled for fall 1990. The semester long course will be aimed at sophomores and juniors, The course will consist of four core units covering environmental chemistry issues associated with air and water, energy, and, materials. Three optional units will examine other issues related to energy and the environment.

Energy and the Environment as Presented in Chemistry Curricula Developed by the American Chemical Society

The American Chemical Society (ACS) is currently involved in the development of two chemistry courses focussed primarily on environmental and energy issues. ChemCom (Chemistry in the Community), a year long alternative course for high school students, has been commercially available for two years. Given the success of the first edition (over 62,000 copies sold), the Society is now revising the course for the second edition, with publication scheduled for late summer 1991. Dr. Henry Heikkinen of the University of Northern Colorado is the ChemCom editor.

ChemText: ACS (Chemistry in Context: Applying Chemistry to Society) is a semester long, college course for non-science majors. The ChemText project began in summer 1989 under the direction of Dr. Truman Schwartz of Macalester College. First draft materials will be available for classroom testing by fall 1990.

Both courses are designed around societal issues that involve chemistry, rather than following the traditional sequencing of chemistry concepts found in more traditional texts. Chemistry is introduced only on a "need to know" basis (see Table 1). If this "need to know" cannot be justified, then the chemistry is not introduced. Given the nature of the issues selected, an amazing amount of chemistry can be introduced without forcing a topic (see Table 2).

The eight chapters of ChemCom cover issues involving water supply and demand; resource depletion and conservation; use of petroleum as a fuel and chemical feedstock; adequate nutrition; nuclear energy and the use of radioisotopes; air quality concerns including ozone depletion, the greenhouse effect, and acid rain; health as a state of chemical balance in the body; and the role of the chemical industries in the US society. Thus, very explicitly, three of these chapters focus on environmental issues (Water, resources, air), and two on energy (petroleum, nuclear) (see Table 3).

To illustrate the approach, the water unit is built around the problems experienced by an imaginary community, Riverwood, when dead fish appear in the local river. This scenario allows for an exploration of the quality and availability of fresh water; the reasons why water is so easily contaminated; the chemistry behind the detection of possible contaminants; the ways in which a society purifies and treats water; and, finally, who pays to solve such problems.

Each ChemCom chapter begins by establishing the importance of the issue to be studied, often through a laboratory activity such as the purification of "foul" water (chapter one). Each chapter contains narrative text, laboratory activities, mathematical problems, and , most importantly, decision making activities. These activities are not always elaborate in design, and may integrate chemistry with expertise from other disciplinary areas.

American Chemical Society

However, it is important to note that ChemCom is a chemistry course, and not an uneasy hybrid of chemistry with the social sciences. This last point cannot be overemphasized, since the unique format and deign of ChemCom may cause certain high school teachers to approach this course with suspicion. Not only is the chemistry covered different from traditional U.S. texts and presented in a different context, but the pedagogy required to teach ChemCom successfully involves a release of class control from the teacher to the students. Thus, the ACS believes it is vitally important to support the dissemination of ChemCom with long-term teacher training. With support from the National Science Foundation, the U.S. chemical industry, and our publishers, the ACS has pledged a seven year commitment to ChemCom teacher training. To date, some 500 teachers have attended extended ChemCom workshops (variously three to ten days in length) with an additional 1,000 or so attending briefer sessions.

As indicated previously, ChemCom is a sales success. Beyond that, while the course was originally conceived as a chemistry literacy course for students unlikely to study any more chemistry, many ChemCom students appear to be continuing their studies in chemistry as a result of their exciting first exposure to the discipline.

ChemText shares the same philosophy of ChemCom, and many similar features. The first four core chapters of the book will focus on issues involving air quality; water pollution; energy needs and generation; and production of materials. These units, like the first four ChemCom units, will be sequential. ChemText will have three optional chapters probably covering topics related to agricultural chemistry, pharmaceutical, nutrition and health. by January 1990, the first two chapters will be available in first draft form, and the second two in outline. However, it is already clear that ChemText and ChemCom will share many features, although, of course, ChemText will be designed for a more intellectually sophisticated audience.

A principal difference will be in the nature of the laboratory activities. ChemCom students spend about 50% of their time in the laboratory. Many ChemText students will not have the opportunity to ever enter the laboratory, since chemistry courses for non-science majors frequently consist of little more than large audience lectures. The intention is to devise a series of brief "packaged microlabs" that can be used with a 100+ audience in a large lecture hall. For those institutions that do schedule a laboratory, there will be optional environmentally related case studies.

In both courses, the integration of environmental and energy topics with the chemistry is complete. There is no introductory chemistry unit. The high student motivation and concern about issues involving energy and the environment drive the "need to know" the chemistry. While more traditional courses follow a linear approach, with one concept following another in an accepted hierarchy, the ChemCom/ChemText approach is essentially holistic and heuristic, developing a web of concepts in the context of the students own interests and concerns. The American Chemical Society supports this particular approach to the teaching of chemistry as an extremely appropriate introduction for all students at the high school level, and for non-science majors in college.

List of References

American Chemical Society. *Chemistry in the Community*. Kendall/Hunt Publishing Company, Dubuque, IA 1988. 518p

Table 1: Chemistry on a "Need-to-Know" Basis

- Introduce students to a societal issue involving chemistry
- Lead students to realize they need additional chemical knowledge to deal with the issue intelligently
- Develop the relevant chemistry; show its connection to the issue
- Apply the chemistry in decision-making activities related to scientific/ technological aspects of the problem

Table 2: Chemical Concepts Grid: ChemCom

Concept	Water	Resources	Petroleum	Food	Nuclear	Air	Health	Industry
Metric (SI) measurement	I	A	E	A	A	A	A	A
Scale and order of magnitude	I	A	A	A	A	A	A	
Physical and chemical properties	I	E	E	A	E	E	E	E
Solids, liquids and gases	I	A	E		A	E	A	A
Solutions and Solubility	I	E	A	A	A	A	E	A
Elements and compounds	I	E	E	E	E	A	E	A
Nomenclature	I	E	E	E	E	A	A	A
Formula and equation writing	I	E	E	E	A	A	A	A
Atomic Structure	I	E	E		E			
Chemical Bonding	I	A	E	E		A	E	A
Shape of Molecules	I		E	A			E	A
Ionization	I	A	E		E	E	E	E
Periodicity		I						
Mole Concept		I	E	A	E	E	A	A
Stoichiometry		I	E	E		A	A	A
Energy Relationships		I	E	E	E	E	E	E
Acids, bases and pH	I			E		E	E	A
Oxidation-reduction		I		A		A	A	E
Reaction rate/kinetics				I	E	A	E	A
Gas laws						I		
Equilibrium								I
Chemical Analysis	I	E	E	E		A	A	A
Chemical Synthesis			I			A		E
Biochemistry				I	A		E	
Industrial chemistry	I	E	E	E	E	E	E	E
Organic chemistry			I	E			E	
Nuclear chemistry					I			

Code: I = Introduced E = Elaborated A = Applied

Table 3: Environmental and Energy Topics in ChemCom

Water
Thermal Pollution
Entrophication
Acid Contaminants
Heavy metal ion contaminants

Resources
Solid waste management
Resource recovery/recycling
Conservation
Strategic minerals

Petroleum
Supplies and demand
Fuel characteristics
US Energy consumption
Alternatives to petroleum

Nuclear
Fission
Fusion
Use of Radioisotopes
Nuclear waste disposal
Radiation damage
Catastrophic risk

Air
Greenhouse effect
Depletion of ozone
Primary and secondary air pollutants
Pollution control
Photochemical smog
Acid Rain

ABSTRACT *Environmental Education in African Universities* Donald E.U. Ekong Association of African Universities, P.O. Box 5744, Accra - North, Ghana •The principal environmental issues in Africa are soil erosion, drought and dessertification, deforestation, urban waste, and recently the unfair dumping of toxic industrial waste from industrialized countries. With the increased public and political awareness of these issues following the ecological disaster and consequent human tragedy in parts of Africa in the early 1980's, eight regional technical cooperation networks on environment and ecodevelopment have been established in the region. Among the networks is the Environment Education and Training Network (ETNET) in which many universities are involved as regional training centers for the purpose of "integrating environmental education and training at all levels of society in Africa". Although specialized programmes in ecology and environmental sciences have existed in African universities for some time, there has been only limited integration of the environmental dimension into the general curriculum of the universities. Unlike the biological science and social science departments, chemistry departments have generally done little towards achieving such integration or addressing environmental issues in their programmes. The need to develop and strengthen capacities in this field in chemistry departments of African universities is urgent and requires a higher priority than is recognized in many African countries.

Environmental Education in African Universities

Association of African Universities

The principal environmental issues in Africa are soil erosion, drought and desertification, deforestation, urban waste disposal, and recently the dumping in Africa of toxic wastes from industrialized countries. After the human tragedy following the ecological disaster of the early 1980's, African governments have become more aware of environmental issues and in 1985 made a major political commitment at the first Ministerial Conference on the Environment (AMCEN) held in Cairo, to implement programmes and strengthen cooperation among themselves to halt and reverse the degradation of the African environment. They adopted a programme named the Cairo Programme for African Cooperation., one of the major elements of which was the establishment of 8 regional technical co-operation networks on environment and ecodevelopment. The networks are in the fields of environmental monitoring, climatology, soils and fertilizers, water resources, energy, genetic resources, science and technology, and education and training. The networks are to concentrate their efforts in the first instance on:

(a) adoption of comprehensive soil and water development and conservation measures in irrigated and rain-fed agricultural areas;

(b) improvement and protection of rangelands and introduction of better rangeland, livestock and wildlife management;

(c) protection of existing vegetation and replanting of denuded areas;

(d) reafforestation and use of alternative energy sources (rather than the widely used fuel wood) as a means of combating desertification.

The Ministers further developed a Programme of Action on Environmental Education and Training in Africa and declared their firm resolve (a) to implement the programme of action by developing and integrating environmental education and training at all levels of society through formal and informal means, and orienting the programme of action towards the solution of specific urgent environmental problems, and (b) to work in close cooperation with UNESCO as the executing agency of the Programme of Action.

