INTERNATIONAL ATOMIC ENERGY AGENCY, VIENNA

AND

ATOMIC ENERGY AUTHORITY EGYPT

NATIONAL SEMINAR ON

NUCLEAR ENERGY IN EVERYDAY LIFE

LECTURES

28-29 JUNE 1994

LE MERIDIEN HELIOPOLIS

CAIRO, EGYPT

National Seminar on " Nuclear Energy in Everyday Life"

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LECTURE 1

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NATIONAL SEMINAR
"NUCLEAR ENERGY IN EVERYDAY LIFE"
Cairo, 28-30 June 1994

NUCLEAR ENERGY AND THE PUBLIC

REMARKS BY DAVID R. KYD, PUBLIC INFORMATION DIRECTOR
OF THE INTERNATIONAL ATOMIC ENERGY AGENCY (VIENNA)

Ladies and gentlemen,

It is a great pleasure and privilege to have been asked to speak at this session.

I know that for many people - including scientists and teachers - the words "atomic" or "nuclear" provoke unease or even fear. They think first and foremost of bombs or of Chernobyl. It is absolutely right to be aware of the risks of some uses of the atom, because they do exist. But equally we should not overlook, for instance, that ionizing radiation is a principal way of combatting cancer. Also, over 16% of the world's electricity supply comes from nuclear power - about the same as what we get from hydro power. Used for peaceful purposes, and prudently, nuclear energy applications have, I submit, tremendous benefits to offer mankind, not only in the industrialized world but also in the developing nations.

Developing countries have many problems in common like rapid population growth, heavy urban pollution, high rate of food losses and food-borne diseases and the need to increase exports of their agricultural products. And the way in which nuclear techniques are applied to help combat some of these problems is part of what we will be discussing over the next two days.

But first just a quick word about the IAEA. It began its work as part of the United Nations family in 1957 with the tasks of both promoting the peaceful uses of nuclear energy and simultaneously verifying that such use was exclusively peaceful. This remains the core of the Agency's work, and I expect you have heard a good deal about our high-profile inspections in countries like Iraq, North Korea and South Africa.

Our total annual budget is approximately $200 million, and some $43 million are available for technical co-operation, technical assistance, technology transfer and training of personnel. Membership today stands at 121 States.

From the outset, the Agency has served as the principal mechanism for nuclear-related services to developing nations, who make up the bulk of its membership. The transfer of technology from the industrialized world to developing countries through technical assistance and co-operation is one such service, tracing its origins to the "Atoms for Peace" bargain defined by President Eisenhower in the early '50s: renounce manufacture or procurement of nuclear weapons and you get access to nuclear know-how and technology, for peaceful purposes.

As of the Chernobyl accident in 1986, and especially since the publicity surrounding our inspection work in Iraq and North Korea, our Agency has been propelled into the public limelight, having previously been perceived as a rather low-key technical and scientific body.

When I started with the Agency in 1989, we embarked on a series of public information seminars like this one around the world on various aspects of nuclear energy in the belief that there was a dearth of sound, basic information available on the facts about nuclear power, which contributes to an inadequate understanding of this subject among members of the general public. Most people, and many journalists, only hear of nuclear when things go wrong, and hearsay can crowd out facts. The best way to reach the public at large, we felt, was through initiating direct dialogue with specialist and non-specialist media. These seminars were one of the methods chosen.

At the very outset, it was determined that these seminars were to be informative and educational, and provide balanced, honest, authoritative background material on the subject of nuclear energy. We hoped that since the Agency's own capability is limited, the seminars would also have a seed effect: we would demonstrate to Member States that this type of seminar could be done; show how it could be done; provide the stimulation and the materials for them to use as templates for their own publications; and help them to expand such a dialogue with their local media.

The key message of the seminars was basic: nuclear power is a complex technology that can be managed safely and economically through high standards of excellence. Such excellence can be achieved worldwide by observing international standards and maximum openness.

Regional media were the primary audience for the seminars. However, local and regional authorities also have attended. The topics discussed included explanations of radiation, nuclear waste, non-proliferation, nuclear applications including power generation, nuclear safety and the environmental impacts of the various energy sources.

The speakers chosen are a mix of IAEA and outside experts from around the world who gave their time and energy to making each seminar a success. Overall, the response was most positive. About 600 participants from 20 countries took part over the initial three years of the programme. Seminar venues included Bombay, Canberra, Budapest, Tokyo, Bangkok, Cairo, Hong Kong, Jakarta, Kuala Lumpur, Santiago, Warsaw, Seoul, Shanghai and Sofia.

In arranging these, we benefitted greatly from extrabudgetary financial support from the Japanese Government.

Towards the end of 1992, upon advice we received not to neglect teachers and, through them, younger people, we decided to reorient the nature of some of these seminars to encompass educators - teachers and officials involved in setting curricula - and to focus more broadly on energy education in which nuclear is of course just one element. We have done this notably in Latin America, although the first symposium of educators was in fact held in Tokyo in December of 1992 and attracted over 200 teachers from Tokyo and the surrounding area. Among the speakers were officials from Canada and France, two school teachers from Sweden who take a special interest in energy education, an educational specialist from the United Kingdom, and of course a number of Japanese educators.

The second day of the seminar was covered by a team from one of the major TV channels, who filmed a panel discussion which resulted in an hour-long documentary shown on prime time on a Saturday evening, interspersing sequences on energy education shot in various European countries with extracts from the panel discussion. The view of the moderator, a TV journalist, was that despite the vital importance of energy for Japan's industrial and economic base, energy education was comparatively neglected in his country compared to others. The reasons given were crowded curricula, the lack of readily available, simple and interesting teaching materials, and teachers' reticence to address nuclear energy, an area seen as both complex and sensitive. He hoped the exercise would stimulate greater efforts in this regard henceforth in Japan. I suspect many of these considerations are also valid in Egypt. Another point made by several Japanese teachers in the discussion, incidentally, was that there is great disinclination on the part of some pupils today to study scientific subjects or set their sights on scientific careers. In this context, aversion to studying nuclear-related techniques was apparent.

I will not attempt to summarize here the presentations made on national energy education policies and experience. Just let me mention that in some of the most "obvious" countries where one might expect energy education to be highly developed - like the United States - this is not always the case. Of course, the United States school system is not centrally directed, and so energy issues may come up in science classes, under physics, in social science, on field trips, even in geography lessons.

As I mentioned, a second symposium of this type was regional in nature and was conducted in Latin America, in Santiago, Chile, in March 1993. It was the first event of its kind ever attempted there. There were 60 participants including 14 invitees from 8 Latin American countries other than Chile, mostly senior officials involved in energy education or public information work. Chile has a very active and effective nuclear education programme indeed, and presented it most vividly to the other Latin American participants. It has as yet no nuclear power stations, but it has extensive research and nuclear technology applications to demonstrate in medicine and industry particularly. Among topics addressed were nuclear education for high school students, media or static exhibits. Other countries which presented their programmes were Argentina, Brazil, and Colombia, and guest speakers also attended from the United States, Canada and the United Kingdom.

Resources permitting, we intend to continue this programme in coming years. Up ahead we have seminars in Morocco, the Philippines, Kenya and South Africa.

An important part of our preparatory work is to put together for participants information packs of the type we distributed here which contain a series of 4-page fact sheets on various aspects of nuclear energy. Typical titles are: Radiation in Everyday Life, Nuclear Techniques in Medicine, Radioactive Waste Disposal and Facts about Energy, Electricity and Nuclear Power. Special emphasis is put on technical co-operation in bodies like AFRA and the transfer of technology and know-how to developing nations.

We also have prepared supporting in-house videos on, for instance, how nuclear reactors work and on nuclear energy and the environment. All in all, we find this an essential part of our public information activity, getting out from our "ivory tower" in Vienna and away from just the typical kind of publications United Nations bodies produce, providing fora for a real dialogue between experts and educators on the one hand, and media on the other.

It goes without saying that we have at our disposal, beyond the seminar programme, the full range of classical public information tools: press releases, press conferences, briefings, speeches, publications, annual reports, visitors' groups, exhibits, responses to media enquiries, written or oral, interviews, etc. Our basic philosophy is to be as accessible as possible and to serve as a central resource and reference point for anyone seeking reliable, authoritative information on any nuclear-related issue, from safety to safeguards, from sterilizing insect pests to protecting skin grafts. You will find mention of these various elements in the material we have brought with us.

As a United Nations organization we of course deal basically with and through the governments of Members States, but we also reach out to wider publics via the media, our publications and films, other specialized organizations with whom we work and through our responses to literally thousands of individual or collective enquiries we handle each year, from politicians to schoolboys, from environmentalists to researchers.

I hope this outline of our own information work has been helpful, and I would be happy to answer any questions.

DAVID R. KYD

David R. Kyd was appointed Public Information Director of the International Atomic Energy Agency (IAEA) in Vienna, effective 3 July 1989.

A native of Aberdeen, Scotland, Mr. Kyd was educated at the universities of Aberdeen, Zürich, Lausanne and Dijon, and holds a Master of Arts degree with First Class Honours in modern languages from Aberdeen.

Following an initial career in journalism, in 1965 he joined the Secretariat of the North Atlantic Treaty Organization (NATO) in Paris, which subsequently moved to Brussels. During his 14 years with NATO, he served as a member of the Political Directorate, specializing in East-West relations and preparations for the Conference on Security and Co-operation in Europe (CSCE). He was Head of the NATO Press Service and Chief Spokesman from 1975 to 1979.

Mr. Kyd became Public Relations Director of the International Air Transport Association (IATA), the world association of scheduled airlines, in Geneva, in March 1979. In that position and with NATO he visited all parts of the world and lectured widely on international affairs, particularly in North America and the developing nations.

He is a member of several professional associations in the fields of public relations and international affairs, including the International Institute for Strategic Studies (London).

Mr. Kyd is married to Anna Elisabeth Kyd (née Schraner) and they have two grown-up children.

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LECTURE 2

Nuclear Energy in Everyday Life

Cairo, Egypt. 28-29 June, 1994

Nuclear Energy and Education in the United Kingdom.

by M.E. Ginniff.

Introduction

The education of the people of any country must take account of the history and the traditions which brought it to it's present standards and to it's status in the world community. In your country education is given a high priority and rightly so. Education must, however, not only take account of what has and is happening in the country and the world but must look to the future so that the people of the country can progress to improved standards of living. An important contributor to the standard of living is the energy available to power industry and to make houses more comfortable so people both adults and children should be given sufficient basic information to make them aware of the sources of energy available to their country and which particular sources are being developed to supply present and future needs.

Energy for lighting, heating and power is a key factor for a given standard of living as it influences home life, transport, industry, in fact the whole spectrum of life in a community.

The source or sources of the energy for a country must be dependable and their use from production of the basic fuel to the disposal of the waste should be to standards which the people are aware of and accept. Therefore the people must be informed about the various options for energy supply and about the effect it will have on their environment.

Energy must therefore be a subject in the schools curriculum and a topic which is discussed and explained in the media. The explanations of the energy position need only be in broad terms because the majority of the population of any country has little interest in delving into the details of fossil fuel, hydro based, renewable or nuclear energy sources. The broad explanation must be factual and presented in a way which is comprehendable to non-technical people as they make up the majority of any general population.

Many sources of energy have been used for thousands of years but the scale of the usage has been small. Modern living standards demand vast quantities of energy. A person can survive on less than a 100 watts of energy for heating in temperate climates but advanced countries now have to provide some 4,000 to 7,000 watts of energy to families for cooking, heating, refrigeration, airconditioning etc.

The sources of such energy are many in general, but particular countries tend to turn first to their indigenous supplies. If these can be developed to supply areas of their country without adverse environmental consequences then it makes good sense to proceed with them. Most countries however, tend to require a diversity of sources so that the future energy supply is more certain.

Sources of Energy.

Historically the most traditional sources of energy were hydro and wind power. Wind power is limited because it requires large areas to collect large quantities and it is not suitable for storage. Hydro power is an extremely valuable source as it is clean, storable and can be available in some areas in a range of quantities from small up to enormous quantities. It's impact on the environment needs careful assessment. Sea wave energy is like that from wind in that it is thinly distributed and not storable.

Fossil fuels play an important role world wide and are very flexible. They are particularly important to transport systems. However, now that they are used in enormous quantities their by-products and wastes produce a very real strain on the environmental conditions not only of their local area but world wide. The cost of the treatment plants needed to deal with their waste products is an important consideration in the economics of their use.

Renewable energy like heat from the sun as well as that from wind, wave and hydro sources, already mentioned, are excellent for isolated and small requirements and are valuable as methods of conserving or reducing demands for energy but they cannot be developed on a sufficient scale to rule out the need for large quantities of energy from other sources.

For some 30 years nuclear power has been used as a major source of energy and the education of people and children should include an explanation of how nuclear power is produced from the mining of the uranium to the final disposal of the waste from the system. This paper attempts to put this source of energy in perspective.

An explanation of nuclear power.

The development of nuclear power has been a remarkable success story from the scientific and technological point of view. Yet after some 30 years of usage for electricity production almost world wide it is still not a favoured source of energy. Factually it is a clean source of energy with little impact on the environment and it's safety record over the 30 years is good. The question to be answered is "Why is it not favoured" and the answer to that is "Lack of education on nuclear power in the schools and homes."

When nuclear power was being developed in the 1950's and '60's the attitude in the world was to glamorise scientific and technological achievement. Supersonic flight, space exploration and nuclear power all were seen to have enormous beneficial potential for the future of mankind. The scientists and technologists enjoyed their work, were excited about it and wanted to expand and develop their technologies. They spoke in glowing terms about the benefits of their discoveries. They did not look at the impact on the layman. They did not consider how the layman was taking on board all these changing ideas and novel concepts. In fact they were indifferent to the thoughts of those very people who would eventually need to make use of the development if the development were to succeed. This was not their fault because they were scientists and technologists and not communicators.

Communication is the oil that keeps modern society running smoothly in all fields of man's interests and education is a major ingredient in communication.