Of the 8 networks established by AMCEN the Environmental Education and Training Network (ETNET) held its first meeting only in February 1989 in Nairobi. The meeting agreed on the designation of 6 regional ETNET Centres, i.e. (a) Institute of Ecology of Obafemi Awolowo University, Ile-Ife Nigeria, (b) Institute of Environmental Studies of University of Khartoum, Sudan, (c) Department of Biological Sciences of University of Zimbabwe, (d) Center for Applied Social Sciences, University of Zimbabwe, (e) Institute of Environmental Sciences, Cheikh Anta Diop University, Dakar, and (f) Faculty of Science, University of Assiut, Aswan Branch, Egypt.

A workplan for 1989-90 was also adopted. The objectives of the network are to:

(1) promote environmental education and specifically environmental training in tertiary institutions,

(2) increase the environmental awareness of the general public and decision maker; and

(3) assist in the environmental training activities of other AMCEN Networks.

The Institute of Ecology of Obafemi Awolowo University, Ile-Ife, Nigeria, has recently been designated the Regional Coordination Unit of the Network. The Association of African Universities (AAU) participated in the first meeting of the Network and is giving every encouragement to AAU member universities to support its activities.

Earlier, under the auspices of UNESCO and UNEP, within the framework of the International Environmental Education Programme (IEEP) a seminar was hosted by the Institute of Environmental Sciences of Cheikh Anta Diop University, Dakar in May 1988 on the integration of the environmental dimension in the curricula of universities in Africa. The seminar provided opportunities for reflection and exchange of experience on how universities in Africa are handling environmental education in their curricula. While there are many programmes in ecology and environmental science located in biology and geography departments for students seeking specialization in those subject areas, environmental issues appear to feature only to a limited extent in other programmes of the universities. The programme structure in many African universities consists of a preliminary, introductory or foundation stage lasting one or two years, during which, besides introductory course in the student's proposed speciality, general courses are offered before the student proceeds to advanced courses in his speciality. It is within the framework of these general and introductory courses that the universities that are doing so, bring in the environmental dimension. The material is generally organized around the traditional disciplines and addresses the environmental dimension of each discipline after a general introduction to basic concepts of environmental science. However, it is only in the biological and social sciences that there are significant offerings of such general courses. Chemistry departments have generally been slow in introducing the environmental dimension in their general courses and many lack the capacity to do so.

An initiative by UNESCO to strengthen capacities in environmental chemistry in African universities led to the formation of an environmental chemistry network in the early 1980's. Although the network implemented a few training activities and published a newsletter, it has since become dormant because of inadequacy of funding. As the need for capability in environmental monitoring becomes more critical especially in view of fears of unfair dumping of toxic wastes from outside the region, the upgrading of facilities for environmental chemistry and strengthening of capabilities in African universities for education, training and research in this field deserves a much higher priority than it at present has in most African countries.

ABSTRACT *Energy and the Environment Activities of the Commission on Geographical Education of the International Geographical Union* **Joseph P. Stoltman Western Michigan University, Kalamazoo, Michigan 49008-5053 USA** •The Commission on Geographical Education of the International Geographical Union has as its principal mission the interpretation of information derived from scientific advances in geography for educational purposes. The mission is pursued through research on the following topics: geographical learning and instruction; teacher preparation; classroom materials design; and perceptual and informational levels of geography as a science within the general population. •The nature of geography as a scientific discipline permits the investigation of a wide range of topics. However, geography is concerned primarily with investigating the spatial attributes of phenomena and applying spatial models of explanation and prediction. •During recent years, the work of the Commission has focused upon two aspects of geographical education that are related to energy and the environment. Projects and materials have been developed which address relationships between environmental change, such as deforestation, and a number of different factors related to energy demand, availability and use. Second, increased attention to the potential for using remote sensing and geographic information systems in classroom teaching provides students the opportunity to address basic spatial problems of pattern, distribution and diffusion relative to environmental issues. While remotely sensed imagery is not widely used in pre-collegiate instruction on an international basis, select images that demonstrate environmental change in relationship to energy are becoming increasingly available. •The Commission on Geographical Education of the IGU is continuing to address energy and the environment as a component of its ongoing activities. The Commission members are anxious to participate in international collaborative activities with colleagues from other scientific fields in furthering the teaching about energy and the environment.

Energy and the Environment: A Geographic Perspective

In this last decade of the 20th century, it seems safe to say that energy and environmental questions and issues are not within the domain of any single scientific discipline. Quite to the contrary, the issues stemming from energy and the environment cross disciplinary lines as easily as polluted air crosses international borders. However, one might, recognizing the many cross-references to other disciplines that are possible, classify disciplines into two large groups: 1) those disciplines that are engaged primarily in the production end of research and development for new sources or improved utilization of existing sources of energy, and 2) those disciplines that are engaged primarily in assessing the effects of energy availability in all forms on the environment. Different disciplines from the sciences are normally engaged close to one end or the other of that continuum describing energy related issues.

International Geographical Union

While the environmental concerns and issues emerge as criteria in the research and development stage, traditionally the most apparent environmental concern of science has been expressed regarding effects in the environment of actual energy usage. With regard to geography as a discipline, considerations of energy begin at the exploration stage with location and site selection for extraction and production, continue with the distribution of energy, and address the environmental effects of energy production and consumption, both at energy resource sites and in the changes made in the general environment. Within that broad theme of energy and the environmental, geography's major contributions are observed primarily at the energy availability and at the environmental effects ends of the energy issues continuum.

To be involved at both ends of the energy issues continuum is not unique to geography. The issues have four essential elements that make them geographic. They are: 1) the spatial perspective; 2) the human - environment relationships; 3) the physical and human characteristics of place; and 4) regional implications. I will elaborate upon each of these in detail.

In discussing the spatial perspective of geography, Macgill stated that the "study of location, spatial distribution, and areal extent of phenomena is widely regarded as being characteristically geographical"(1986). She also urged scientists to recognize that while the narrow interpretation of geographical concerns is often no broader than physical and distance spatial characteristics, the discipline does permit "an accounting for and explaining the spatial characteristics" of environmental phenomena (Macgill, 1986). The spatial perspective enables geography to examine energy and environmental relationships ranging from the distributions of phenomena (location, areal extent, and intensity) to human response from both an ecological issues and as a public policy issue.

One of the oldest traditions in geographical study is analysis of relationships between humans and the environment (Pattison, 1964). Human inhabitants as members of the ecological community form the central theme of this geographical focus, recognizing the balance between humans and the environment from the physical and biosphere as well as from the cultural standpoints. It is within this tradition that geographical science has explored the capacity of humans to exercise control, or serve as change agents, both intentional and unintentional, in environmental systems. The study of the functional elements of the environmental and the effects of energy upon those elements is an area of primary concern for geography (Wilson, 1980).

The geographical analysis of the human and physical characteristics of place is more than the delineation of individual sets of data regarding a place. Instead, it is the synthesis of ways in which geology, vegetation, climate, energy, and human uses and alterations of the environment provide that place with a unique personality. It is at places that the interactions between energy and the environment begin and diffuse to broader regions.

Regional analysis in geography, as defined by Macgill, entails the study of an area for its "composition and complexity" (1986). It is in the context of the region that geography is challenged to demonstrate its holistic underpinnings in serving as an integrating discipline. While many of the energy and environment issues rest within the realm of specific physical interactions and outcomes, it is geography's concern that a holistic concern will be safeguarded, attending to the broadest interpretation of environment.

The Commission on Geographical Education of the International Geographical Union has as its principal mission, the interpretation of information derived from scientific advances in geography for educational purposes. The mission is pursued through research on the following topics: geographical learning and instruction; teacher preparation; classroom materials design; and perceptual and informational levels of geography as a science within the general population.

During recent years, the work of the Commission has focused upon two aspects of geographical education that are related to energy and the environment. First, there has been an ongoing interest in the relationships between people and the environment. Projects and materials have been developed which address relationships between environmental change, such as deforestation, and a number of different factors related to energy demand, availability and use.

Other projects have involved Commission members in the production of classroom materials. In most cases those are national projects, but they provide important models for materials design that have been diffused through the Commission network. One example is the Geography 16 - 19 Project in the United Kingdom that developed an instructional unit entitled Energy and the Environment (Rawling, 1983). The unit engages students in investigations using geographical information about energy and environmental issues in the UK. It entails applying and testing models, analyzing spatial patterns, and decision making. The unit engages students in the application of geographical investigation in developing responsible citizenship as summarized by the following.

> It may seem at first that a new oil terminal in the Shetlands is not of great significance to your own lives if you live elsewhere in the UK. In terms of the implications this holds for the way decisions are made about the environment and the future, it is suddenly very significant. The nest proposal might be for a coal mine in your area, or for a nuclear power policy which will affect everyone's future (Rawling, 1983).

Commission members collaborated in the design and development of Global Geography (Backler, 1988). Global Geography is a series of 10 video programs that examine issues of geographic importance and implement geographical skills in the study of issues (i.e. environmental change through deforestation, international trade, natural hazards, etc.). The video materials are models of educational design, incorporating geography in addressing scientific and societal issues, that are now being adopted in several countries.

Second, increased attention to the potential for using remote sensing and geographic information systems in classroom teaching provides students the opportunity to address basic spatial problems of pattern, distribution, and diffusion relative to environmental issues. While remotely sensed imagery is not widely used in pre-collegiate instruction on an international basis, select images that demonstrate environmental change in relationship to energy are becoming increasingly available in less costly, printed material.

There are examples of successfully using remote sensed images with pre-collegiate students in The Netherlands (Becker, 1989) and the United States (Walsh, 1985). Becker argues that remote sensing not only allows student;s "to see the Earth as it truly is, but also provides opportunities for detailed study of . . . ecological relationships" (1989). Remote sensing provides an important way to incorporate spatial analysis from geography and date collection using modern technology in studying energy and the environment. It is an essential too for high lighting geography's important role as an integrating discipline.

The Commission on Geographical Education of the IGU is continuing to address energy and the environment as a component of its ongoing activities. The Commission members are anxious to participate in international collaborative activities with colleagues from other scientific fields in furthering the teaching about energy and the environment.

References

Backler, A.L. (1988). *A Teachers Guide to Global Geography.* Bloomington: Agency for Instructional Technology.

Becker, T.W. (1989). "Teaching remote sensing as public classroom instruction". *Photogrammetric Engineering and Remote Sensing*, 55 (10). 14345-1439.

Macgill, S.M. (1986). "Environmental questions and human geography". *International Social Science Journal*, 109, 356-375.

Pattison, W.D. (1964). "The four traditions of geography". *Journal of Geography*, 63, 211-216.

Rawling, E. (1983). *Energy and the Environment.* Burnt Mill, UK: Longman.

Walsch, S.J. (1985). *Remote Sensing for Earth Science Honors Teachers.* Stillwater, OK: Oklahoma State University.

Wilson, A.G. (1980). *Geography and the Environment: Systems Analytical Methods.* New York: Wiley.

Commission for Biological Education

Peter J. Kelly

The Commission for Biological Education of IUBS consists of 25 members drawn from the same number of countries agreed world-wide. Members are appointed for three-year periods by the IUBS Executive.

The major purpose of the Commission is to undertake projects of international relevance to biological education, usually four at any one time. The projects are served by members of the Commission with the help of outside experts and supported by UNESCO and other bodies besides IUBS itself.

Two projects, one just completed, the other aimed to finish in 1991, are of relevance to this conference. In cooperation with UNESCO a teacher training manual has recently been published in the UNESCO Science and Technology Document Series titled "Field Work in Ecology for Secondary Schools in Tropical Countries". It was produced as a contribution to the IUBS "Decade of the Tropics" program and contains many references to environmental matters and is concerned with topics such as energy flow through ecosystems which clearly need to be considered in any treatment of energy in its broader context, It points to the need for an integrated approach across the science when we are dealing with the topic of energy.

International Union of Biological Sciences

The other project is concerned with developing biological education in relation to future human needs. Under the coordination of the Chairman of the Commission, Professor Gerhard Schaefer, teams in countries as widely dispersed as Kenya, West Germany, Egypt, China and Japan have investigated what is perceived by samples of the population to be the social and other issues which will affect their countries in the next decade or so. From the information so obtained, the project team is putting forward proposals for new biology curricula with a core which is applicable internationally. As part of the project's program a seminar with the same title was held at the Lomosonov State University, Moscow in September 1989.

Two projects which are also on the point of completion are concerned with "Bioethics and Education" and "Biotechnology Education". Both projects will be published in book form in 1990.

Bioethics and Education deals with a range of biological topics with profound ethical implications such as human reproductive biology, human heredity, medical research and attitudes to animals. It was developed through a seminar held at Macquarie University, Sydney, in 1988 and, of course, is particularly concerned with the teaching methods required for ethical issues.

"Biotechnology Education" is a project developed with UNESCO. It covers a broad range of the biological technologies - not just genetic engineering - and a book of practical guidance for secondary teachers and teacher educators is being compiled. It includes consideration of biotechnology in terms of ethical and social policy as well as its scientific aspects.

The Commission has three projects lined up for the future. One on "Taxonomy Education" tackles the worrying depletion of taxonomy in biology course. It will investigate the current situation in schools and universities in relation to a range of disciplines and aims to develop methods of teaching the subject which show its scientific importance in a lively and interesting way, and point to the significance of taxonomic knowledge in applied fields such as ecology, agriculture and medicine. A project on "Biolit-eracy" is concerned with developing strategies for the public understanding of significant biological topics. It is emphasizing the environmental disciplines and is particularly related to community education in the Third World. The third project is to do with higher education. It will focus on first year university inter-disciplinary courses which lead to the more specialist studies of the biological disciplines. Case studies of innovations in curriculum, teaching methods including the use of information technology and laboratory work are being established.

Further details of work of IUBS-CBE can be obtained from Professor Dr. Gerhard Schaefer, Faculty of Education, Institut 9, University of Hamburg, Von-Melle-Park 8, 2000 Hamburg 13, West Germany.

The Committee on Teaching Chemistry

The Committee on Teaching Chemistry (CTC) of IUPAC is one of the specialized committees of this Union, meant to deal with all educational aspects of chemistry. This implies a collaboration with other IUPAC Divisions, which was not so close but has been notably increasing during the last years.

CTC has a traditional domain of activities to which activities in teaching chemistry in relation to the environment and energy have been recently added. The most important activities pertain to domains.

Low cost locally produced equipment This project started ten years ago under the combined impulses of K.V. Sané and D. Waddington with considerable help from J. Kingston at UNESCO. The project was primarily directed towards developing countries, as an answer to the lack of teaching materials and maintenance. The fundamental idea was to enable teachers to build their own equipment, using components which are easily available in their country, and to design experiments associated with this equipment.

The project was very successful and spread quickly from India, where it had originated, all over the world. Groups appeared in numerous countries, national and regional workshops (more than 30 of them) were organized and exchanges resulted in the constitution of networks. The original network produced more than 1000 pieces of equipment (pH meters, colorimeters, spectrometers, conductimeters, etc.). More than 600 teachers learned to build, use and maintain them.

The french speaking network based on the Centre International Francophone pour l'Enseignement de la Chimie (CIFEC) started five years ago and produced the same kind of equipment. The latter allows a safe and inexpensive use of an enormous variety of chemicals by pupils in the classroom.

Organization of Symposiums and Conferences International Conferences on Chemical Education (ICCE) are held every two years and attract 500 - 700 participants, including about a third of foreign teachers. The 9th ICCE was held in Sao Paulo, Brazil, in 1987 and the 10th ICCE took place in August 1989 at Waterloo, Canada. The 11th ICCE will be held in York, United Kingdom, in 1991 and the 12th in Bangkok, Thailand in 1993. Several countries have applied to host one of the ICCEs of the end of this century and we even have an application for 2001. These ICCEs play an important role in facilitating the development of Chemical Education in the host countries.

CTC is also organizing International Symposia associated with its annual meetings during even years. The first was held in Rome, 1986, in collaboration with the Italian Chemical Society on the topic "Themes and Problems of Teaching Chemistry" The second was held in Lisbon, 1988, on the topic "Energy and Environment as related to Chemistry Teaching". The third will be organized in Moscow, 1990. These Symposia allow useful exchanges between CTC members and National Representatives and teachers and students in the host country.

Production of Written Materials CTC publishes an International Newsletter in Chemical Education, twice a year. 3500 copies are printed and distributed free all over the world. Some special issues are devoted to topics such as microcomputers in chemical education or Mendeleev's classification. A special issue on Safety in Schools was published in English last year and has already been translated into other languages.

CTC produced some years ago, in collaboration with UNESCO, a book called *Teaching School Chemistry*. CTC members contributed to several other books. An important resource book on Solid State Chemistry, prepared by Professor Y. Tretiakov, will be published in the near future. Several other resource documents, to be produced in collaboration with IUPAC Divisions, are planned or under preparation.

International Union of Pure and Applied Chemistry

IUPAC-CTC activities related to Chemistry Teaching connected with Energy and Environment IUPAC-CTC's involvement into environmental aspects of chemistry teaching coincides with the increasing importance given by IUPAC to environment issues. IUPAC recently decided that there should be in place at any one time at least three "horizontal" interdisciplinary programmes involving several divisions. The first horizontal programme will be "Chemistry and the Environment". Starting from February 1989 preliminary talks were held with the Scientific Committee on Problems of the Environment (SCOPE), the International Council of Scientific Unions (ICSU) and the United Nations Environment Programme (UNEP). As a basis for discussion a booklet was prepared with abstracts of reports issued by IUPAC Commissions during the last five years. The booklet is divided in six chapters. The first chapter relates to the determination of chemical substances in air, water, soil, living organisms and food, with 18 abstracts on general problems, 20, 21 and 11 abstracts respectively for determination of inorganic substances, organic substances and natural toxins. Other chapters are: measurement of physico-chemical parameters related to the environment (11 abstracts), transfer and transformation of chemical substances in the environment (14 abstracts), environmental legislation and standards (5 abstracts), toxicology of synthetic and natural substances (15 abstracts), prevention of environmental pollution using chemical and biochemical methods (3 abstracts). The six conferences, held form 1978 to 1987 have also produced a wealth of data containing a lot of precious information on environmental aspects of chemistry.

IUPAC-CTC started a programme directed towards Environment and Energy as related to Chemistry Teaching in 1988. Representatives from Teaching Commissions and other Scientific Unions (biology and physics) and of Teacher's Associations have been involved in the Lisbon Symposium and to help us to deal with interdisciplinary aspects of the theme. UNESCO was closely associated with the preparation of this successful Symposium, as it is in the present Workshop at Berkeley. Their two meetings and the Symposium to be held in Moscow in 1990 are important steps in our programme. One of the aims is to produce, on a broad international basis, teaching units which will be used and tested in different cultural environments and teaching situations. At the same time, this workshop will experiment in a new type of international cooperation in production of teaching materials. I am sure that, thanks to your work and enthusiasm and to the frame provided by the Lawrence Hall of Science and its staff, this workshop will provide worthwhile benefits.

ABSTRACT *The International Union of Pure and Applied Physics: Commission C-14 — The International Commission on Physics Education* **E. Leonard Jossem Department of Physics, The Ohio State University, 174 W. 18th Avenue, Columbus, Ohio 43210-1106** •The International Commission on Physics Education (ICPE) was established as Commission C - 14 of the The International Union of Pure and Applied Physics (IUPAP) in 1960. The mandate of the Commission instructs it to "promote the exchange of information and views among the members of the international community of physicists in the general field of Physics Education including: a) the collection, evaluation, coordination and distribution of information concerning Physics education at all levels; b) information relating to the assessment of standards of performance of students of physics and to the evaluation of the qualifications and effectiveness of teachers of physics; c) suggesting ways in which the facilities for the study of physics at all levels might be improved, stimulating experiments at all levels, and giving help to physics teachers in all countries in incorporating current knowledge of physics, physics pedagogy and the results of research in physics education into their courses and curricula". The Commission also recommends for IUPAP sponsorship international conferences in its field which qualify for support under IUPAP regulations. Where appropriate, it may initiate or assist in the organization of such conferences.

THE International Commission On Physics Education

This paper is intended to provide a brief introduction to the nature and work of the International Commission on Physics Education (ICPE), which is Commission C-14 of the International Union of Pure and Applied Physics (IUPAP).

Origin, Membership and Mandate:

The Commission was established by IUPAP in 1960, and currently has thirteen members: a Chair, a Vice-Chair, a Secretary and ten other members who represent physics teaching communities in IUPAP member countries throughout the world. All members of the Commission are elected for three year terms at the triennial meetings of the General Assembly of IUPAP.