It must be remembered however, that all of the population do not think in the same terms. Scientists know their subject and actually think and speak in their scientific language. Other groups of people like say musicians know their subject and think and speak their language. The scientist and the musician will not understand or even accept each others endeavours unless they are educated to some extent in each others work. To achieve this the scientist must explain his interest to the musician in terms the musician can understand and visa versa. This is the essence of communication.

Nuclear power must therefore be explained to the public in factual but simple language and not made important or exclusive by the use of scientific jargon as most scientists try to do.

Nuclear power is essentially mining uranium, like mining coal, burning it in a reactor, like burning coal in a furnace and using the heat, and lastly disposing of the radioactive waste, like getting rid of the ash from coal.

Each stage of the coal or uranium process has safety hazards to man and environmental considerations which require assessment.

It is good that in the 1990's the safety and environmental considerations are receiving much more emphasis and detailed assessment than they did thirty years ago.

The acceptance of hydro and fossil based energy systems has developed over centuries and higher standards of safety have evolved over that time albeit all too slowly. Nevertheless people are generally familiar with what is involved in the systems but few understand the complexities.

Nuclear power is some 30 years old, a recent development in comparison with the hydro and fossil systems, but 30 years surely is long enough for to-day's generation of people to know something about it. Unfortunately that little that they do know is cloaked in fear due to the fact that 'nuclear' means 'bomb.' Proper education will allow people to reassess the position and make their own judgement.

Nuclear Energy in the United Kingdom.

Nuclear energy in the United Kingdom has supplied commercial electricity for over 30 years. Gas cooled reactors of the uranium magnox type have now an average life of 27 years and continue to operate reliably and well giving a Unit Capability Factor of over 80%. The Advanced Gas Cooled reactors which followed the Magnox type have had some operational problems mainly the on-load refuelling which was the design intention but has not been achieved. They now have improved performance and are supplying 13% of the electricity for England and Wales. The Pressurised Water Reactor design is now adopted in the United Kingdom and the first station is having a rapid construction programme of some 63 months and is expected to enter commercial operation in 1994. Planning consent is now being sought for a twin Pressurised Water Reactor station with a net output of around 2,600 M.W.

Fuel reprocessing is well developed in the United Kingdom and the storage of spent fuel and the radioactive wastes is carefully controlled. The wastes are at three levels, that is, low, intermediate and high. The low level wastes are being stored for 300 years at a fully operational site. The intermediate level wastes are to be encased underground in stable rock strata and a site is presently being explored. The high level wastes - spent fuel, is being encapsulated in glass for 50 years in cooled storage before underground emplacement.

Nuclear power produces over a fifth of the electricity in England and Wales and for the last six months of 1993 the level of production was 25%. With the further increases in output predicted it is expected that nuclear power will become the least cost producer within the next few years.

Radioactivity.

The element of hazard of the nuclear process is 'radioactivity'.

Although the nuclear fuel cycle has been with us for some thirty years radioactivity has been part of the world since the planet was formed. In fact nuclear fusion in the sun is the earth's greatest and most beneficial energy source.

Radioactivity is natural and everywhere.

The hazard from radioactivity comes from man making concentrations of it or converting it to more hazardous forms. Man does this to many of the natural materials, be they fuels, chemicals etc. and then has to control and safeguard the products. For radioactivity the safeguarding methods are understood and applied.

Radioactivity has a useful property - it can easily be detected. A simple geiger counter will detect even the low levels of the natural radioactive background which is present everywhere in the world.

So the first requirement in nuclear power is to develop an appreciation of radioactivity in the world. Scientists do this mathematically but for lay people illustrations and 'hands on experience' are necessary. Children should have it explained to them at an early age as their bodies are subjected to it continuously. It is a natural process. In the United Kingdom a simple geiger counter suitable for use in home and school has been developed and marketed so that children and parents can have 'hands on experience' experimenting with materials found in the countryside which are naturally radioactive, and also with products used in everyday life.

When it is appreciated that radioactivity is natural and everywhere the education system should explain the need to respect and control it. Like many things a little radioactivity like the natural background is part of our normal living conditions but concentrated radioactivity can be harmful unless managed properly.

Concentrated radioactivity must be contained. The containment is necessary to stop inhalation or ingestion of air borne particles or for isotopes that produce harmful radioactive rays. The containment must be a form of shielding which absorbes the rays.

So from the initial mining of the natural uranium to the final disposal of the radioactive waste man must be protected from the radioactivity of the process by containment and shielding. The methods of doing this are well proven and universally applied. Great stress is placed on maintaining high standards even under what is called maximum credible accident situations. That is where an independant group of specialists assess what might be the unlikely yet just possible accidents which might lead to a breach of the containment of any part of the processes in the nuclear plant. There must be a safety device to deal with this likelihood unless the likelihood of the event is almost incredible.

The nuclear process.

It would not be realistic in a single paper discussing nuclear energy and education to attempt to deal in any detail with the technical side of the nuclear cycle. Not that the subject is too complicated for those who are deeply interested. Indeed it's science and technology is probably the most thoroughly explored subject of any modern development and with hundreds of reactors operating around the world it's feasibility and practicability are well demonstrated. Further there are excellent scientific publications on all aspects of the nuclear cycle.

The important task, as emphasised above, is to bring the reality of the nuclear fuel cycle into clear perspective for non-scientists. To do this many countries have available books, pamphlets, slides, videos and exhibitions which present the elements of the nuclear cycle in the language of 'imagery' and relative to other more accepted processes.

The nuclear reactor is a vessel to heat water or gas to provide steam for the normal generation of electricity. The reactor needs very infrequent fuelling, in fact some of the uranium fuel will last for more than five years continuously generating heat. Hence unlike hydro or fossil systems, the volume of the fuel to supply the energy is tiny by comparison. This means that the quantities of waste arisings from the nuclear fuel cycle are in turn very small.

The waste arisings are mainly of low level activity. However a small part of them is highly radioactive and would be very dangerous if not carefully controlled. All operators of nuclear plant are required by international standards to isolate the radioactive waste. The low level waste needs some 300 years isolation and the high level some 1,000's of years isolation. This can be achieved by placing the waste in special cannisters in deep geological caverns isolated from water. Such rock formations exist in many areas where the rocks have been stable for hundreds of millions of years and waste isolated in such a place will safely decrease it's activity.

The education resources.

In the United Kingdom, albeit somewhat belatedly, a useful range of documents and videos has been prepared offering information about nuclear matters. They can also be used to provide a complete educational service. In the Appendix a list is given of items for an information service with some comments about them.

In many other countries some equivalent information is available. International co-operation in maintaining the availability of such material is valuable but the standards of the material must always be on a sound factual base.

Conclusion.

In the united Kingdom nuclear energy has been used for some 30 years and now provides over 20% of the nation's electrical requirements. The nuclear reactors are primarily of the gas cooled type but the Pressurised Water Reactor type is now being adopted. Nuclear power electricity is becoming cost competitive with other fuels.

Education about the basic concepts of new technological developments should be kept abreast of the progress of the technology. The education should not be a simplified version of the scientific or technological material but should be presented in language suitable for people who are non scientific and think more in terms of the Arts where imagery and historical background form a platform for appreciation of new ideas.

The impact on society and the environment should be clearly and factually assessed and presented. It is important nuclear power is included and well presented in the school curriculum.

APPENDIX:- Comments on Educational Material.

1 Nuclear Industry Education Programme

2 Mission

To contribute to public understanding and awareness of nuclear power as part of the energy mix of the UK.
To address issues in a responsible way for education, tailoring the messages to be used in conjunction with the national curricula requirements of the UK.
The education programme has been designed to contribute to public understanding of the energy issues which face the UK and the world now and in the future. The information is presented in a balanced and positive manner and is available to the general public and also to school students. The resources available to the students range widely and expand on topics which are mandatory in the National Curricula of the UK.
The resources available through the programme are designed so that they can be used by the whole of the industry to provide a complete education service.

3 Traditional areas

The programme has opened out the traditional areas covered by nuclear power education to incorporate energy as a whole. This gives a good basis to promote nuclear power as part of the energy mix which is necessary to the way we live today.

4 Curricula of the UK.

There are three sets of studies in the UK: the National Curriculum for England and Wales, the Northern Ireland Curriculum and the 5 - 14 Curriculum, Standard and Higher Levels for Scotland. All of these contain direct reference to the production of electricity through nuclear power and also include other topics on which NIEP produces resources.

5 Magazine for children

The flagship of the education programme is Activate, the energy magazine for students aged 11 to 19. It has a bold design and has been formatted to provide classroom material that can be copied by the teacher and includes an activity for the students to do on their own.

6 Activate - 3rd world

This approach to energy allows us to explore areas such as the developing world and how it's energy needs are being met with solar, wind and water power as well as more conventional methods.

7 Activate - Electricity generation from different sources

We can compare how different sources of energy can all produce electricity in similar ways. This positions nuclear, wind, water as a normal part of the production processes.

8 Activate - Radiation and Medicine

We can also look at the spin offs from nuclear technology into medicine and other applications.

9 Activate - Teachers update section

It also includes details for teachers on new publications and events related to science and technology and has a full assessment of how each feature fits into the curriculum.

10 Comments on Activate from Teachers

Excellent
Informative
Colourful
Lively

The first issue of Activate has produced some very positive comments from teachers. We plan to conduct a survey after the second issue to evaluate the strengths and weaknesses of Activate so we can tailor the approach to meet the needs of teachers even better in the future.

11 No Easy Answers

The programme includes a selection of videos which cover various topics. No Easy Answers discusses the issues behind energy production eg acid rain, CO2 emissions, lead in petrol. It gives reasons and effects and prompts classroom discussion of these difficult areas.

12 Discovery and the Atom

This video looks at the history and the people behind the discoveries.

13 Big Science

Of course various aspects of nuclear power are covered by video, like fusion at the JET project.

14 Radiation Causes and Effects

Explains the differences between ionising radiation and radioactivity and looks at natural background and man-made radiation; the dangers and the benefits.

15 Exploring Light and Electricity

We also address fundamental education at primary level, 5 - 11 years. This video looks at the basic concepts of light, shadows and things powered by electricity and is aimed at 5 - 7 year olds. A video being launched this year takes this a step further and looks at the history and more applications of electricity; logic circuits which give choices, dimmer switches and gives ideas to teachers for presenting the topics in the classroom. Both of these packs have been written in conjunction with a primary headteacher.

16 Radcount

Apart from the videos, there are other resources. Radcount is a portable radiation counting system which schools can use inside and out for measuring radiation either naturally occurring or from sources. This is a good way to show students that radiation is part of the world and not confined to nuclear power stations. The pack includes 20 graded experiments from GCSE through to A level and beyond.

17 Energy Book

The Energy Book was written by an education examiner and was designed to fit in exactly with the GCSE - the general certificate of secondary education. There are also a selection of assignments that can be copied by the teacher for classroom or homework use.

18 Greenhouse Effect

There are a series of free booklets available which cover many of the main topics which are raised when discussing nuclear power. They range from The Greenhouse Effect through Radiation to Safety. These have proved very popular and were designed to answer the questions most often asked by the public. They are designed to be descriptive in pictures and words and can be easily understood by the public.

19 Reactors

Looks at the different types of reactor and explains how they work and differ from each other.

20 Radiation Around Us

This allows people to calculate their own annual dose of radiation depending on where they live, how often they fly, how many X-rays they have had etc. It shows the differences in man-made and natural radiation and how where we live affects the doses we receive.

21 Radiation and Medicine

Shows the benefits of radiation and how it is used in medicine.

22 Radioactive Waste

This gives a complete picture of the different levels of waste and how it is processed and stored.

23 Atoms at Work

This is a definition of what is an atom and relates directly to uranium and the fission process in a reactor.

24 Talks Service (lecture)

To complement the resources the education programme also includes a talks service. Any school can ring and request a talk on a subject related to nuclear power given by a senior scientist. The talks usually last for about an hour and includes some hands on experience for the students.

25 Educational Resources Catalogue

To enable schools to order any of the resources a full catalogue has been produced. Each entry has been thoroughly assessed as to its curricular content and a summary on each item, for each curriculum is included. The resources are held at a central distribution warehouse which enables them to be shipped out quickly and efficiently.

26 Advert - Teach Your Class About Energy

Advertising is done to publicise the programme nationally and raise public awareness that the nuclear industry takes education very seriously and supports the nation's teachers with useful materials.

27 Advert - Their Energy Seems Limitless

The publications are the national press for general awareness and trade publications to target teachers.

28 Nuclear Electric Competition leaflet

Other projects are undertaken to provide support to members of the nuclear industry. At the moment the programme is managing a competition on behalf of the Nuclear Electric which is open to secondary students. There are two challenges, one to design part of a nuclear heritage and exhibition centre and another to design a new use for electricity in the 22nd century. This is a departure from the normal essay competitions and reflects the way technology and design is now taught in schools.

C.V.

MAURICE GINNIFF

Educated in Northern Ireland and graduated in engineering at Queens University.

In 1949 joined the UK Aircraft Industry and in 1956 was responsible for the design of the turbine blade of the Olympus jet engine of "Concorde".

In 1957 joined the United Kingdom Atomic Energy Authority at Windscale and worked on the Windscale piles, the Calder Hall reactors and the Windscale advanced gas cooled reactor over a period of 25 years.

In 1982 was asked by the UK Government to form the UK radioactive waste disposal organisation "UK Nirex". Retired in 1990. Helped start nuclear education courses for children aged about 10 years and still interested in such work.