In common with the other Commissions of IUPAP, the Commission on Physics Education is charged with making recommendations to the IUPAP Executive Council concerning applications for IUPAP sponsorship for international conferences in its field. The specific mandate of the Commission also charges it to promote the exchange of information and views among the members of the international community of physicists in the general field of Physics Education including:

a) the collection, evaluation, co-ordination and distribution of information concerning Physics Education at all levels;

b) information relating to the assessment of standards of performance of students of physics and to the evaluation of the qualifications and effectiveness of teachers of physics;

c) suggesting ways in which the facilities for the study of physics at all levels might be improved, stimulating experiments at all levels, and giving help to physics teachers in all countries in incorporating current knowledge of physics, physics pedagogy, and the results of research in physics education into their courses and curricula.

International Union of Pure and Applied Physics

In addition, the mandate of the ICPE instructs it to initiate international conferences in its field as the need arises, to assist in the organization of such conferences where practical, to promote the free circulation of scientists, to award medals, to publish newsletters, circulars, occasional books, journals, or handbooks in its area, and to maintain liaison with the other commissions of IUPAP and with other commissions or committees of other Unions or of the International Council of Scientific Unions (ICSU) or other scientific organizations with a view to collaborating and cooperating in sponsoring joint conferences and to participating in joint projects when need arises.

ICPE Activities:

A history of the first twenty years of the ICPE was written by a former chairman of the Commission, A.P. French, and appears in *Contemporary Physics* Vol. 21, No.4, pp. 331-344 (1980). Additional detailed information about the membership and activities of the ICPE appear in the Reports of the IUPAP Commissions to the IUPAP General Assembly in 1981, 1984, and 1987.

Since the ICPE has no permanent staff or budget of its own, its primary role as a Commission is that of a catalyst in encouraging international conferences and projects in physics education. In this process it has cooperated with other international organizations where appropriate. In particular, it has had a long working relationship with UNESCO and with the International Council of Scientific Unions and its Committee on the Teaching of Science (ICSU-CTS). The ICPE invites cooperation with other appropriate international organizations in areas of mutual interest.

During the last decade, the ICPE has inaugurated and/or co-sponsored international conferences on the following topics:

The Postgraduate Education of Physicists
Charles University, Prague, Czechoslovakia, August 1980

Education for Physics Teaching
I.C.T.P. Trieste, Italy, September 1980

First Summer Workshop "Research in Physics Education"
La Londe les Maures, France, 1983

Using History of Physics in Innovatory Physics Education
University of Pavia, Italy, September 1983

Teaching Modern Physics:Elementary Particles, Relativity,Cosmology
CERN, Geneva, Switzerland, September 1984

Communicating Physics
University of Duisburg, Duisburg, FRG, August 1985

Trends in Physics Education
Sophia University, Tokyo, Japan, August 1986

Conference on Physics Education
Nanjing Institute of Technology, Nanjing, P.R.C. September 1986

Low-Cost Experiments and Demonstrations in Physics Education
Cairo University, Giza, Egypt, April 1987

Chaos in Education: Teaching Non-Linear Phenomena
Lake Balaton, Hungary, April 1987

InterAmerican Conference on Physics Education
Oaxtepec, Mexico, July 1987

Teaching Modern Physics: Condensed Matter
University of Munich, Munich, FRG, September 1988

Energy Alternatives and Risk Education
Lake Balaton, Hungary, September 1989

A conference on "Physics Education through Experiments" is scheduled for April 1990 at Nankai University, Tianjin, PRC

While many of the conferences listed above have some degree of relevance to the work of the current conference, the conference on Energy Alternatives and Risk Education held at Lake Balaton in September 1989 is the most immediately relevant. A separate report on the Balaton conference is being presented here by the conference organizer, Professor George Marx.

ICPE Publications:
Books: Two books have been published under the auspices of the ICPE:

Einstein: A Centenary Volume
A.P. French (Editor)
London, Heinemann / Cambridge, Harvard U. Press, 1979.
Translations have been published in French and Japanese.

Niels Bohr: A Centenary Volume
A.P. French and P.J. Kennedy (Editors)
Cambridge, Harvard University Press 1985

The ICPE Newsletter:
Beginning in 1977, the ICPE has published a *Newsletter* at more or less regular intervals, the latest issue being Number 19, published in September 1989. The *Newsletter* is distributed gratis to about a thousand physics educators throughout the world.

The ICPE Medal:
Several of the IUPAP Commissions award medals in their respective fields to persons who have achieved international recognition for their work, e.g. the Boltzmann Medal for work in Thermodynamics and Statistical Mechanics and the London Award for work in Low Temperature Physics. In 1980 the Commission established a medal which is awarded from time to time for distinguished contributions to international physics education which have been "major in scope and impact and which have extended over a considerable period". The ICPE Medal was awarded to E. Rogers in 1980, P. Kapitza in 1981, J.R. Zacharias in 1983, V.F. Weisskopf in 1985, and to J.L. Lewis in 1987.

ABSTRACT *The World Bank and the Environment* Erik Thulstrup, World Bank, Washington, DC •The primary mission of the World Bank is to support developing countries in their struggle against poverty. This does not mean that only short term economic gains are sought. In particular, the Bank has increased its awareness of ecological realities during the last couple of years. It has realized that long-term economical interests usually coincide with good environmental management, and for this reason, environmental issues are today given high priority in the Bank. •Economic development in the Third World should not be considered an isolated issue. It must be closely connected with developments in education, health and cultural, social and environmental policies. A proper balance is not always easy to find. However, it is much easier to achieve in a country where the population is well-informed. Thus education may hold the key to the solution of many problems. This seems to be particularly true in the environmental area.

The World Bank and the Environment

Environmental Concern In 1969 the World Bank hired its first environmental advisor, and a few years later the Office of Environmental Affairs was established in the Bank[1]. This had some impact on Bank projects, but the importance and complexity of environmental issues were not fully realized until much later. After a heated public debate in the 1980s about the environmental impact of several Bank loans to large projects in *e.g.* Indonesia, Brazil, and Botswana, the Bank responded by dramatically increasing its emphasis on environmental management.

This adjustment was not only a result of public criticism, it was also based on the realization that economic development and environmental conservation are often closely connected. The concept "depreciation of natural capital" was introduced. It puts a price on environmental degradation which makes it simpler to include in evaluations of proposed projects. The effect is often considerable; it is estimated that the impressive increase on the gross national product of Indonesia (7% a year from 1970 to 1984) would fall dramatically if the environmental depreciation was included in the calculation. The true number might be only around 4% a year.

World Bank

Environmental Knowledge Even with the knowledge of and concerns for environmental issues, it is often difficult to design projects which satisfy all requirements, including those related to the environment. The environmental effects of simple burning of fossil fuels are still debated in some of the world's most technologically advanced countries. Thus it is not surprising that the effects on the environment of more complicated projects in developing countries may often be unclear. But "doing nothing" is also a decision with environmental impact, and limiting projects to those for which the environmental effects are completely predictable would be a dangerous strategy.

The obvious solution is to perform studies of high quality of all issues relevant to a given project in a country and to help increase the environmental knowledge in the country, both among specialists and in the general population. The Bank has reacted very decisively in the first of these areas. In addition to the general awareness of and concern for environmental issues among the Bank staff, several studies have been carried out. These range from simple environmental issue papers and internal discussions documents to comprehensive environmental action plans for whole countries. Such country plans have been worked out for Madagascar, Lesotho, and Mauritius and are underway for several other countries. Major studies of tropical deforestation in Brazil, Indonesia and the Philippines have been carried out and the Bank is involved in the preparation of an environmental plan for the Mediterranean.

Environmental Education and Research The efforts of the Bank may be less visible within environmental education and research. The Bank supports a large number of education projects in developing countries, including some major university projects, and it is likely that this area may be able to provide significant long-term support to environmental protection. If engineers as an integral part of their education are informed about modern environmental science and technology, they will not only be able to help protect the environment, they will also be able to help industry deal with environmental issues in a more efficient and economical way. Similarly, graduates in both science and agriculture (and even law) can not be considered properly trained today without a solid knowledge of relevant environmental issues. In the table below are listed the World Bank loans for selected sectors given in the fiscal year 1989 and together with a list of those loans which have important environmental objectives, covering 5% or more of the total project cost:

World Bank Loans 1989[1]

Sector	No. of loans	No. of loans with env. elements	% with env. elements
Agriculture	51	39	76
Water and Sewage	10	7	70
Energy	23	12	52
Industry	14	5	36
Transportation	22	7	32
Education	19	2	11

The environmental efforts in education projects seem low. Part of the reason may be the accounting method - often environmental education is closely integrated with science education and cannot be listed separately. In fact, integrating environmental studies with education in the science subjects has many advantages.

It is likely that the Bank will increase its emphasis on environmental science in education projects considerably in the coming years. This education will not be restricted to higher education or education related to specific trades. On the contrary, knowledge of the most important environmental issues should be part also of basic education. We will all be better consumers and voters if we know the facts about our environment and the threats to it. And good consumers or voters provide the best guarantee for a development which will place environmental concerns high on the list of priorities.

1. J. Warford and Z. Partow: "Evolution of the World Bank's Environmental Policy" and references therein. *Finance and Development*, December, 1989.

DRAFT

Burning Fuels: How Can Chemistry Help Us Minimize Waste in Materials and Energy?

A Teaching Guide

Prepared by Workshop Participants
to Support Development
of Instructional Materials
Related to Energy and the Environment
for International Implementation
in Chemistry Teaching

UNESCO Workshop/Seminar
in Cooperation with IUPAC/CTC and DOE
on Energy and the Environment as Related to Chemistry Teaching

Lawrence Hall of Science
University of California at Berkeley
December 3-9, 1989

Contents

Introduction

This draft material is the result of a cooperative, four-day "experiment" in international instructional material development. Participants from 37 nations (see list at end of this document) attending the December, 1989, *UNESCO Workshop/Seminar on Energy and the Environment as Related to Chemistry Teaching* at Lawrence Hall of Science, University of California at Berkeley, created these working materials in large-group discussion sessions and small working groups.

The goal was to create draft materials of a teaching unit on energy and environment which could be used in upper secondary schools in all parts of the world. In light of workshop time constraints (approximately 11 hours were devoted to this task), participants first selected a specific, focused topic for the proposed teaching unit. Selection of the topic was based on these criteria:

- Focused on energy and environment as related to chemistry teaching.
- International in scope with local/regional consequences.
- Reasonable and appropriate for upper secondary level students.
- Leads to a variety of teaching strategies; especially student activities.
- Contemporary in nature.
- Can be extended and treated at various levels.
- Materials and equipment are safe, inexpensive, and readily available.
- Leads students to sense of optimism, hope, and control.
- Can be developed meaningfully within 10 to 12 hours of class time.