LECTURE 3

نشاطات الطاقة النووية
في مصـــــر

أ.د. هشام فؤاد على
رئيس هيئة الطاقة الذرية

هيئة الطاقة الذرية

تاريخ انشاء هيئة الطاقة الذرية

- القانون ٥٠٩ لسنة ١٩٥٥ بشان انشاء لجنة الطاقة الذرية
- القرار الجمهورى رقم ٢٨٨ لسنه ١٩٥٧ انشاء مؤسسه الطاقه الذريه

بدأ النشاط النووى

- معمل الفانديجراف ١٩٥٩
- مفاعل مصر البحثي الاول ١٩٦١
- معمل انتاج النظائر المشعة ١٩٦٢

هيئات تفرعت من
هيئة الطاقة الذرية

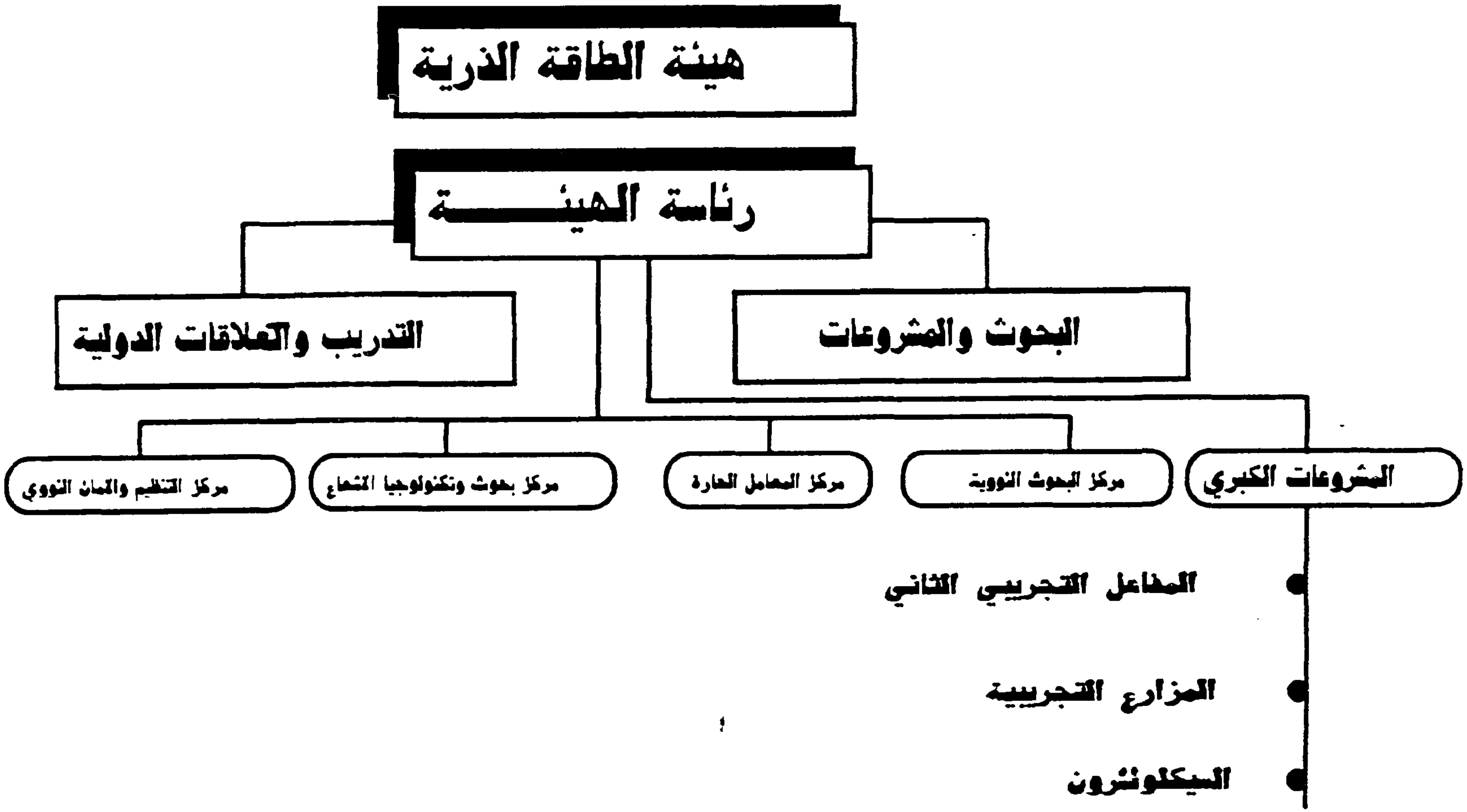
هيئة المواد النووية ١٩٧٦

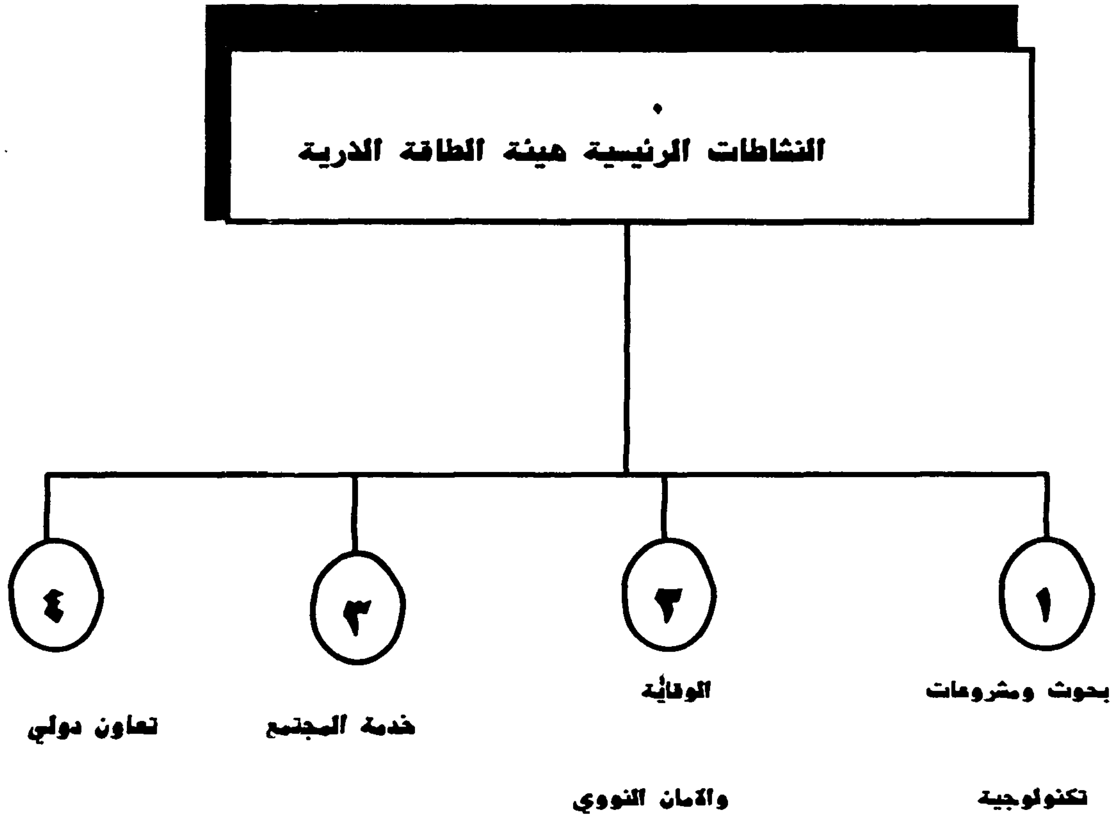
هيئة المحطات النووية ١٩٧٧

وزير الكهرباء والطاقة

الهيئات النووية

هيئة الطاقة الذرية	هيئة المواد النووية	هيئة المحطات النووية


هيئة الطاقة الذرية
رئاسة الهيئـــــة
التدريب والعلاقات الدولية
البحوث والمشروعات
المشروعات الكبري
مركز البحوث النووية
مركز المعامل الحارة
مركز بحوث وتكنولوجيا الإشعاع
مركز التنظيم والأمان النووي
المفاعل التجريبي الثاني
المزارع التجريبية
السيكلوترون



النشاطات الرئيسية هيئة الطاقة الذرية
١
بحوث ومشروعات
تكنولوجية
٣
الوقائية
والامان النووي
٣
خدمة المجتمع
٤
تعاون دولي

البحوث والمشروعات التكنولوجية

تتركز النشاطات البحثية والتكنولوجية في ثلاث محاور رئيسية

* البحوث الاساسية
* بحوث تطبيقات النظائر المشعة
* بحوث وتكنولوجيا دورة الوقــود النــووي

البحوث الاساسية

* بحوث رياضية وعلوم الحاسب
* بحوث فيزياء نظرية وتجريبية
* بحوث كيميائية
* مشروع السيكلوترون وتطبيقاته

بحوث وتطبيقات
النظائر المشعة والاشعاع

* الطب
* الزراعة
* الصناعة
* الهيدرولوجيا
* تكنولوجيا الاشعاع
* مشروع المزارع التجريبية

بحوث وتكنولوجيا
دورة الوقود النووي

أولا : الطرف الامامي لدورة الوقود النووي

ثانيا : المفـــــاعـــلات

ثالثا : الطرف الخلفي لدورة الوقود النووي

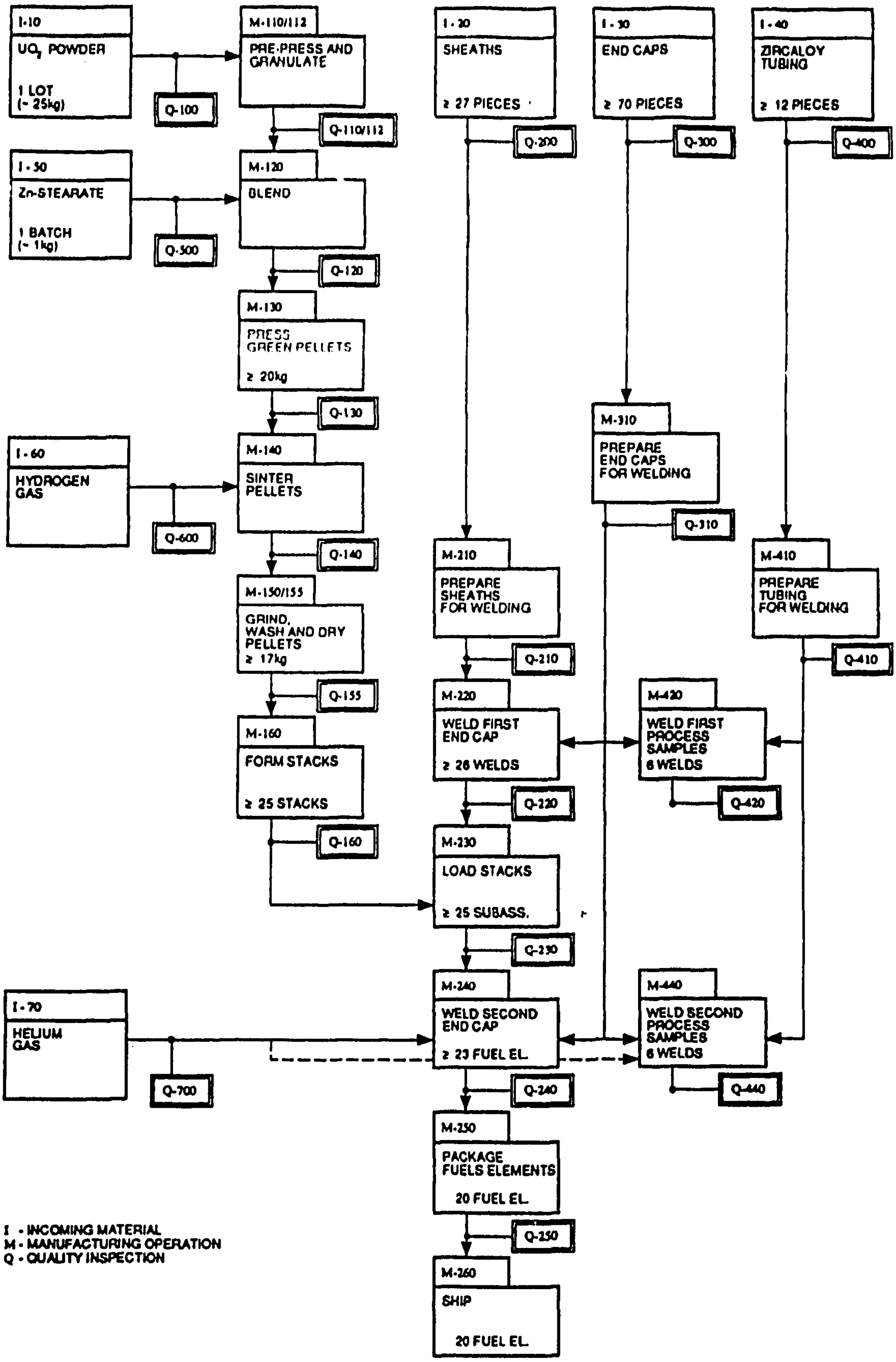
أولا : الطرف الامامي لدورة الوقود النووي

* بحوث في مجالات :

- الوقود النووي والمواد المغلفة
- المواد الانشائية للمفاعلات
- الهندسة الكيميائية

* مشروعات تكنولوجيه تم انجازها

- معمل الوقود النووي لانتاج وحدات وقود مفاعلات الكاندو علي مستوي معملي (١٩٨٩)
- معمل اختبارات صلب المفاعلات والمواد الانشائية (١٩٩١).