Participants divided into four working groups to select a topic theme. A theme incorporating the preferences of all groups was identified: ***Burning Fuels: How Can Chemistry Help Us Minimize Waste in Materials and Energy?***

New working groups drafted detailed ideas to support major teaching components of the unit. Finally, participants considered alternative ways in which these materials could be organized to produce an effective teaching unit.

These working materials are intended to be further revised and refined during the coming months through pilot testing within a variety of secondary school chemistry classrooms internationally. It is intended that feedback from these classroom trials will lead to a more completely-developed and workable teaching unit on this vital topic.

As noted above, this intensive international effort represents a unique "experiment". It is an experiment in international cooperation, as well as an experiment in creating a new curriculum framework for secondary school science. Finally, it is an experiment in implementing relevant, contemporary themes and topics in secondary school chemistry. These materials represent a collaborative effort among chemists and chemical educators worldwide. These individuals share joint ownership of the process and the products.

Henry Heikkinen (University of Northern Colorado, USA) and Lee Summerlin (University of Alabama at Birmingham, USA) coordinated this component of the UNESCO Workshop/Seminar.

Berkeley, California
December 9, 1989

Content In a Nutshell

The Issue

About 500,000 years ago humans began to use fire for producing energy. Burning wood, our ancestors obtained heat for cooking to meet their nutritional needs. Two hundred years ago, mechanical energy became available through the invention of the steam engine. Again, fire was used to make the machine go. And the engines in our gasoline and diesel powered automobiles are also operated by the process of combustion. The development of electrical energy led to the construction of great power plants. Once again, the burning of fuels provided the needed energy. The list of fuels has widened; coal has played an important role since 1800 and in this century petroleum is used in great quantities.

However, the process of burning materials to obtain heat and energy has created a difficult situation for our world. All the fuels mentioned above contain a large amount of carbon. The resulting carbon dioxide may alter the world's climate. Furthermore, the fuels contain significant amounts of other elements, especially sulfur. Sulfur dioxide, created by combustion, produces an acid environment. In addition, burning fuels at high temperatures leads to nitrogen oxides, major contributors to atmospheric pollution.

In an attempt to solve these problems, great research efforts must be made by scientists and engineers, and societal decisions must be made. These decisions must be supported (or, in some cases, even initiated) by citizens. Here is where social and science education prove their relevance. Since these problems have a chemical component, education in chemistry can lead to a well-informed public, able to understand the problems and to judge the possible solutions relative to public welfare.

The Relevant Chemistry Concepts

- Burning involves the oxidation of a fuel to produce energy and products, some of which may be viewed as wastes.
- Burning causes both energy and mass to become more diffuse (spread out).
- The quantities of energy and matter released in burning depend on the chemical reactions involved.
- The advantages and disadvantages of various fuels (biomass, fossil fuels, etc.) can be weighed in terms of cost, energy content, convenience, waste, environmental impact, alternate uses for the fuel material, etc.
- The impact of specific fuel use by society may include local, regional, and global effects such as health problems, acid rain, global warming, etc.
- Effective policy decisions about the use of energy and materials requires scientifically literate decision-makers.

Some Chemical Solutions

- Eliminate nitrogen oxides and sulfur oxides from exhaust gases (smoke).
- Reduce the amount of carbon dioxide and carbon monoxide released.
- Use alternative fuels (*e.g.* H_2) - only a partial solution.
- Seek more efficient methods of fossil fuel combustion.
- Reduce society's per capita consumption of energy.
- Realize that energy saving is equivalent to a new energy source.
- Chemical solutions can, alone, produce substantial savings in material and energy consumption, but the role of other scientific disciplines is essential.
- "People power" is an effective method of producing policy change in a democratic society.

The Societal Decisions

- Can the design and operation of combustion engines be modified so as to reduce the consumption of fuels and the generation of products.
- Can the lifestyle of the general population be modified to minimize the need for energy sources?
- Can the recycling of 'waste' products reduce the demand on primary energy sources?
- Should alternative sources of energy (*e.g.* nuclear) be considered as primary energy sources?
- What changes in governmental energy policy will be necessary to accomodate desirable new initiatives?
- How can the average citizen be responsible for bringing about the desired changes?

Prerequsite Concepts

- **Matter:** Substances, Compounds, Elements, Mixtures, Chemical Symbolism
- **Changes:** Physical Changes, States of Matter, Chemical Changes, Chemical Reactions, Chemical Equations, Stoichiometry
- **Energy:** Heat, Work, Electricity, Light, Temperature
- **Energy in Chemical Changes:** Exothermic and Endothermic Reactions; Oxidation and Reduction
- **SI Units** for Temperature, Amount of Substance, Mass, Volume, Concentration
- **Material Processes:** Balance of Materials, Cycles (Carbon and Oxygen), Concentration, Pollutants

Co-Requisite Concepts

- Photosynthesis

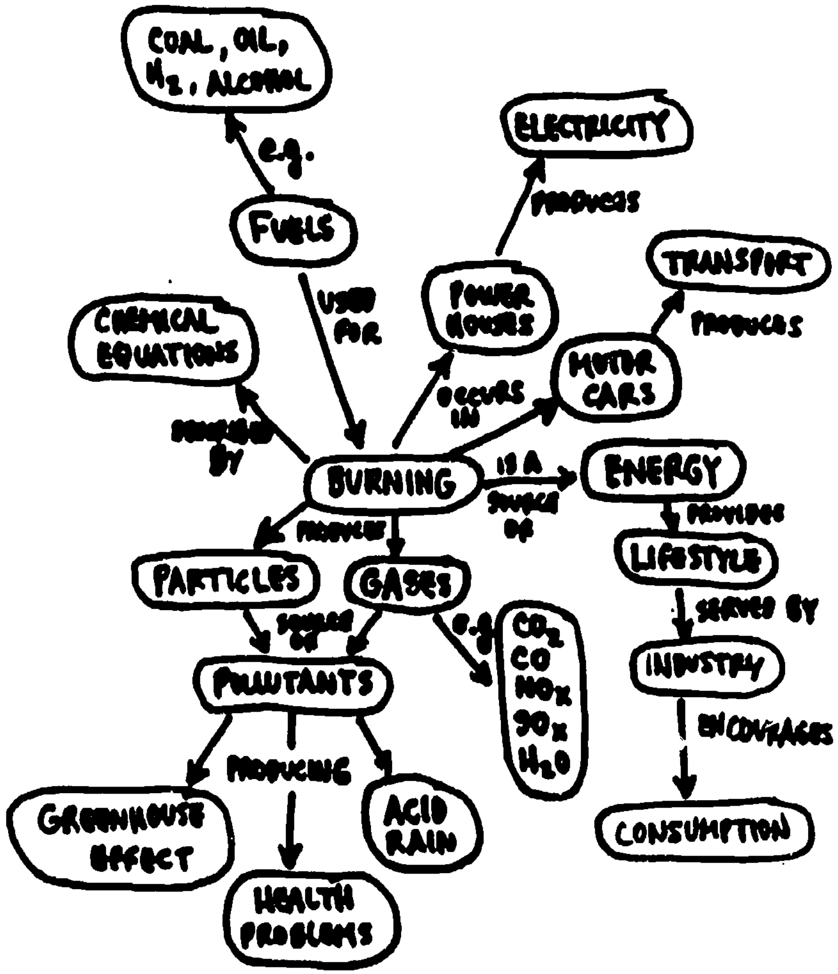
- Respiration
- Alternative energy sources
- Social implications
- Economic and legal issues

Co-Requisite Cognitive Skills

- Ability to establish relationships from empirical data.
- Classification
- Cause/effect reasoning
- Control of variables
- Ability to perform library research
- Ability to communicate and support ideas

Co-Requisite Manipulative Skills

- Safe use of common laboratory equipment
- Ability to make precise quantitative measurements



A CONCEPT MAP FOR TOPIC

Pedagogical Concerns

Strategies

The teaching strategies selected in support of this unit should allow and encourage students to become actively engaged in their learning. These strategies should be based on:

- problem solving
- decision making
- library research
- data analyses
- collecting of samples
- individual action
- making choices
- role playing
- values clarification
- attention to student misconceptions

Criteria

These criteria should be considered in planning and implementing classroom strategies:

- experiments should be chosen in accordance with locally-available equipment and materials.
- teaching materials should include international as well as national data.
- teaching should be based on active participation of students.
- planning of studies should include activities both inside and outside the school.

Model Teaching Unit Plans

Here are several ways that a 10-12 hour teaching unit for upper secondary school chemistry classes can be organized for the topic *Burning Fuels: How Can Chemistry Help Us Minimize Waste in Materials and Energy?*
Four model teaching sequences are suggested by Workshop participants (for convenience, desig- nated Models A through D), with two variations offered on one of them (Models C1 and C2).

Model A

- **Select a chemical/fuel related problem that is of local importance.** Why is the problem important for reasons of energy, environment, chemistry? (What do the students know about the problem; *i.e.*, news, local or national policies, etc.)
- **What are the parts of the problem?** (*i.e.*, economic, social, political, etc.) How can chemistry contribute to solving the problem?
- **Laboratory experiment with burning** (*i.e.*, using a local fuel; develop a definition of what a "fuel" is in a chemical sense).
- **Laboratory experiments or demonstrations with different fuels.** (There should be attention to the environmental/social costs of using different fuels based upon the material products. The dimension of time in the formation of a usable fuel source, such as comparisons of gas from biomass and from natural gas, or coal vs trees should be considered.)