رسم تخطيطى لعمليات انتاج وحدات الوقود النووى
معمل الوقود النووى – انشاص

قائمه بوثائق توكيد الجوده فى عمليات تصنيع الوقود النووى
معمل الوقود النووى - انشاص

Purchasing Specification	Technical Specification	Product Specification	Inspection & Test Plan	Drawings	Equipment Commission	Quality Inspection Instructions		Additional Documents
						Incoming	In-Process	
Pur-EG-01-90	TS-EG-01-90 TS-EG-02-90 TS-EG-03-90	PS-EG-02-90 PS-EG-03-90	ITP-EG-01-90	Pellet Pellet Stack Sheath End Cap Fuel Element	Inspection Equipment Manufacturing Equipment	QII-100-EG-01-90 QII-200-EG-01-90 QII-300-EG-01-90 QII-400-EG-01-90 QII-500-EG-01-90 QII-600-EG-01-90 QII-700-EG-01-90	QII-110-EG-01-90 QII-120-EG-01-90 QII-130-EG-01-90 QII-140-EG-01-90 QII-150-EG-01-90 QII-160-EG-02-90 QII-210-EG-02-90 QII-310-EG-02-90 QII-410-EG-02-90 QII-220-EG-02-90 QII-240-EG-02-90 QII-420-EG-02-90 QII-230-EG-02-90 QII-440-EG-02-90	MDPL-EG-01-90 MDPL-EG-02-90 QAM-EG-01-90 TRV-EG-01-90 TRV-EG-02-90 NMN-EG-01-90 QGI-EG-01-90 CPL-EG-02-90 Powder Characterization Report Pellet Visual Standards CR-EG-01-90 CPL-EG-01-90 CPL-EG-03-90

* مشروعات تحت الانشاء

- معمل بحوث وتطوير الماء الثقيل بسعة ٢٠ كجم سنويا (متوقع ١٩٩٥)

- معمل دراسات زحف الفلزات والسبائك (متوقع ١٩٩٥)

* مشروعات يجري اعدادها

- تكنولوجيا الانابيب الرقيقة لسبائك المواد المغلقة وانابيب التبادل الحراري .. الخ

* ثانيا - المفاعلات

* مفاعل مصر البحثى الاول

- القدرة ٢ ميجاوات حرارى : الفيض النيوترونى
(١٠)١٣ نيترون/سم٢/ث

- بحوث في مجالات :

فيزياء المفاعلات النظرية

فيزياء المفاعلات التجريبية

تصميم المفاعلات

الانتقال الحراري

اعذاب المياة المالحة

- انتاج النظائر المشعة

* مفاعل مصر البحثي الثاني
(مفاعل اختبار المواد " تحت الانشاء ")

القدرة : ٢٢ ميجاوات حراري

فيض (١٠)^١٤ نيترون/سم٢/ث

الفيض النيتروني

- اعداد الكوادر
- بحوث في مجالات
  فيزياء المفاعلات ... الخ
  اختبار المواد
- انتاج النظائر

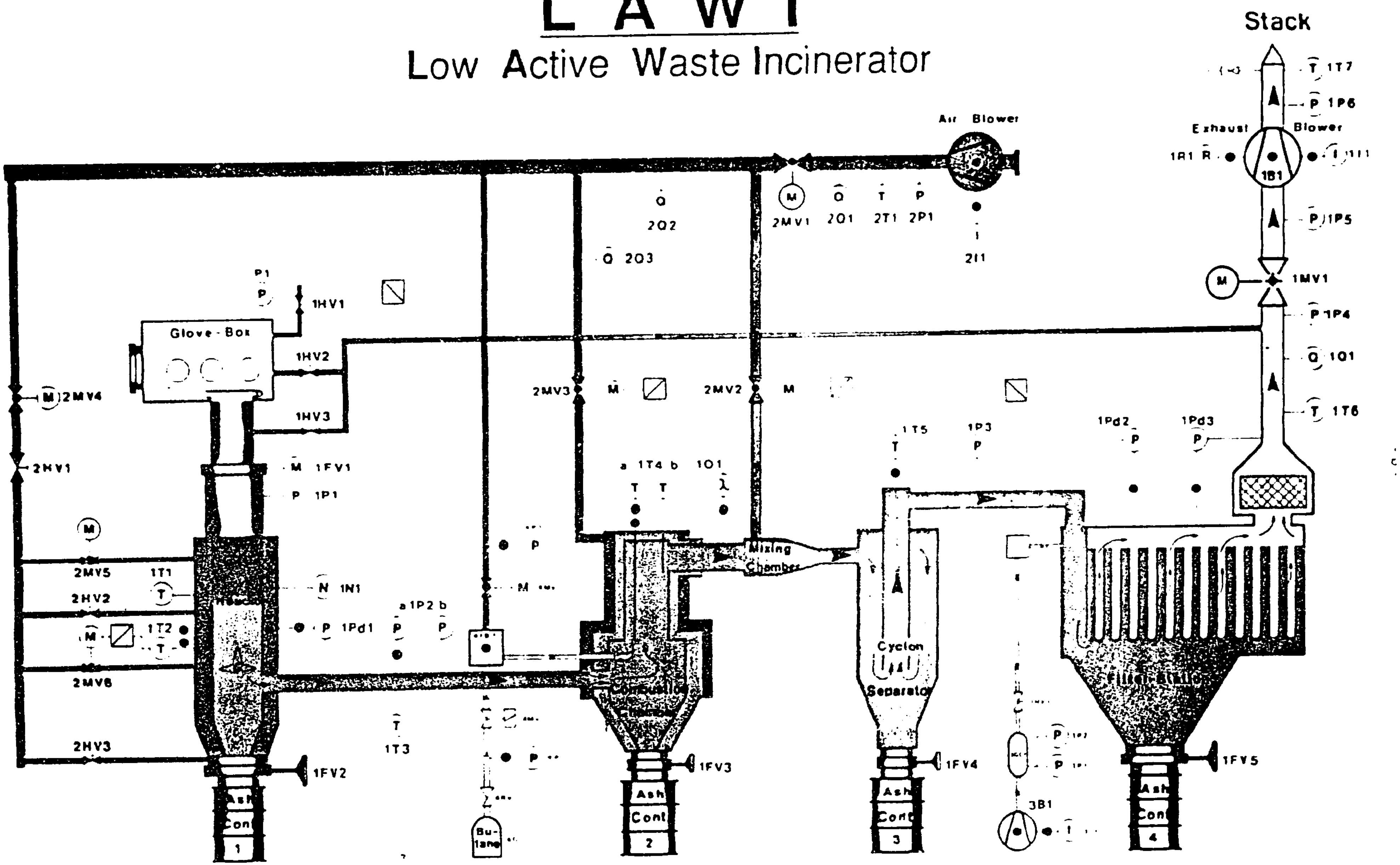
ثالثا : الطرف الخلفي لدورة الوقود النووي

- بحوث في مجالات :
- معالجه النفايات المشعه والسامه السائله والصلبه
- كيمياء وتكنولوجيا استخلاص العناصر المشعه
- التقويم البيئى لتداول النفايات المشعه
- استخلاص عناصر مشعه وتحضير مصادر للاشعاع
- معالجه السوائل الملوثه اشعاعيا
- ازاله التلوث والتحفظ على النفايات المشعه

- مشروعات تكنولوجية تم انجازها
- محطة معالجة النفايات السائلة متوسطة الاشعاع بسعة عشرة متر مكعب يوميا (١٩٩٣)
- محطة معالجة النفايات الصلبة منخفضة الاشعاع بسعة ١٥ كجم /ساعة (١٩٩٣)

L A W I

Low Active Waste Incinerator



الوقاية والامان النووي

* اصدار التراخيص
* الشبكة القومية للرصد الاشعاعي
(انتهاء المرحلة الاولي ١٩٩٣)
* المسح الاشعاعي للبيئة
* المحاسبات والضمانات النووية
* توكيد ورقابة الجودة

خدمات المجتمع ونقل التكنولوجيا

* تعقيم المواد والمعدات الطبية
* استخدامات النظائر المشعة
  - التشخيص والعلاج الطبي
  - الزراعة وتنمية الثروة الحيوانية
  - الصناعة والبترول
  - حفظ الاغذية
  - الكشف الاشعاعى على الاغذيه
* التدريب في مجالات متعددة
  - توكيد الجودة (ISO - 9000 ...... الخ)
  - تحليل الانهيارات
  - اللحام
  - الوقاية الاشعاعية
  - الالكترونيات
  - الحاسبات
  - نقل ومعالجة المخلفات المشعة
  - ا ستخدام الوسائل النووية في الامن الغذائي

التعاون الدولى

- تعاون مع الوكالة الدولية للطاقة الذرية

(حجم مشروعات الوكالة في الفترة ١٩٨١ حتى الان يقرب من ٣٠ مليون دولار) شملت مجالات :

- معالجة النفايات
- المفاعلات
- توكيد الجودة
- المعجل الالكترونى
- الاختيارات غير الاتلافية
- انتاج النظائر المشعه
- الخ ...

- تعاون مع دول العالم المختلفة

في مجالات التطبيق السلمي للطاقة الذرية تشمل دول

- الولايات المتحدة - المانيا
- كندا - الدنمرك
- المجر - روسيا
- المركز الدولي للفيزياء النظرية بتريستا - بايطاليا
- الهند - الارجنتين
- الدول الافريقية
- تعاون اقليمي من خلال الهيئة العربية للطاقة الذرية والمركز الاقليمي للنظائر المشعة

هيئات اخري تساهم في التطبيقات السلمية للطاقة النووية

- هيئة المواد النووية

- هيئة المحطات النووية

هيئة المواد النووية

تتولى الهيئة اساسا

- البحث والتنقيب عن الخامات النووية (اليورانيوم والثوريوم)
- دراسات وبحوث عمليات تصنيع هذه الخامات

النشاطات الحالية:

- فى مجال الخامات النووية التقليدية
  - يتم حاليا تنمية ثلاث مواقع رئيسية بالصحراء الشرقية وموقع رابع في غرب وسط سيناء
- في مجال الخامات النووية غير التقليدية
  - دراسات وبحوث عن خامات الفوسفات
  - دراسات وبحوث عن خامات الرملة السوداء
  - العناصر الارضية النادرة اضافة للثوريوم واليورانيوم والزركونيوم "
- دراسات وبحوث عن معادن اخرى ذات اهمية استراتيجية وصناعية .

هيئة المحطات النووية

تتركز نشاطات الهيئة في الوقت الحالي في المجالات الاتية:

١ - مشروع نقل التكنولوجيا لتصميم وتصنيع مكونات المحطة النووية ويشمل دراسة جدوي تصنيع الوقود النووي من طراز كاندو

- دراسة جدوي انشاء وحدة لانتاج الماء الثقيل بقدرة ٣٠ طن سنويا من شركة كيما.

- تصنيع مكونات المحطة النووية من طراز كاندو قدرة ٦٠٠ ميجاوات كهرباء.

- دراسة امكانيات شركات الانشاء للمشاركة في تشييد المحطة النووية.

- دراسة الخامات المصرية وامكان استخدامهافىانشاء المحطة.

٢ - دراسة مواقع بسيناء لامكانيه اقامه محطات نوويه فى المستقبل

٣ - هناك مشروعات مشتركة بين هيئه الطاقه الذريه وهيئه المحطات النوويه هي

- تصنيع الوقود النووي من طراز كاندو
- دراسة جدوى تحلية مياه البحر ،

هيئات اخري تتعامل بالنظائر المشعة ومصادر الاشعاع في مصر

الطب
الزراعة
البترول
الصناعه

خاتمــــــة

- تساهم النشاطات النووية في مصر مساهمه فعاله في الحركــة العلمية والتكنولوجيــة المصريــة من خـلال تفاعل الهيئات العامله فى المجال النووى مع الجامعات و مراكـز البحـوث والصناعـة والمجتمـع بصفـة عامـه ٠ ويشـمل ذلـك مختلـف النواحي البحثية والتكنولوجية في مجالات العلوم الاساسـية والهندسية وعلوم الحياة ٠

- تعتبر الكـوادر العاملـة فـي المجـال النـووي مـن الخـبرات العالية على المستوى المحلى والعالمى فى هذه التكنولوجيـا المتقدمة ويؤدي تواصلها مع الصناعة الي الارتقاء بمفـاهيم الجودة للمستوى المعمول به نوويا ٠

- كما تعد الخبرات المتوفرة في مصر من الرعيل الاول في المجال النووى رصيدا هائلا وثروة قومية تساهم فى اعداد الاجيال الجديدة وتؤمن سلامة اتخاذ القرار الوطنى فى مجال النشاط النووى ٠

LECTURE 4

EG P501472

Radiation
in everyday life

Björn Wahlström
Head of Radiation Protection
IMATRAN VOIMA OY
Loviisa NPS
FIN-07900 Loviisa
FINLAND

It's a pity not everybody has got a radiation meter. Everybody who owns one, already knows that there is radiation everywhere. Turn on the meter where ever you go, and it starts counting radiation pulses. At some places it counts faster and at other slower. But there is **no** place where there is **no** radiation.

If you put a radiation meter close to an old watch, an expensive camera, a smoke detector or certain crockery, or if you take it with you in a plane that takes off, the count rate increases. This means that the radiation is stronger close to these items and at higher altitudes. You can hear this with your ears and see it with you own eyes from the display. So, it must be true.

The world we live in is radioactive. Radiactive substances and radiation existed on Earth before the first man was born. Radiation reaches us from the cosmos and is also emitted from radioactive substances in the ground, in construction material, in the food we eat and the air we breathe. All people are radioactive, too. For instance, all of us have got radioactive Radium and Polonium in our skeleton, radioactive Carbon and Potassium in our muscles and radioactive noble gases and Tritium in our lungs. The radiation emitted by your body can be measured by a very sensitive radiation meter called a Whole Body Counter.

This has nothing to do with anything that mankind has ever done right or wrong. This is simply how nature is and how it has always been.

Additionally to radiation from these *natural sources* we are nowadays exposed to radiation from *man-made radioactive substances*, from X-rays in medicine, from our TV-set, from radioactive fall-out and from certain consumers' goods containing some radioactive substance.

In many professions the personnel is exposed to *increased levels* of *natural* or *man-made* radiation. Examples of this are work in mines, in many hospitals, in nuclear power plants, in some research institutes, in several branches of metal industry and in aviation. More examples will be given later.

So, all of us have as well natural as man-made radioactive substances *in our bodies* and all of us are exposed to radiation from natural and man-made *external radiation sources* every hour of our life. Some people are exposed to values *tens or hundreds times higher* than others. Should we be concerned about all this? When does the radiation form a health hazard to us? Let us find out.

NORMAL EXPOSURE TO NATURAL RADIATION

Everything is built of *atoms*. The nucleus of an atom may be *stable or un-stable*. Most nucleii are stable. They are in good harmony and will stay so for ever. *Stable nucleii never emit radiation.*

Un-stable nucleii, on the other hand, have got *excess energy*, that they at must get rid of. This is done by emitting an *energy pulse* and maybe a *particle*. A stream of those pulses and particles is called *radiation*. When the excess energy is released the atom turns from its un-stable state to its stable state and will cause no harm anymore.

The radiation around us which origins from natural radioactive substances is called *background radiation*. Everyone is continuously exposed to natural background radiation. The *radiation dose* caused by background radiation is about *one millisievert (mSv)* per year. Millisievert (abbr. mSv) is the unit for exposure to radiation.

The natural background radiation varies from place to place. The annual radiation dose may be 1 mSv in a certain place but 1.6 mSv in a place hundred meters away and 0.9 mSv "around the corner". In some regions the natural annual radiation dose may reach 10 mSv or even 20 mSv, which equals the exposure of an X-ray examination. The background radiation also depends on weather and seasons, air pressure and wind direction.

The radiation dose we receive for natural reasons also depends on what kind of house we live in and what consumers' goods we use. The construction material of our house contains radioactive substances, concrete more than bricks, bricks more than wood. There is radioactive Radium in watches and other instruments with fluorecent numbers, there is radioactive Americium in smoke detectors used in homes, radioactive Thorium in certain optics, radioactive Uranium in special crockery etc. Also our TV–set emits some radiation when it is used.

So, nobody can avoid normal exposure to natural radiation. We are hit by it every second of our entire life. The annual radiation dose from normal levels of background radiation is never smaller the 1 mSv, it is most often between 1 and 10 mSv, and in some cases higher.

INCREASED EXPOSURE TO NATURAL RADIATION

In many situations people are exposed to *increased levels of natural radiation.* For instance, fairly high doses are caused in many countries by a natural radioactive gas named *radon.* It oozes out from the ground everywhere. It causes no problem outdoors, because it is diluted to harmless concentrations, there.

However, in regions where the houses must be heated, houses are built very tight, the ventilation is minimized and the windows are kept closed to prevent the heated air from escaping. For instance, this is the case in Europe, in the USA and in Canada. In those countries *the radon gas will concentrate* in the house and cause the inhabitants an annual radiation dose of *several mSv.* In extreme cases the annual radiation dose caused by radon gas in houses may reach up to *500 mSv or more.*

As the radon gas leaks out of the soil everywhere and reaches high concentration if it cannot escape, the radon exposure is a special problem in coal mines. Before this problem was recognized the miners could receive radiation doses up to *several hundred thousand mSv* a year. That extremely high exposure caused the miners an increased lung cancer incidence. Nowadays this risk has been lowered to an acceptable level by means of better ventilation. (Lately, see Risk Analysis, Vol 14, No 1, 1994, it has been questioned, whether the lung cancers actually were caused by radon gas or rather by inhalation of mineral dust, toxic ores, gasoil exhaust fumes, nitrous gases from explosives etc.)

Aircraft staffs annually receive radiation doses exceeding those normally received in nuclear industry. The cosmic radiation, which causes an annual radiation dose of 0.3 mSv at sea level, is much stronger at an altitude of 10 000 meters. Aircraft crews spending more than 1000 hours a year at that altitude, receive an extra dose of *3 to 4 mSv annually*, and that is more than the average dose to workers in the nuclear industry. Of course, air travelers will receive a small extra radiation dose, too.

Burning of fossile fuels, i.e., coal, oil and gas, is another interesting example of increased exposure to natural radiation. All fossile fuels, especially coal, content natural radioactive substances. As long as these stay deep in the earth they don't cause exposure to anybody. But, when mining coal or drilling oil the radioactive substances are brought up to the surface of the ground.

Later, when the coal or the oil is burned the radioactive substances are *spread into the environment* with the exhaust gas, thus causing some additional exposure to people living in the vicinity. This contribution is not high, but it may be interesting to know that the *release of radioactive substances* from coal fired power plants is of the *same order of magnitude* as that from well operating *nuclear power plants*.

In fact, *there is* a difference between the radioactive releases from well performing nuclear power plants and from coal fired plants. Most radioactive substances released from nuclear power plants are shortlived. They where "artificially produced" in the reactor, and they will decay within some months or years. This means they don't continouosly accumulate in the environment in a perspective of decades of years. On the contrary, the radioactive substaces released from coal fired plants are longlived. They have excisted for billions of years deep in the ground. And they will excist for billions of years more on the surface of the ground. So, they will accumulate in the environment.

So, most people are exposed to increased levels of natural radiation. The extra dose received on the top of the natural background radiation may be small or it may reach up to thousands of mSv annually. Still, the only situation, when increased exposure to natural radiation was shown to possibly have caused adverse health effects, was the radon gas in coal mines. This was at the beginning of the century, before the importance of ventilation was reco

NORMAL EXPOSURE TO MAN-MADE RADIATION

In 1895 mankind for the first time *added* radiation to the natural amount. That year the X–ray tube was invented and taken into use. The X–ray tube emits the same kind of radiation as radioactive material does, even if the apparatus itself is not radioactive. The radiation disappears when the power is switched off. The use of X–rays medical diagnostics and treatment has saved an enormous number of lives and lots of suffering. X–rays are also used in metal industry for the inspection of welding seams and in safety technology to look trough packages and travelers bagage.

The first man–made radioactive substances were produced in 1934. That year a method was discovered for turning stable atoms into an un-stable state. This means that *non–radioctive material could be made radioactive*! Since that man–made radioactive substances have been widely used in medicine, research and industry. Radioactive substances are used for marking water streams and air masses in the research of ecosystems. In mutation related biotechnology radiation has been used to produce disease and pest resistant wheat, rice, sorghum, cocoa, banana, pear and citrus. Radiation is also used in the SIT (Sterile Insect Technique) as a non–polluting metod for insect control. Successful results have been received with the tsetse fly in Nigeria, the melon fly in Japan, and the Mediterranian fruit fly in Mexico. During 1990–1991 the New World Screwworm was eradicated from Africa by means of this method.

In 1938 another astonishing discovery was made. It was observed that nucleus of the Uranium atom could be made to split into two parts forming two new smaller nucleii. These were often radioactive. At the very moment when the Uranium nucleus split a radiation pulse was emitted and some heat was released.

The new skill of mankind, to split the Uranium atom, has later been used in the service of good as well as bad:

–If the useful Uranium was enriched to a concentration of 90 to 100 % it could be used for the fabrication of atom bombs. Since the sixties some 1000 nuclear detonations have caused radioactive fall–out all over the world. This fall–out contributes with some small amount to the background radiation, to which we are exposed every day.

–If the concentration of useful Uranium is only about 3 % it cannot be used in a bomb, but a controlled heat producing reaction can be maintained. This reaction is the power source of nuclear power plants. Today *17 % of the global demand for electricity* is generated by nuclear power, which does not affect the atmosphere or the environment in the way fossile power does.

In a nuclear power plant radioactive substances are produced as by-products. Most of these never get into contact with the living nature. They stay in the waste and are treated and stored in a safe way.

The *releases of radioactive substances* during operation are kept so small that they really are of no significance. In most cases their influence on the dose in the environment is *smaller than the fluctuations caused by changes in weather and seasons.*

To make *professional work* with radioactive material and radiation *safe* international recommendations for maximum exposure have been given. The International Commission on Radiological Protection (ICRP) has recommended, that the radiation dose received at work should not exceed *20 mSv* a year as an average and not *50 mSv* in any single year.

The dose limit for public, to exposure caused by man-made radiation, is 1 mSv/year, exposure from medical use of radiation not included.

Despite the very large use of man-made radiation and radioactive substances, there is no evidence of health effects of radiation doses within the modern dose limits. As workers, exposed to their dose limits, show no adverse health effects - how could the insignificant doses to the public from nuclear or coal fired power plants have any effects?

HIGH EXPOSURE TO MAN-MADE RADIATION

Radiation used in medicine *saves lives*, but it is also true that radiation *can kill*. However, to be acutely fatal the dose must be very high and it must be received in a short time. The bombing of Hiroshima and Nagasaki in 1945 is the best known example of this.

A few people have also been killed by radiation in accidents. Radiation accidents have occurred with X-rays, with radiation apparatus for sterilizing surgery equipment and in research facilities. *Such accidents are very rare indeed.*

Still more rare, even unique, is the *only one reactor accident* at a *commercial power plant*, where people were *killed by radiation* – the one in Tshernobyl 1986. In that accident 31 firemen were acutely killed by radiation. Their doses were in the range of 4 000 to 16 000 mSv.

The Tshernobyl reactor concept is unique for Russia. No other country has built similar reactors and Russia has announced, that they will not build them anymore. In that reactor concept the nuclear fuel is enclosed in a huge Graphite block of 1900 tons weight. When the Graphite block caught fire no force could put it out. It kept burning for ten days. This destroyed the nuclear fuel and caused heavy radioactive fall–out in the environment. Lighter fall–out was observed all over the world.

There has been only one more accident at a commercial nuclear power plant resulting in a vast *damage to the nuclear fuel.* That was the Harrisburg accident in USA in 1979. However, that plant was a so called *pressurized water reactor*, which is *the most frequent reactor type* in the World. In that reactor type there is no Graphite. Instead, *the fuel is kept under water* inside a steel tank during operation. As *there was no Graphite to catch fire* that accident caused no damage to the nature nor to any people. Not even did any single worker receive a radiation dose exceeding the annual dose limit.

The word "accident" itself involves the possibility that people are killed. Thus high exposure to man–made radiation occurring in accidents may be fatal. However, radiation accidents are very rare. They really do not belong to our everyday life.

RADIATION IN EVERYDAY LIFE

Man consists of atoms, some of which are radioactive by nature. Additionally we have incorporated some man–made radioactive substances from radioactive fall–out. The amount of man–made radio–activity in our body is *insignificant compared to the amount of natural radioactivity*, and the man–made radioactivity in our environment is *insignificant compared to the radioactivity of virgin nature.*

The normal background radiation belongs to the nature, and the natural radioactive substances inside our body are a part of ourselves. Radiation is a natural part of our everyday life. So it has always been.

And – the contribution of man–made radioactive substances has not really, as a whole, changed the situation very much.

Compact C.V. for the Regional Seminar on
Nuclear Energy for Better Life,
Sofia 16 - 18 May 1994

Björn Wahlström

Mr. Björn Wahlström received
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Mr. Wahlström is responsible for the **radiation safety** of the personnel, for the treament of **radioactive waste,** the control of **radioactive releases** and related **environmental tasks.**
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LECTURE 5

NATIONAL SEMINAR ON
"NUCLEAR ENERGY IN EVERYDAY LIFE"

Organized by the International Atomic Energy Agency (IAEA) in co-operation with the Ministry of Electricity and Energy

28-29 June 1994

Le Meridien Heliopolis
Cairo, Egypt

NUCLEAR ENERGY VERSUS OTHER ENERGY SOURCES

F.K. King[1]

1. INTRODUCTION

Energy, whether it is derived from nuclear or other means, is a fundamental part of everyday life. It is what keeps us warm, cooks our food and powers the machines we use in all aspects of our work and leisure activities. The availability of cheap energy in many countries has fostered widespread industrial development with resultant high standards of living. The production of energy can also entail negative impacts and in recent years there has been increasing concern regarding the environmental consequences of all human activities, but particularly activities associated with energy production.

This paper deals with nuclear and other sources of energy as they relate to the production of electricity. It first examines the current role of electricity in the world and its means of production and how future economic growth, associated with growing populations striving for better living conditions, will lead to increased demands for new electricity generation. The second part of the paper deals with the health and environmental impacts of the major options for generating electricity likely to be used to meet this need, and how a comparative assessment of these impacts is important to understand the full implications of electricity generation planning decisions.

2. THE ROLE AND DEMAND FOR ELECTRICITY

Electricity is perhaps the most convenient and versatile form of energy. It can be used in a wide variety of applications, it can be made available at the flick of a switch and

[1]Safety Assessment Section, Division of Nuclear Safety, IAEA

is non-polluting at its point of use. Increased use of electricity is an important factor in modernization and in achieving greater efficiency in total energy use. Studies (Nathwani 1992, NRC 1986) have clearly shown a high correlation between electricity consumption and national economic output for a wide range of countries, with the obvious conclusion that developing countries will need a large expansion of their electricity-producing capacity if their aspirations for economic growth and higher standards of living are to be achieved. Full participation in the information and communication age the world is now entering will require the availability of reliable sources of electricity. Even when total energy consumption is not rising, or in countries where it is even declining, data shows that electricity consumption, as a share to total energy usage, continues to grow. To illustrate this point Figure 1[2] shows how world electricity production is increasing as a percentage of total world energy production. From 1950 to 1990 the share of electricity has grown from 13 to 30 percent even considering the fact that two billion people in the world still do not have access to electricity in their homes. The world-wide phenomena of urbanization, allowing easier access to electrical distribution systems, together with the electrification of rural areas, will result in a still greater share for electricity in the future. Direct use of oil, gas, coal and wood is being displaced by electricity. Figure 2 shows how the world per capita consumption of electricity has increased over the period 1950-1990. In this period annual consumption rose from 407 to 2217 kWh per person.

If we look at per capita electricity consumption in individual countries it is seen, as illustrated in Figure 3, that low per capita consumption in a country is often combined with a large population. It is quite obvious that if the per capita consumption of electricity in developing countries is to increase substantially, as it must if increased economic growth and improved standard-of-living goals are to be achieved, then there will be a large world demand for new electricity generating facilities. Looking at the example of South Korea, where the per capita rate of electricity consumption has grown from 70 kWh per year in 1960 to almost 3000 kWh in 1990, it clearly shows that large changes in economic prosperity, with correspondingly higher demands for electricity are possible. This future demand in developing countries will likely be dominated by countries such as China, India, Indonesia, Pakistan and Brazil with their large populations and current low rates of electricity consumption.

In developed countries the growth rate for electricity production has dropped substantially in recent years. This can somewhat be explained by economic recessions which have occurred in many countries in the early 1990s but also by the general difficulties in getting new generating facilities approved and built. Demand management, through the active promotion of conservation and load shifting, is now an important tool for utilities. Controlling load and more effective use of the generating facilities already available have been found to be more socially acceptable than the construction of new facilities. However, developed countries already have a high per capita consumption of electricity and enjoy the ensuing benefits.