  Fossil fuels
  Biomass fuels
  Waste
- **Efficiency of different types of fuels** - including laboratory experiment (quantitative; energy and matter released in burning depend upon the chemical reasons).
- **Material output** - mainly pollutants, from different types of fuels, including laboratory experiment.
- **Alternative energy sources** - other solutions (*i.e.*, hydrogen for burning and comparisons with non-burning fuels).
- **Local, national, global connections** - maps and graphs; data tables.
- **Weigh the pros and cons of various fuels** - feature an activity in which students makereasoned decisions, evaluate public policy and formulate recommendations or take action

Model B

- **Introduction.**
  a. (Pre-assigned) Collection of newspaper articles related to energy.
  b. Demonstration/discussion (possibly focused on the burning candle) to review pre-requisite concepts and to introduce issues/concerns related to energy.
- **Gases produced by burning fuels** (pollutants; laboratory test for SO_2, CO_2)
- **Problems associated with burning fuels**
  a. Acid rain (Expeirments: production of acid rain; effects of acid rain on environment)
  b. Greenhouse effect (Introduce what a "greenhouse" is using simulation. Discussion at molelcular level: How CO_2 causes greenhouse effect. Other gases causing greenhouse effect - O_3 and CH_4.)
- **Sources of CO_2** (Global context)
- **Experiments** (Comparison of energy value of different fuels; Incomplete *vs* Complete Combustion - See *Classroom Activities* E and F.)

- **Field trip to a power plant or factory** (Magnitude of energy use and pollutants emitted; measures taken to reduce pollutant emissions.)
- **Spreading of energy and matter** (Activity: Rubber band stretching; note direction of enthalpy and entropy changes on stretching and "snapping back." Relate discussion on energy and matter "spreading out" to field trip observations.)
- **Chemistry in fueling automobiles**
- **Implications of new research on the chemistry of energy and the environment**
- **Ethical aspects** (Role playing; decisions on actions to be taken)

Model C1

- **Scenario posed by newspaper, TV or film.** (Small/whole group discussion to identify what issues are involved.)
- **Class debate:** What are the important chemical questions that address the issues identified above? (Small group work followed by whole group deciding upon a list of questions to be investigated.)
- **Skills and procedures to investigate** (Decide in small groups what knowledge and experiments might be needed to investigate the questions.)
- **Parallel exploration of key questions.** (Students work in small groups for several days to investigate their questions and prepare resulting reports — one major question pergroup. Research —> Lab Investigating —> Reporting. Some examples of possible questions, assuming that the initial scenario dealt with the environmental effects of a coal-fired power station: What are the chemical effects of CO_2/SO_2 in rain water? Can CO_2/SO_2 be eliminated from the products of coal-fired power stations? What quantities of CO_2 areproduced by different fuels? What are the effects of gaseous pollutants on the growth of plants? What are the heats of combustion from different fuels?)
- **What are our findings regarding each of the questions?** (Small group reports to whole group, resulting in class discussion.)
- **What decisions should we make?** (Students should form their decisions as informed and responsible citizens of the world. Decision-making deliberations procede from personal level to small groups, to whole class group.)
- **Alternative energy sources** - other solutions (*i.e.*, hydrogen for burning and comparisons with non-burning fuels).
- **Evaluation criteria** (One strategy for evaluation is based on actual student performance during completion of this teaching unit. For example, Procedures and knowledge identified by library research to be necessary = 30%; Laboratory exercise results = 25%; The small-group report = 30%; The presentation to the whole group = 15%.)

Model C2

Essentially the same approach as **Model C1**, except with a different start and a different ending:

Different Start:

- Have students offer free verbal associations involved with energy and the environment or with the burning of fuels, based on their prior knowledge and experience.
- Following that, the teacher then presents the possibilities and necessities for study in this unit.

Different Ending:

- Students complete a cumulative role-playing exercise dealing with the issue, where individual students assume roles of Producers, Scientists, Consumers, and Politicians.
- **Evaluation criteria** (In this model, student testing would be completed in a traditional way.)

Model D

- **Need for energy** (Energy transformations into useable form.)
- **Importance of burning** (As an important initial source of energy.)
- **What is burning?** (Identify reactants as a fuel plus oxidizer, and products; exothermic chemical reaction.)
- **Which fuel should we use?** (Some criteria: Availability of energy; Comparison of energy values of fuels; Efficiency of burning; Bond "breaking/making" ultimately is the energy source. Practicality of fuel use for particular purposes. Undesirable consequences of burning — laboratory activity and reference data on quantity of CO_2 produced; demonstration of pollutant effects; use of natural resources.)
- **Minimizing undesirable consequences** (Removal of pollutants — practicality of doing so; Conservation — more efficient burning, less use of fuels, increasing efficiency of energy-using devices such as cars, lamps, houses, etc. Alternative sources.)

Classroom Activities

***Important Note:** Due to time and facility limitations at the UNESCO Workshop, the practical (laboratory) work described in this section represents a group of preliminary ideas that have not been bench-tested or, in most cases, developed in any detail. Before these ideas are implemented in classrooms with students, the procedures most be carefully developed and checked, potential hazards clearly identified, and the actual instructional value determined.*

A. Carbon Dioxide Elimination

1. Develop test for carbon dioxide - bubble unknown gas through limewater.
2. Develop method for absorbing carbon dioxide. Pass CO_2 thru NaOH(aq) or $CaCO_3$ suspension. Prove absorption has taken place by showing no reaction when resulting gas is passed through limewater.
3. Show limited absorbancy of a given amount of absorbant. Determine capacity of absorbant by passing measured volume of SO_2 through unit mass of absorbant.
4. By calculation, show amount of absorbant required for 200 km journey by auto. How much CO_2 produced? How much absorbant required? Mass of residue produced? Is this practical? How should absorbant be disposed?
5. By calculation show amount of absorbant required for use in a power station in one day. How much fuel consumed? How much CO_2 produced? How much absorbant required? Mass (or volume) of residue?
6. Is CO_2 practical in power stations? What would be the consequences in terms of waste absorbant disposal?
7. Discussion of cost *vs* percent removal of CO_2 produced. Is this worth it?

B. Sulfur Dioxide Elimination

1. Develop test for SO_2. Add dilute KCl to sodium metabisulfite. Test by decolorizing acidic $KMnO_4$ paper.
2. a. Develop method for absorbing SO_2 using aqueous $CaO/Ca(OH)_2$ (limewater) to give $CaSO_3/CaSO_4$ (?). Prove absorption using $KMnO_4$ paper. (See Activity B1 above.)
   b. Determine capacity of absorbant. Volume/mass of SO_2 absorbed by unit mass.
   c. Determine volume of SO_2 produced by given fuel(s) - will vary according to nature andsource of fuel.
   d. Determine amount of fuel a given mass of absorbant will "clean up."
   e. By calculation, determine quantity of absorbant required to clean up one day's burning in a power station.
   f. Discuss the practicality/desirability of installing SO_2 scrubbers in power stations.
   g. Obtain data on actual quantity of absorbant used and efficiency of absorbtion in given power station.
   h. Discuss the cost of "clean up"; cost of increasing efficiency of "clean up". Is it worth it?

C. Detection and Semi-Quantitative Determination of Pollutants

1. SO_2 in gases: absorption in alkaline solutions (pH 10); decolorization of I_2-solution; detection of SO_4^{2} with $BaCl_2$.
2. Pb^{2+} in soils (near highways and further away in fields): reaction with HNO_3, $HNO_3 + HClO_4$ (*hazard!*); filtration and then extraction with dithizone (masking of interfering ions).
3. CO in gases: Absorption in solutions of $Cu(NH_3)_4^{2+}$ —> decolorization

D. Removal or Masking of Pollutants

1. SO_2 from gases: Absorption in alkaline solutions (NaOH)
2. CO from gases: Absorption in solutions of $Cu(NH_3)_4^{2+}$
3. Pb^{2+} in aqueous solutions: Masking with EDTA against the reaction with I

E. Burning Causes Energy to Become More Diffuse (and therefore less useful)

1. a. Determine quantity of fuel required to cook an egg (fry on hot plate).
   b. Burn the same quantity of fuel and store the heat energy produced in water.
   c. Use thermal energy in the water to try to cook an egg. *[This proposed procedure assumes egg will be only partially cooked.]*
   d. Discuss energy (as chemical energy in fuel) is "concentrated" and relatively easy to use, compared to "dilute" energy stored thermally in water.
2. Given 100 cm^3 (mL) of water at 90 °C and 1000 cm^3 at room temperature, how warm can you get the 1000 cm^3 of water? Now given 1000 cm^3 of water at the temperature you achieved, try to warm up 100 cm^3 of water to 90 °C. What temperature can you achieve? What does this tell you about "concentrating" and "diluting" energy?
3. A car has a full fuel tank. You drive 200 km. What has happened in terms of energy?
4. Where has the energy gone from the lights that have been burning in your home?

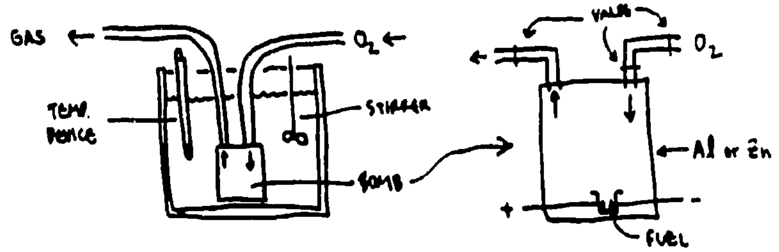
F. Incomplete *vs* Complete Combustion

Compare the quantity of heat using a bunsen burner with and without air entering the burner. To be able to determine the quantity of energy in both cases, heat a given quantity of water for a certain time interval under each condition. Record the temperature increase in both cases.

G. Heat of Combustion Using Different Fuels

1. Quantity of Gas (CO_2) Produced for Different Fuels

a. Design a calorimeter and later construct one using locally-produced low-cost materials. (See preliminary sketch below.) *[Caution: This will need extensive testing to safeguard the teacher and students since the pressure developed is relatively high.]*



b. Perform the experiment, first with gas outlet valve closed. Measure H of fuel combustion. Use about 0.2 g or less of the fuel. Temperature-measuring device could be a thermocouple, thermometer (Hg) or another locally-produced thermometer.

c. Perform the experiment, later, with the same amount of fuel, but this time, open thevalve of gas outlet to measure the amount of gas. (You already know the volume of the bomb for calucation of the total volume.) Here we collect the gas by displacement ofwater. The quantity of fuel used in this case has to be relatively high in order to observe a significant difference in the amount of CO_2 produced. In this part, pressure developed is not a problem because the system is open. CO_2 could be absorbed in a sample of NaOH. The gas should be passed through a Drierite ($CaCl_2$) type material in order to absorb water first.