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[2] Most data in Sections 2 and 3 of this paper have been obtained from the latest version of the IAEA Energy and Economic Data Base(IAEA-TECDOC-735, Feb. 1994) which in turn derives its data from the UN Statistics Office in New York.

3. GENERATION OF ELECTRICITY

The primary means of producing electricity and their contributions to world electricity production are shown in Figure 4. As is seen, thermal, that is, the burning of coal, oil, gas and biomass, is the dominant means of producing electricity in the world today, contributing almost 64 percent of the total. Hydraulic follows with 18.7 percent, nuclear with 17 percent and geothermal with 0.5 percent. Contributions of other means are not now significant. The same information from a regional viewpoint is seen in Figure 5. What is first obvious here is the large share of North America and Europe to the total and the domination of thermal means in most regions. For Egypt the information is shown in Figure 6. The thermal contribution in Egypt is from oil and natural gas.

Nuclear electricity generation expanded rapidly in the 1970s and by 1980 had reached 694.3 TWh, almost a nine-fold increase since 1970, and contributed 8.3 percent of the total electricity production, representing an average growth rate of 24 percent in the decade 1970-1980. In the period 1980-1985 nuclear electricity generation increased to 1448.5 TWh, corresponding to an average annual growth rate of 16.3 percent. During 1985-1990, generation increased to 1901.2 TWh which corresponds to an average growth rate of 5.6 percent. In the period 1990-1993, nuclear electricity generation increased at an annual growth rate of only about 1 percent, growing to 2096 TWh. At present there are 430 nuclear power stations in the world today producing electricity.

The decisive factors which influence decisions regarding the construction of electricity generating facilities vary widely from region to region and with time. Decision factors which have been traditionally important are local availability of fuel, generation reliability and overall cost. Other factors include: security of supply, planning flexibility, environmental impact and capital requirements. One of the major impacts on the energy planning process in many countries in recent years has been the emergence of environmental issues. A common trend in many countries is to reduce the need for new generating facilities by promoting energy conservation and demand management. However, the construction of new facilities is inevitable, to meet, as discussed earlier, the needs of increasing populations and enhanced economic growth, as well as for replacement of current facilities at their end of life.

The options which are now often considered for new generation capacity by world utilities are:

- pulverized coal with scrubbers
- pressurized fluidized bed coal combustion
- simple cycle combustion gas turbine
- combined cycle gas turbine
- hydro
- pumped storage hydro
- nuclear (PWR, BWR, PHWR)

Non-hydraulic renewable sources such as geothermal, biomass, wind, solar photovoltaic, fuel cells, wave, and tidal power will play increasingly important roles but are only estimated to meet a small percentage of the world demand within the foreseeable future.

The choice among the various alternatives is driven by the most important local decision factors and is often considered by governments and utilities to be a choice amongst necessary evils. All have their negative attributes and finding the best option, considering all the applicable decision factors, becomes a challenge for energy planners and their political counterparts. With increasing environmental awareness, comparative assessment can play an important role in this decision process and is the subject of the next part of this paper.

4. HEALTH AND ENVIRONMENTAL IMPACTS OF ELECTRICAL GENERATION

4.1 INTRODUCTION

There have been many studies in the last twenty years which attempt to estimate and compare the health and environmental impacts of the various means of generating electricity. Through the efforts of many researchers the methodologies for comparative health and environmental risk assessment have progressed to the point where such assessments are commonly used as input to the energy planning decision-making process.

One of the important features of these assessments is that they analyze the complete energy chain involved with the production of a unit of electricity. For example, it is important to look at fuel mining, the processing and transporting of fuel, the building and operation of electrical generation facilities, and also to consider the decommissioning of facilities and the impacts of waste products associated with all parts of the energy chain. It is only through this comprehensive look at all actual and potential impacts from each energy chain that a complete assessment can be made.

4.2 HEALTH IMPACTS

Health impacts for the various means of producing electricity are usually estimated under two categories - occupational and public. *Occupational* refers to impacts on workers. These workers could be miners, construction workers, facility operators, or others. *Public* refers to members of the general population whose health, by the fact they may be located near to activities associated with the particular energy chain under consideration, could be impacted by such activities.

A survey of results from various assessments has been made by Fritzsche (Fritzsche 1989) and the results with respect to occupational fatalities are shown in Figure 7. The acute risk of death due to accidents to workers employed in the energy production processes is shown in the right-hand part of Figure 7. For the first group of fossil fuel systems, this risk is of the order of 1 fatality/GWa. It is distinctly higher for the coal cycle than for oil and gas. If the coal is mined under bad working conditions in an out-of-date mine the risk can be at least an order of magnitude higher (see point). The risk in the case of the renewable systems is also of the order of 1 fatality/GWa and is due to the large requirement for construction materials to build these systems. The occupational acute fatality risk due to nuclear systems has been found to be the lowest.

Fritzsche's results for acute public health risks (excluding severe accidents) are shown in Figure 8. These risks are primarily due to transportation accidents involved with the movement of fuel and building materials. The results are based on average values of transportation distances.

4.3 ENVIRONMENTAL IMPACTS

The generation of electricity by any means usually entails emissions and disposal of waste products to air, water and land. There are economic and technological limitations to the reduction of such emissions and waste products and their associated impacts. Thus, there will always be residual environmental risk as a result of generating electricity by any fuel cycle. The nature and extent of this risk depends on the type and quality of the fuel used, the method of conversion, the level of pollution control technology in place and the efficiency of its operation.

Environmental risks are highly technology and location specific and can affect the air, water and land in very many ways. Local impacts such as air and water pollution, disruption of habitat and others, must be evaluated on a facility-specific basis, taking into consideration the neighboring ecosystems which are of particular concern to the local populace. In addition, there can be regional and global impacts which are of wider concern.

The burning of fossil fuels leads to emissions of the oxides of sulphur, nitrogen and carbon as well as the emission of heavy metals and other pollutants. The levels of SO_2 and NO_x emitted depend on the fuel burnt and on the method of combustion and on the extent and efficiency of any abatement technology in place. The emission of CO_2 on the other hand depends primarily on the type of fuel used.

SO_2 and NO_x are closely linked with the phenomenon of acid rain, which leads to materials corrosion, soil damage and the acidification of lakes. These latter effects in turn lead to forest degradation and negatively impact the life supporting function of affected lakes. The use of fossil fuels produces large amounts of greenhouse gases, particularly CO_2 and CH_4 ; in fact, nearly three-quarters(IEA 1993) of all CO_2 production comes from the burning of fossil fuels for the production of electricity. Figure 9 shows how the level of CO_2 emissions is increasing, while Figure 10 shows the results of several researchers who have estimated CO_2 emissions from various energy chains. At present concentrations the greenhouse gases are not toxic. However, increasing atmospheric levels of greenhouse gases are of concern because of their important role in the global atmospheric energy balance which, if significantly disturbed, could result in various kinds of dangerous climate changes. The increase in atmospheric CO_2 concentrations from 1960 to 1990 is displayed in Figure 11. Environmental issues with respect to nuclear energy are discussed in more detail in an accompanying paper at this Seminar (Skjoeldebrand 1994).

4.4 SEVERE ACCIDENTS

When comparing the potential health and environmental impacts of different means of producing electricity, severe accidents are normally considered separately. This is because data on such events is sparse and predictions of future risk is more uncertain than risks associated with emissions from normal operation. Severe accidents can happen with respect to many electricity-producing technologies as can be seen in Figure 12. These accidents, while in many cases dramatic, do not make large contributions to overall health and environmental risks. However, in response to public demand much effort is being made to reduce the likelihood of severe accidents for all technologies.

5. SUMMARY

A study of the world energy situation leads to a number of conclusions.

The first of these is that there will be a large demand for new electrical generation facilities in the coming decades. This demand will be concentrated in developing countries with large populations and whose economies are in transition, leading to large growth rates.

Coal, by its shear abundance of supply, will continue to be used in large amounts to generate electricity in the next couple of decades. Natural gas is becoming increasingly attractive to utilities based on cost, planning flexibility and environmental impact reasons, and a large movement to natural gas, especially in Europe and North America, is foreseen in this time period. Fossil fuels will probably continue to have important roles until their environmental impacts reach a point of critical importance on the world political agenda. In the case of natural gas; availability, cost and security of supply are also important concerns which may curtail its use following an initial large expansion.

Non-hydraulic renewable energy sources will receive increasing levels of support from governments but are unlikely to contribute more than a few percent to total electricity production in the next twenty years.

Nuclear power, due to accidents at Three Mile Island and Chernobyl, is in a period of low growth in many parts of the world, but the demands of an increasingly environmentally conscientious world society and a desire for energy independence should ultimately lead to its revival as a widespread option of choice. There is currently no other way to meet the vast energy needs of a growing, more prosperous world population and to sustain the world environment for future generations. Also, it can be considered unethical for the generations of today to squander the limited world supplies of such valuable multi-use commodities as oil and natural gas, while uranium, which cannot be used for other purposes, goes under-utilized. However, a large move to nuclear will require new dimensions of public understanding and acceptance and this in turn will probably require a crisis brought on by the continued expansion of the burning of fossil fuels. Widespread public acceptance of nuclear will also require nuclear power plants which virtually eliminate the possibility of significant off-site accidental releases of radioactivity, as well as a demonstrated capacity to handle radioactive waste safely.

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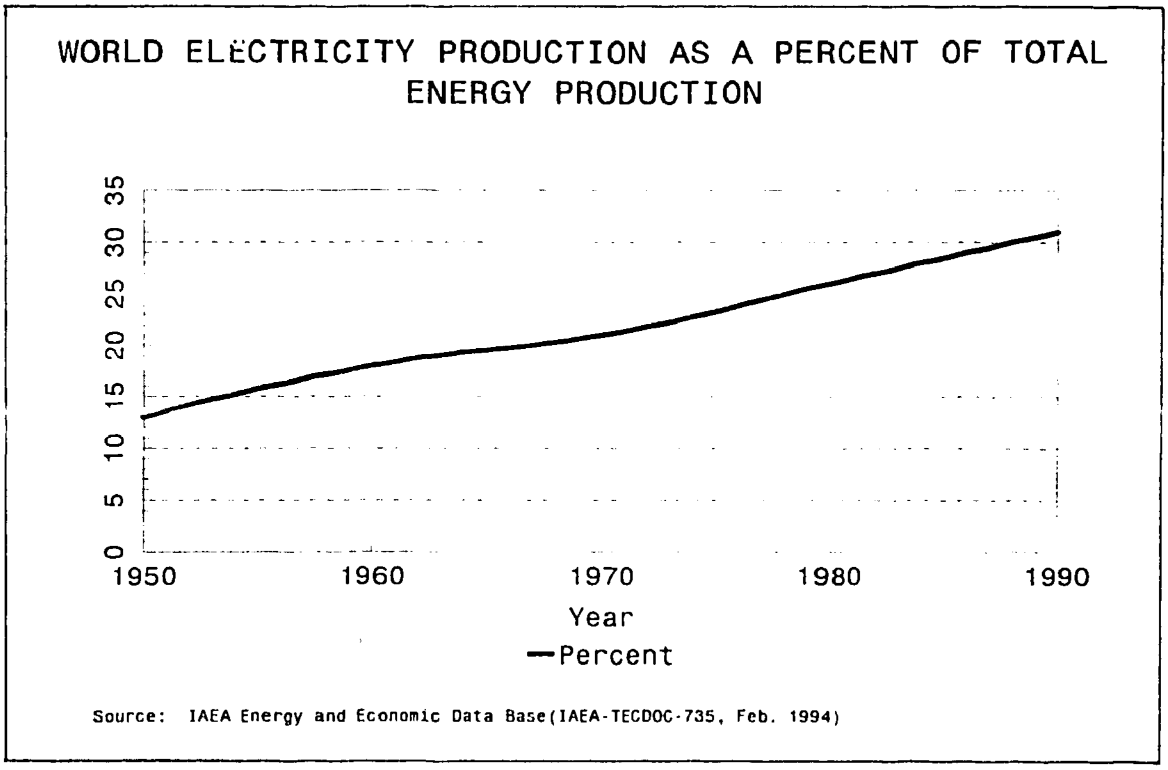
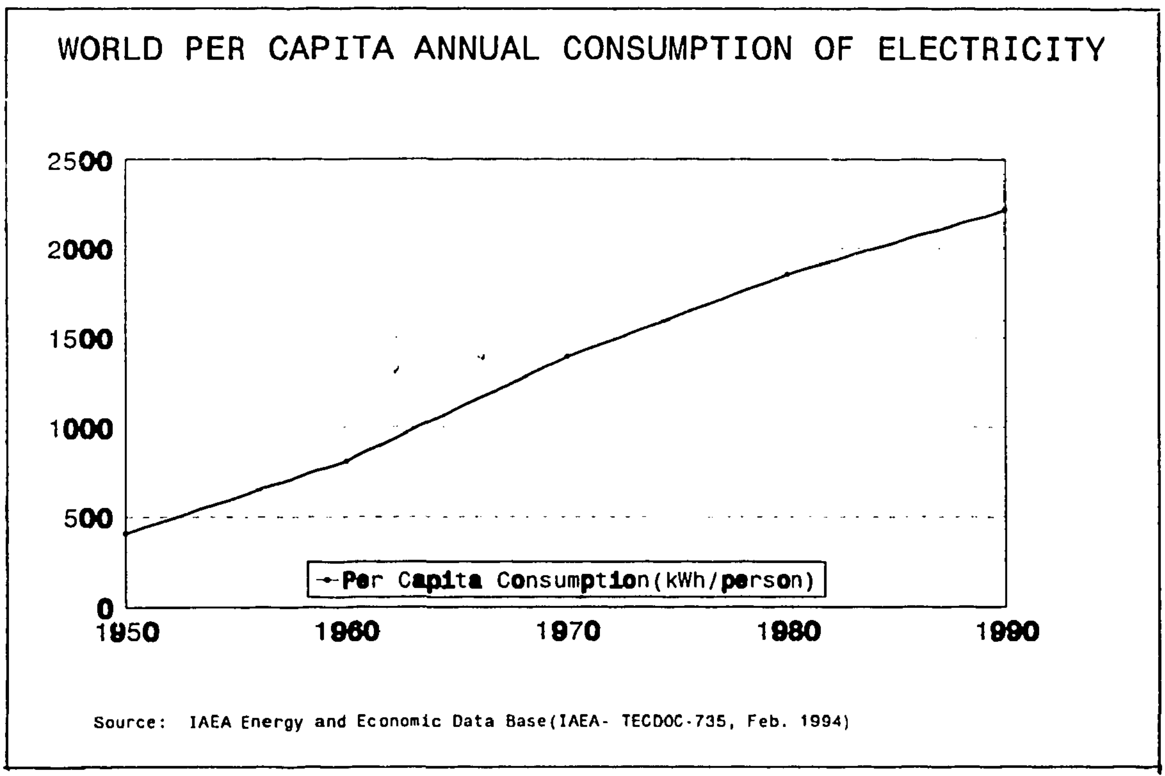