2. Comparison of Energy Content of Different Fuels

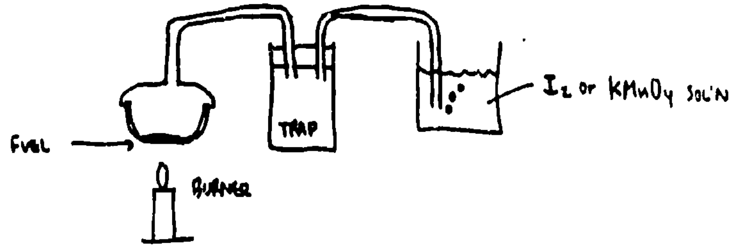
a. In this case heat a known, constant quantity of water by a given quantity of fuel. Observe the temperature rise for different liquid fuels. *[Important: The dish containing the fuel needs careful design to minimize potential hazards.]* This will give a qualitative idea of energy content of different fuels.

H. Effects of Gaseous Pollutants on Plants

1. Put two similar plants in pots inside two separate plastic bags; label them 1 and 2. Inflate Bag 1 with air and close with a pinch clamp. In Bag 2, place 1 mg of $Na_2S_2O_5$ in 10 cm³ of dilute HCl and immediately inflate the bag with air; close it with a pinch clamp. Observe the changes taking place during one day.
2. What changes do you observe in the plants in Bags 1 and 2?
3. What do you think are explanations for your observations?
4. Consider the chemical reaction between the $Na_2S_2O_5$ and HCl in Bag 2. What is theconcentration of the gas (in ppm) produced?
5. [*Note:* In a heavily polluted locality, students should try to do the experiment by putting the control plant in a "clean" environment, and the second in a more polluted area. Observations of the plants should be made over several hours or days.]

I. Determination of SO_2 in the Combustion Products of Fuels

1. a. Place 1 g of solid fuel (carbon) in a ceramic crucible with a lid having a gas outlet. Insert the gas outlet into a beaker containing I_2 solution or $KMnO_4$ solution. Heat the crucible to a high temperature and bubble the gaseous product through through the solution in the beaker. Observe the change in the beaker.

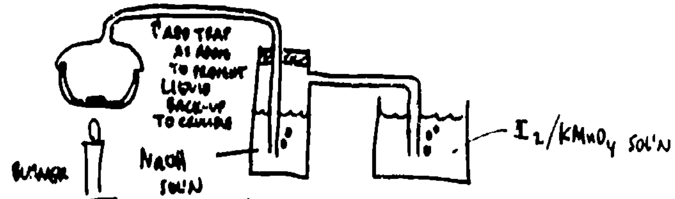


b. What do you observe in the beaker? Note any changes in color, etc.

c. Explain your observations in terms of a chemical reaction.

d. What conclusions can you make about the combustion of coal as a major source of energy?

2. a. Assemble the set up shown below, inserting a trap of NaOH solution between the gas outlet and the beaker:



b. Observe changes in the beaker. Titrate the NaOH solution at the end of the experiment with standardized $KMnO_4$, after acidifying the solution in the "trap."

c. What is the effect of the NaOH trap? What changes have occurred in the beaker containing the $I_2/KMnO_4$ solution, when compared to the original observation in Experiment 1 above?

d. What conclusions can you draw about the use of a NaOH trap?

e. Calculate the concentration of absorbed gas (SO_2) in the "trap".

J. Determination of Lead and Carbon Monoxide in Combustion Products of Fuels

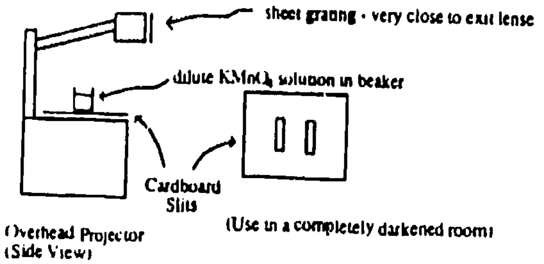
Purpose would be to gather data on lead concentration in soil *vs* distance from a major road(assuming leaded auto fuel is used by vehicles). Also could sample air on side of highway. Air analysis would need collection via pump for extended period. Possible methods: CO by absorption by Cu/NH_3 complex; color change. For lead method, see Part C above.

K. Infrared Detection

1. Objective: To illustrate that the a photocell (Visible/IR) responds to emissions beyond the red end of the visible spectrum and, to a lesser extent, to radiation beyond the violet end of the light spectrum. *[Note: If a glass prism is used, UV radiation will be absorbed by the glass and thus will not be detected by the photocell.]*
2. Equipment: Photocell (IR/visible), prism, light source.
3. Set up equipment as shown in the block diagram below:
   Light source ——> Prism ——> Photocell (connected to Light Meter)
4. In a fully-darkened room, turn on the light source.
5. Adjust the prism so that the photocell receives light (a) above the violet end of the spectrum *[Note: If a glass prism is used, UV radiation will be absorbed by the glass and thus will not be detected by the photocell.]*; (b) in the blue region; (c) in the green region; (d) in the yellow region; (e) in the red region; (f) under the red end of the spectrum. In each case, record the light meter reading.
6. Place a transparent material absorbant to IR in the light path. Show meter response change.

L. Spectral Absorption of Materials (Selective)

1. Prepare a "concentrated" stock solution of $KMnO_4$ in water (12 g $KMnO_4$ per 100 cm³ H_2O).
2. Place 10 cm³ water into a 50-cm³ beaker.



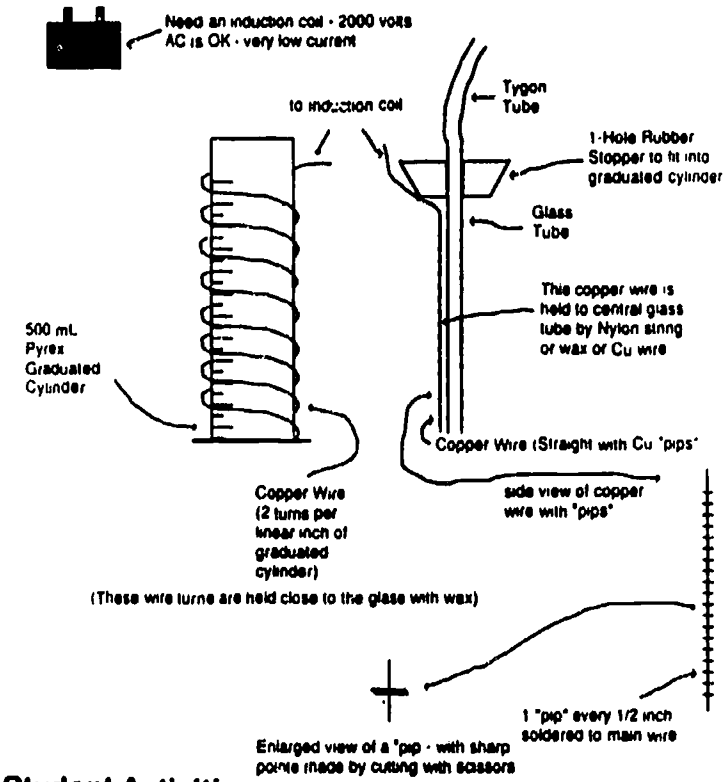
3. Place beaker over one slit in the cardboard (which is on the overhead projector platform as shown in diagram above).
4. Add $KMnO_4$ stock solution (stir it) dropwise until satisfied with the extent of absorption of the blue-gree portion of the spectrum by the solution in the beaker.
5. Possible additional activity: Write a report discussing why some colors of light were absorbed by solution, and some weren't. Where did the energy of the absorbed light go?

M. Demonstrate or Infer (a) Presence of UV, IR; (b) Absorption of UV by transparent material.

N. CO_2-Filled Model House to Demonstrate Greenhouse Effect

O. Cottrell Precipitator

Demonstrate removal of smoke from air sample. *[See equipment sketch below]*



Additional Student Activities

All of the following student activities are aimed at minimizing waste in materials and energy. The activities can be categorized into five main groups, as shown.

1. Local Field Trips (collect information and follow-up discussion)

- Field trip to a recycling plant or a plant using biomass as a fuel to show how energy can be used responsibly. Also power generating station can be visited.

- Have students write reports on field trips.
- Examine ways that power companies and automobile companies attempt to reduce sulfur oxide emissions and nitrogen oxide emissions. What do you do with the sulfur that remains?

2. Analyzing and Interpreting Data (include discussion of accuracy and how data are collected) *[Need sources of data.]*

- Kinds of data that can be used with students: global distribution of fuels; CO_2 production from cars, people, energy generation; human physiological data on energy needs and CO_2 production; energy equivalents (how much oil, coal saved in not using certain quantity of electricity); energy required to raise or lower the temperature of a house 1 °C from outside temperature; what is saved in entire country by adjusting the thermostat by 1 °C.
- Descriptions of how environmental data are collected (e.g. measurement of gas concentrations) so students can appreciate levels of accuracy and certainty of measurement in data.
- Bring in a guest speaker who does research in environmental studies, so students can be informed and involved.
- Use data from actual scientific studies (toxicology, fuel selection) as basis of discussion.
- Use maps showing world energy reserves (types of energy, distribution, demand).
- Use available data to estimate CO_2-removing ability of various plants (trees, grass, grain). How many trees would it take to stop the greenhouse effect?
- Study of energy use (waste) in school and home with the view of reducing waste. How high a flight of stairs could you climb with the energy wasted? Have students change their lifestyles to reduce waste of energy and materials.
- Calculate individual energy consumption. Average person consumes 100 W just staying alive. (*i.e.*, 0.100 kW x 24 h = 2.4 kWh = 2.4 kWh x 3.6 MJ/kWh = 8.6 MJ per day).
- Have students in northern countries estimate the savings of energy when that country goes on daylight saving time. This makes the point that one can make order-of-magnitude calculations on energy consumption. It also makes the point that mandated policy can affect a country's energy consumption.
- Student discussion of risk/benefit analysis based on information in articles.
- Use computer models to simulate the effects of burning fuels and to consider the effect of different variables. Some computer programs may already be available. Student could develop their own programs. Decision-making on energy alternatives. Modeling of many different processes.

3. Monitoring Local Environment (qual/quant) - particulate matter, garbage disposal

- TERC - Technical Education Research Center (Robert Tinker, Director, 1696 Massachusetts Avenue, Cambridge, MA 02138, USA) - pH of rain (KidNet)
- Student monitoring of local meteorological conditions (qualitative and quantitative), *e.g.*, visibility each day, check the filter in a vacuum cleaner that has run for 30 min.