Figure 1



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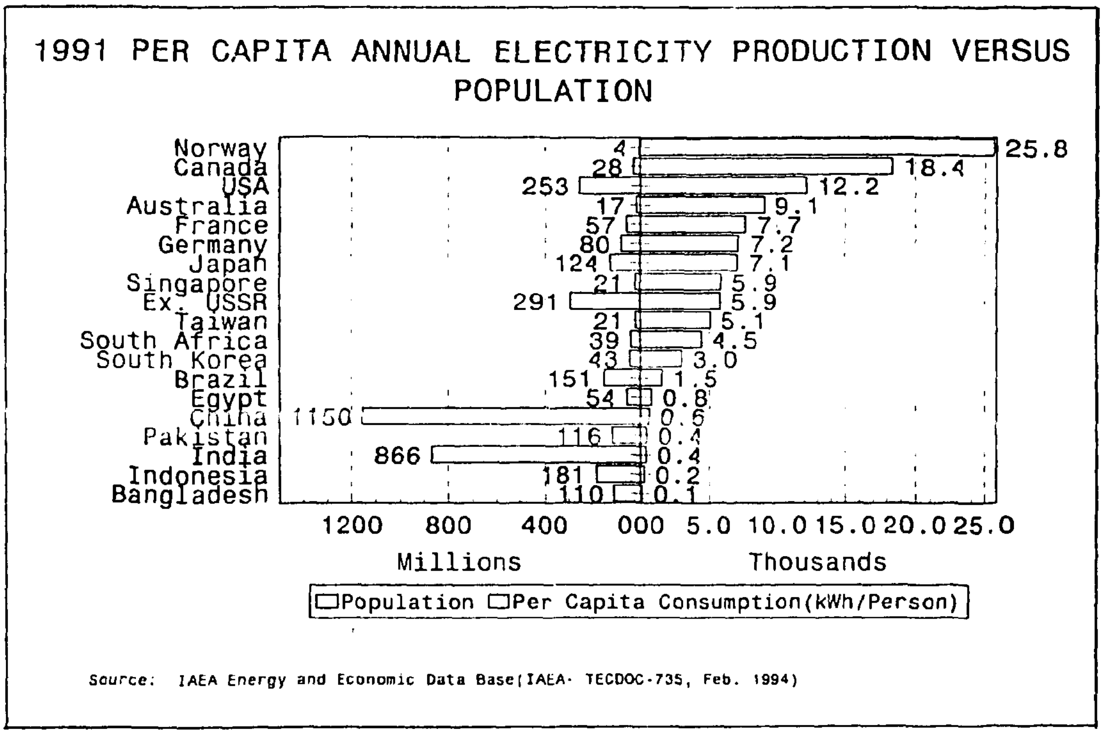


Figure 3

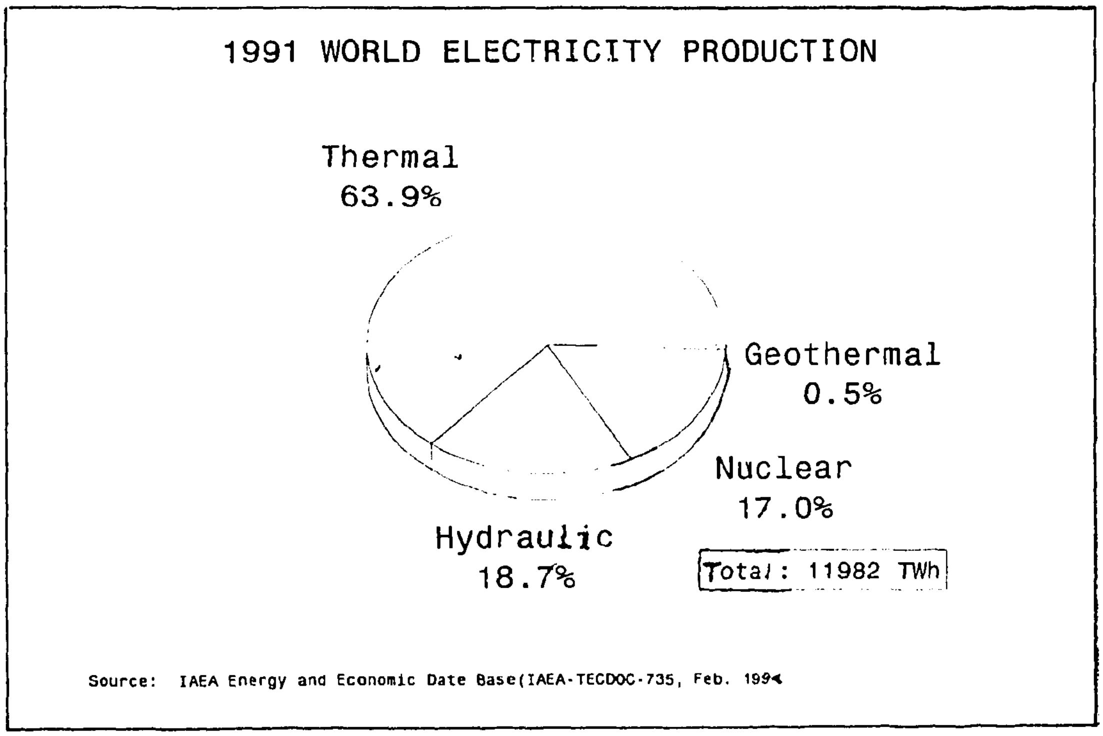


Figure 4

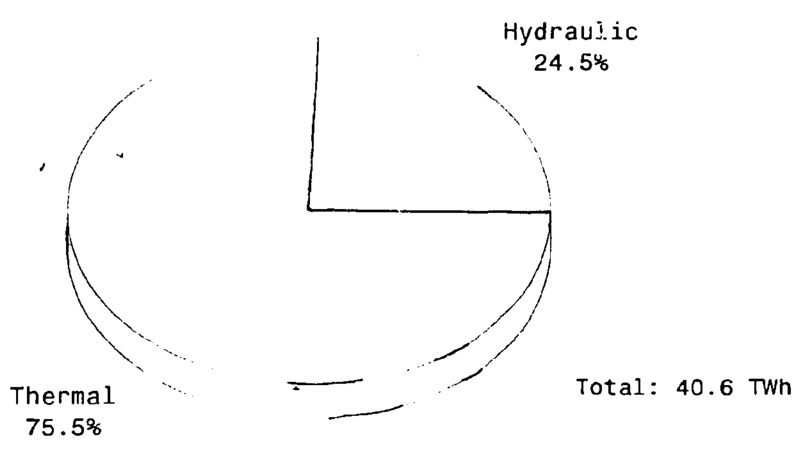
1991 WORLD ELECTRICITY PRODUCTION BY REGION

Region	Percent of World Total Prod.	Thermal	Hydraulic	Nuclear	Geotherm.
North America	29.9	63.5	16.7	19.4	0.4
Latin America	5.5	36.6	60.6	1.9	1
Western Europe	20.4	50.6	18.7	30.6	0.1
Eastern Europe	17.8	74.5	13.1	12.4	0
Africa	2.8	81	16.1	2.8	0.1
M E./South Asia	4.8	80.6	18.5	0.9	0
SE Asia/ Pacific	2.8	82.3	17.2	0	0.5
Far East	16	69.3	14.8	15.5	0.4

Source: IAEA Energy and Economic Data Base(IAEA- TECDOC-735, Feb. 1994)

Figure 5

1991 ELECTRICITY PRODUCTION - EGYPT



Source: IAEA Energy and Economic Data Base(IAEA- TECDOC-735, Feb. 1994

Figure 6

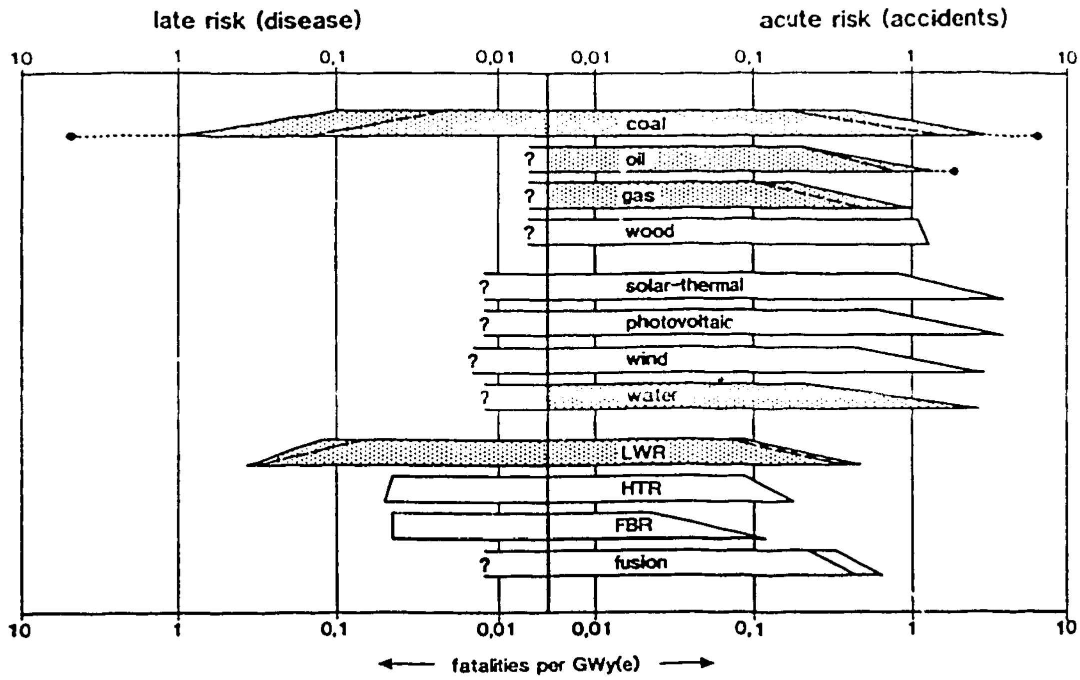


Figure 7 Occupational mortality risks due to electricity production (all steps of the fuel cycle; without severe accidents).

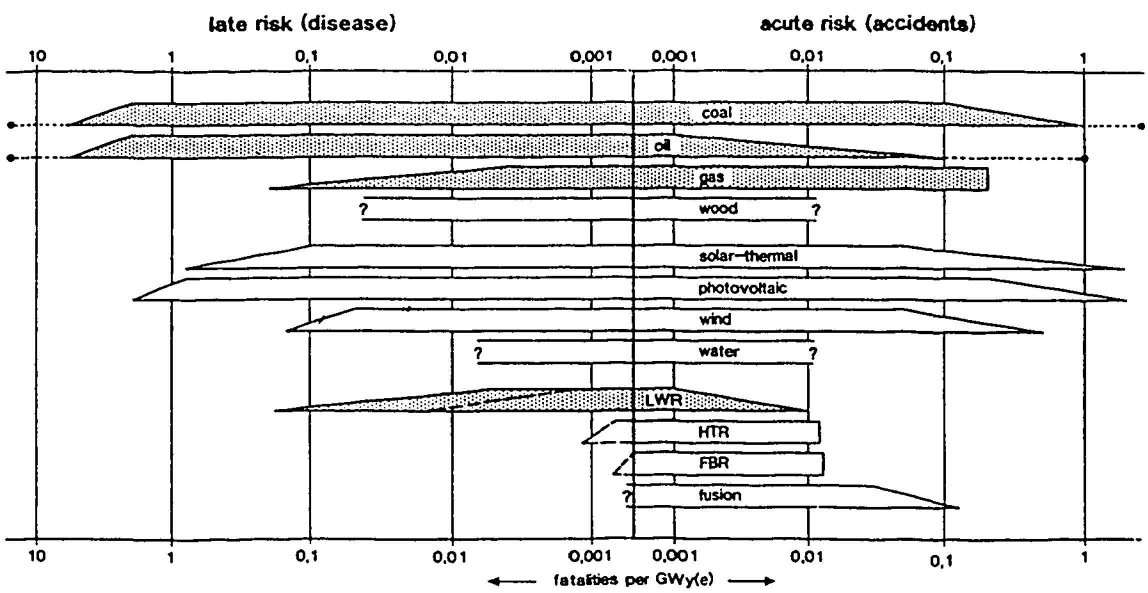


Figure 8 Public mortality risks due to electricity production (all steps of the fuel cycle; without severe accidents).