4. Library Research

- How much CO_2 does a person produce compared to a car? Other natural sources of CO_2, NO_x, CH_4.
- Library research to find out for what other uses traditional fuels (*e.g.*, petroleum, coal, wood) can be used.
- Consider conservation of energy issues *vs* esthetics.
- Case histories that show the positive effects of human action (e.g. improvement of air quality in London).
- Library research on comparison of leaded vs unleaded fuels.
- Library research comparing environmental regulations in other countries - how political action is taken.

5. Taking Action - personal life style at home and at school, research on environmental legislation, produce recommendations for government, establish recycling to increase awareness of environmental problems.

- Have students investigate local legislation relating to fuel use (combustion) in their community and what to do about changing the legislation. Students should also investigate legislation regarding conservation of energy (insulation, architecture, etc.).
- Have students take some action in their community regarding waste of energy/materials.
- Make posters, displays, films to dramatize energy and environmental problems.

Societal/Technological Issues

A. Some general observations apply to an analysis of the impact of burning fuels.

1. All people (and other living things) are users of energy to varying extents.
2. Burning is a chemical process causing chemical, biological, and geographical effects.
3. Burning has social costs and benefits.
4. Burning fuels produces two common effects:
   a. Reduction of available fuels and oxygen gas.
   b. Production of carbon dioxide to varying extents.
5. *[See Summary Table below]*

Summary Table - Relevant Fuel Characteristics

Fuel	Availability	Distribution/ Refining	Burning	Other Uses	Material Output
1. Fossil Fuels					
Natural Gas	localized, limited	clean but risky can be liquified	convenient	some	(NO_x), CO_2
Oil	localized, limited	environ. risks removal of S	extremely convenient	many	(SO_2, NO_x) CO_2
Coal	localized, plentiful mining risky	less convenient costly less risky	less convenien	few	SO_2, (NO_x), solids, CO_2
2. Waste					
Municipal Agricultural Industrial	locally available, limited	collection, sorting	less convenient	none	many, some unknown
3. Biomass					
Wood	locally available, renewable	collection	less convenient	some	solids, CO_2
Sugar	less available renewable	fermentation	(alcohol) convenient	some	soot, CO_2

B. The extent and implications of burning fuels are so great that attention to ethics and social responsibility is essential. Social responsibility and ethical considerations regarding the burning of fuels are based on answers to questions such as those below. Such questions must be examined on local, national, and global levels.

1. How much non-renewable fuel can the earth provide?
2. What is the rate of consumption of non-renewable fuels?
3. What are the predictions for future non-renewable fuel consumption?

C. Social responsibility and ethics require that citizens return chemical systems to an environmental balance.

1. Technologies for the reduction of carbon dioxide associated with energy production must be evaluated.
2. Reliance upon improved natural systems, such as biomass, for carbon dioxide reduction.

D. Social responsibility and ethics are essential in resolving future issues related to the burning of fuels.

1. The clearing of forests for crop land and food production.
2. The use of crop land to grow crops that can be converted to fuel (*i.e.* alcohol).

E. Citizens' effective participation in public policy issues is directly related to their level of education.

General Applications and Illustrations

A. Productive Energy from Fuels

1. Generation of Electrical Energy (Power Stations)
   We note that this is also a primary source for use in other areas listed below. We alsonote that in some nations such "power" generation is by hydro or nuclear means.
2. Generation of Heat Energy for
   a. Domestic heating
   - Cooking (municipal gas, bottled gas, coal, charcoal, wood, animal dung)
   - Heating of homes
   - Heating of water

   b. Industrial
   - Generate heating for melting, drying, distilling (some industrial byproducts, e.g. production of pig iron, could also be burnt to produce energy, e.g. CO from pig iron production and bagasse from sugar cane after juice-removal)
3. Generation of Mechanical Energy
   a. Transportation
   - Air (e.g. planes, rockets)
   - Sea (ships)
   - Land (commercial vehicles, buses, cars, motorbikes)

   b. Industrial Processes

4. Generation of Light Energy
   a. Illunination of home (candles, oil lamps, calcium carbide lamps)
   b. General (flares, flash bulbs, etc.)
5. Generation of Energy from Foods
   a. Oxidation of carbohydrates, fats, proteins to produce biochemical energy.
   b. Fermentation and distillation to produce alcohol
6. Miscellaneous
   a. Explosives
   b. Natural processes (earthquakes, etc.)

B. Unproductive Energy from Fuels

Burning of fuels may be seen as unproductive in the case of (a) accidental fire, (b) burning of forests, rubber tires, etc., (c) smoking of cigarettes/tobacco, (d) bonfires.

Connections

A. To Other Areas of Chemistry
- Oxidation-Reduction
- Analytical Chemistry
- Thermochemistry
- Organic Chemistry
- Environmental Chemistry (C, N, water cycles)

B. To Technology
- Design of incinerators, stoves, cars, power plants, etc.
- Designs to reduce pollution (scrubbers, precipitators, etc.)

C. To Physics
- Energy Interconversions
- Mechanics

D. To Biology
- Respiration
- Ecology

E. To Agriculture
- Reforestation
- Energy and the Green Revolution

F. To Social Sciences
- Distribution of fuels nationally and globally
- Historical development of energy sources
- Use of energy in developed and developing world
- Political implications of fuel availability

G. Ethics/Religion
- "Thou shalt not pollute thy neighbor."
- Concern for future generations
- Developing a "global ethic"

H. Health and Medicine
- Respiratory distress
- Chronic illnesses
- Energy value of foods

Program

Sunday, December 3rd

	Arrival	Shattuck Hotel
18:00	*Reception*	Berkeley Conference Center
19:00	*Opening Dinner and Welcoming Remarks* Judson King, Provost, University of California at Berkeley Alexander Pokrovsky, UNESCO Maurice Chastrette, Chairman, IUPAC/CTC Pier Oddone, Deputy Director, Lawrence Berkeley Laboratory, DOE Marjorie Gardner, presiding	Berkeley Conference Center

Monday, December 4th

8:15	Buses depart from Shattuck Hotel for Lawrence Hall of Science	
9:00	*Welcome to Lawrence Hall of Science;* *Conference Goals and Logistics;* Marjorie Gardner Alexander Pokrovsky	Amphitheatre
9:30	*Plenary Lecture*: "Energy Sources for the Future" Dr. Glenn T. Seaborg, Chairman, Lawrence Hall of Science andDirector at Large, Lawrence Berkeley Laboratories	Amphitheatre
	Coffee	
11:00	*Teaching Commission Reports* IUPAC - Maurice Chastrette IUPAP - Leonard Jossem IUBS - Peter Kelly IGU - Joseph Stoltman Reg Friesen, presiding	Amphitheatre
12:00	*Lunch*	Room 150
13:00	*Tour of Lawrence Hall of Science*	
14:00	*Group Work with Lawrence Hall of Science Modules*	
	Jacquey Barber, Director of Chemistry	Room 119
	Cary Sneider, Director of Physics	Room 150
	Herbert Thier and Ron Laugen, Chemical Education for Public Understanding Project	Conference Room B
17:00	*Special Reports* Leonard Jossem for George Marx - Energy Conference in Hungary Sylvia Ware - ACS Education Erik Thulstrup - World Bank Aleksandra Kornhauser - International Center for Chemical Studies Yuri Tretiakov, presiding	
18:00	*Dinner*	Galaxy
19:00	Films, Audio/Visuals, Computer program	Rooms 119, 120 and Library

Tuesday, December 5th

8:30	Buses depart from the Shattuck Hotel	
9:00	*Plenary Lecture*: "Energy and Global Warming" Mark Levine, Program Leader, LBL Energy Analysis Program Robert Bucat, presiding	Amphitheatre
10:00	*Country Reports* T. Nevaneeth Rao, presiding	Amphitheatre
12:00	*Lunch*	Room 150
13:00	*Curriculum Development Working Groups* Henry Heikkinen, Lee SummerlinCo-Chairs	Room 150 Room 119
15:00	Country Reports Musa Nazer, presiding	Amphitheatre

16:00 *Low Cost Equipment and Computers* — Amphitheatre
Ram Lamba

17:30 *Global Climate Change Development Project*
Rollie Otto
Theodros Solomon, presiding

18:00 *Dinner* — Galaxy

20:00 *Special Interest Groups* — Rooms 119, 120 and Library
Computer programs, films, etc.

Wednesday, December 6th

8:30 Buses depart from the Shattuck Hotel

9:00 *Country Reports* — Amphitheatre
Reiko Isuyama, presiding

11:00 *Curriculum Development Working Groups* — Room 150, Room 119, B-Level Conference Room

13:00 Afternoon free for sightseeing in San Francisco

18:00 Dinner and Exploratorium Visit with Penny Moore

Thursday, December 7th

8:30 Buses depart from the Shattuck Hotel

9:00 Amphitheatre
Plenary Lecture: "Combustion of Fossil Fuels and the Human Society"
Professor Y.T. Lee
J. Bradley Moore, presiding

10:00 *Curriculum Development Working Groups* — Room 150, Room 119, B-Level Conference Room

12:00 *Lunch* — Room 150

13:00 *Country Reports* — Amphitheatre
Hans Hoekman, presiding

15:00 *Curriculum Development Plenary Session*

18:00 *Dinner* — Galaxy

19:00 *Special Interest Groups* and Audio/Visuals — Rooms 119, 120 and Library

Friday, December 8th

8:30 Buses depart from Shattuck Hotel

9:00 Lawrence Berkeley Laboratory
Plenary Lecture: "Global Warming: The Bad News, the Good News"
Arthur Rosenfeld
Rollie Otto, presiding

Tour of Lawrence Berkeley Laboratory

12:00 *Lunch* at Lawrence Berkeley Laboratory

13:00 *Country Reports*
Pirawan Bhunthumnavin, presiding

13:30 *Curriculum Unit Completion* — Amphitheatre and small groups

15:30 *Action Plans for Pilot Testing* — Amphitheatre

16:00 *Review of Development Process* — Amphitheatre

16:30 Special Reports — Amphitheatre
ICSU - Joseph Stoltman
IUPAC/CTC - Maurice Chastrette
UNESCO - Alexander Pokrovsky
Moscow Meeting - Yuri Tretiakov
Heinrich Stork, presiding

18:00 *Closing Dinner* — Galaxy
Entertainment by LHS Staff: Susan Aberg
Kerith Ennis, Precious Perry

Saturday, December 9th

Departures

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