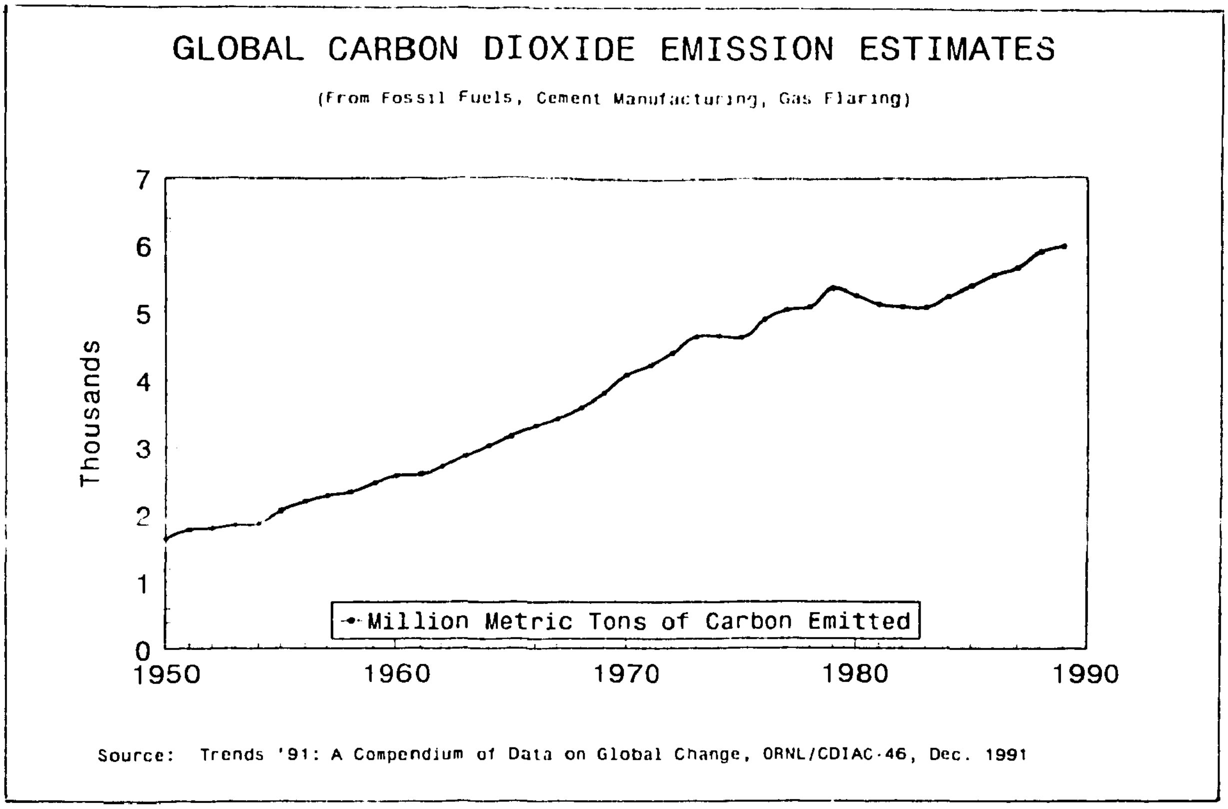
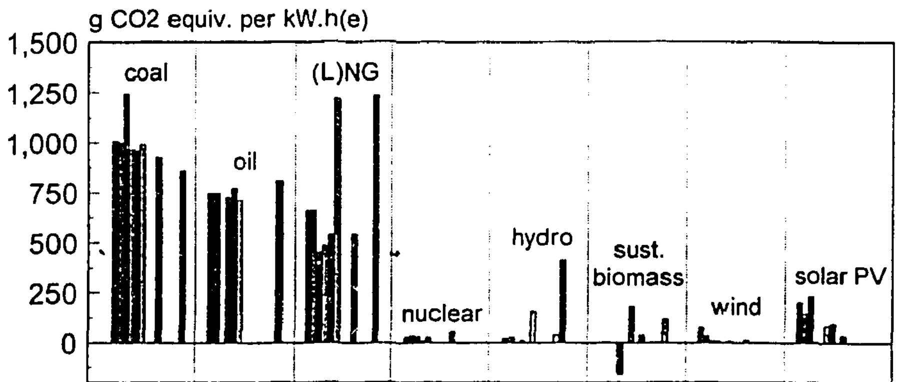


Figure 9

FULL ENERGY CHAIN GREENHOUSE GAS EMISSION FACTORS OF VARIOUS ENERGY SOURCES



	coal	oil	(L)NG	nuclear	hydro	sust. biomass	wind	solar PV
Uchiyama	1,008.0	748.0	880.0	27.0	21.0		74.0	301.0
Yasukawa	1,001.0	748.0	880.0	33.0	26.0		33.0	147.0
Lewin	1,244.0		453.0	29.0			11.0	228.0
San Martin	964.0	726.0	484.0	7.8	10.0	(160.0)	7.4	5.4
Science Conc	960.0	770.0	536.0	25.0				
Van de Vate	920.0	711.0	1,220.0		156.0	160.0	7.4	63.0
Haene								83.0
Born						37.0		
Fritsche	829.0		542.0	34.0			15.0	32.0
Rudd-1					35.0			
Rudd-2					410.0			
Turhollow						116.0		
Sullivan	980.0	808.0	1,234.0					

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Figure 10

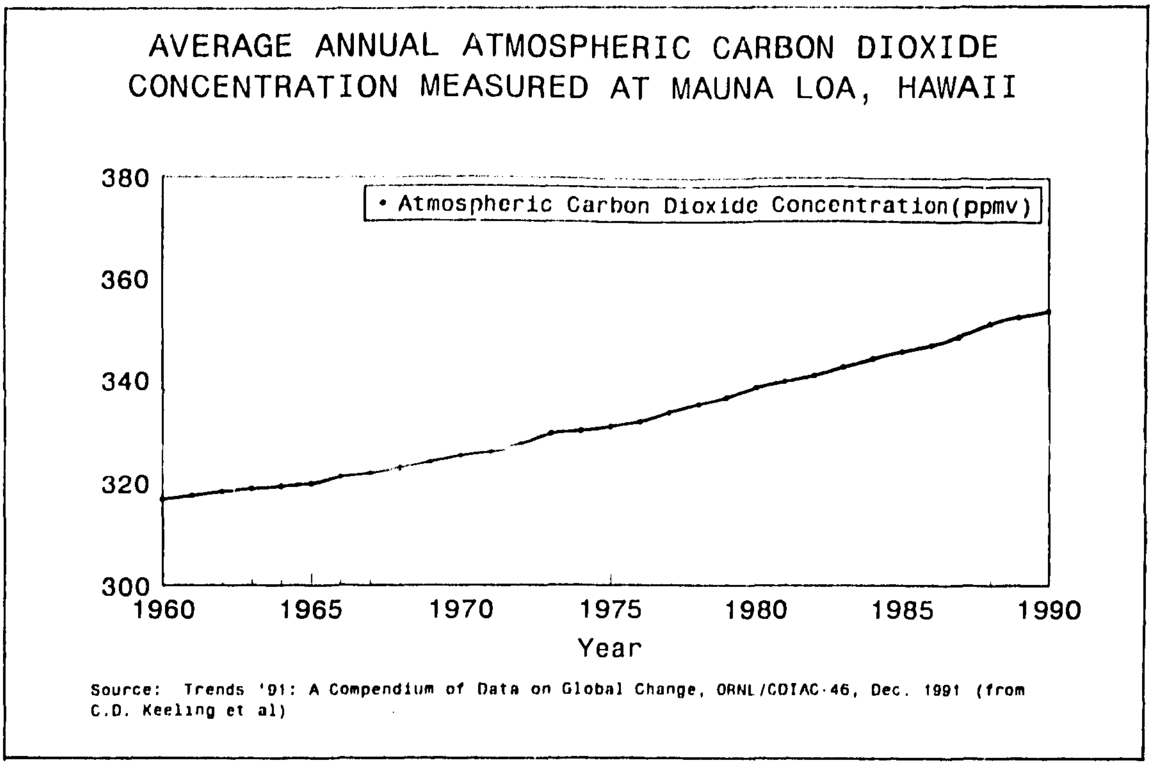

Figure 11

Energy Option	Severe Accidents: No.	Cause	Installation	Number of fatalities: Per event	Average per year
Coal	62	mine disaster	coal mines	10...434	over 200
Oil	6	capsizing	oil platforms	6...123	
	15	fire/explosion	tank farms	5...145	ca. 25
	42	fire/explosion transport accident	during transport	5...500	over 90
Natural gas	24	fire/explosion	various	6...425	over 80
Water	>8	over-topping	dams	11...2500	over 200
Nuclear	1		Chernobyl	31 (+ 130 000 evacuat.) + land contamin. (latent effects?)	

Source: A.F. Fritzsche: The Health Risks of Energy Production.
Risk Analysis, Vol. 9, No. 4, 1989

Figure 12 Severe Accidents World Wide 1969-1986

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LECTURE 6

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NUCLEAR ENERGY AND THE ENVIRONMENT

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NATIONAL SEMINAR ON

NUCLEAR ENERGY IN EVERYDAY LIFE

Cairo, Egypt

28-29 June, 1994

13 June 1994

NUCLEAR ENERGY AND THE ENVIRONMENT

R. Skjoeldebrand

ACID RAIN AND THE GREENHOUSE EFFECT

My thesis is simple: The world will need more energy and not less in the coming decades but we must recognize that this enormous energy consumption entails dangers to our environment not only locally but regionally and internationally through the emissions from the burning of fossil fuels which now provide 85% of the world's commercial energy supply.

More than 20 years ago we knew that the sulphur and nitrogen oxides (SO_2 and NO_x) coming from the burning of coal and oil cause acid rain which in turn can cause the death of forests and lakes. The costs of forest destruction in Europe from acid rain has been estimated to some US$ 30 billion per year and there are tens of thousands of lakes in Scandinavia which are dead or dying with little or no biological life. There is a disaster area around the corner between Germany, Poland and the Czech Republic. In many European countries the deposits of SO_2 and NO_x are imported (figs 1 and 2). The damage is by no means limited to the energy hungry industrialized countries. One example is the northeastern region of China with heavy pollution and serious damage to biological life. Still, we have in 20 years not been able to explain the biological process by which the forests are affected.

We know that we have made significant changes in the earth's atmosphere. Since the beginning of the industrialization the content of carbon dioxide (CO_2) has increased by more than 25% due to the burning of fossil fuels. In the same time span methane has more than doubled and nitrous oxide gone up by 10%. We have also added manufactured CFCs which did not exist in nature before. (Fig.3) All these gases have in common that they absorb heat radiating from the earth which is assumed to lead to global warming and global climate change through the so-called greenhouse effect. This is by no means a newly found phenomenon. Already 1896, the Swedish chemist Svante Arrhenius stated that without the heat absorption of CO_2 in the atmosphere the earth would be some 30° cooler, probably excluding any human life. Serious scientists now fear that the changes in the atmosphere will increase this effect. The contributions of the four main greenhouse gases have been calculated as shown in fig. 4. As we know from where the gases originate it is also possible to calculate the contributions of the sectors of human activities (Fig.5) Fossil fuel use contributes almost 50%. There is now far-reaching agreement on a gradual phase-out of the production of CFCs which also contribute to the thinning of the ozone layer and the formation of the ozone holes over the poles. Methane emissions are difficult to reduce because of their origins which are coupled with the production of staple foods for most of the people. Thus, the highlight has come on CO_2 and what can be done to reduce emissions of it. Many would have us believe that the answer is simple: Just use less fossil fuels!

Global climate change was one of the principal concerns at the 1992 Conference on Environment and Development in Rio, the so-called "Earth Summit". It was, however, remarkable that very few speakers addressed the question of energy. The Conference adopted a Framework Convention on Climate Change which establishes the goal of stabilizing greenhouse gas concentrations in the atmosphere at levels which would not interfere dangerously with the climatic system. However, the Convention does not say **how** this is going to be done. Some countries, especially industrialized countries in Western Europe, have set themselves goals of stabilizing CO_2 emissions at or even below the level of 1990.

The predicted increase in the greenhouse effect is by no means undisputed. It was unequivocally stated by the prestigious Intergovernmental Panel on Climate Change (IPCC), in which many of the world's best atmospheric scientists have worked together for more than 6 years, that we must expect a global warming. Still, there are some questions to which we still do not know the answers:

- If the changes in the composition of the atmosphere already are so significant, why do we now only see climate changes which are totally within the normal range of variations?
- What can possible countereffects, such as increased cloud formation mean?
- The increase in the CO_2 content corresponds to only about 1/2 of the total emissions. Where did the rest disappear? And why are the greenhouse gas contents in the atmosphere beginning to stabilize?

In addition, we must admit that our calculation methods for the expected climate change are inadequate. They do not permit to forecast with any certainty how a global climate change will affect different regions of the world. There is thus at least some reason for governments to doubt the predictions and they are in a classical situation of having to take decisions in the face of uncertainty. In addition they are told that there are basically only two options between which to chose: energy conservation and substitution of coal and oil with new renewable energy sources, i.e., biomass, solar, wind and geothermal. These now contribute some 0.1% to the world's commercial energy supply and the development potential of them still remains hypothetical. There is, of course, one energy source which is proven on a large scale, now contributes 6% of the energy supply and has no emissions of either CO_2 or SO_2 and NO_x, namely nuclear power. This is, however, deemed at least inopportune to mention by most of those engaged in the greenhouse debate.

FUTURE ENERGY NEEDS AND SUPPLIES

It may be useful to take an unprejudiced look at the situation and to separate facts from wishes. For that purpose some neutral sources can be quoted, sources which cannot be accused of being either pro- or antinuclear, namely the International Energy Agency (IEA) of the OECD and the World Energy Council (WEC). These organizations see a clear increase in the energy demand over the next decades up to 2020. The foremost reason is the increasing world population (Fig.6) and the ever increasing part of that population which will live in urban areas (Fig.7). The great majority, living in the present developing countries, have a justified ambition to improve their lots and will need more energy in order to do that. At present, a Western European on the average uses 136 GJ of energy per year while the corresponding figure for an Indian is 13 and here in Egypt it is 24. Especially energy use in the form of electricity is a measure of the stage of development. A Western European uses 5,700 Kwh of electricity per year, in India it is 356 Kwh and in Egypt 754. Briefly, developing countries with 3/4 of the world's population now use 1/3 of the the energy and 1/4 of the electricity produced in the world. It is clear that there is a strong need to move towards more industrialization and, consequently, more energy use in the developing world. It is also clear that here it is not possible to save or conserve energy which is not available to use. The best we can hope for is, that in the developing countries, it will be possible to adopt more energy efficient processes from the beginning, avoiding some of the past wastage committed in the present industrialized countries and thereby slowing the rate of increase in the demand. It is not surprising that IEA foresees a possible increase in global energy demand of 30% between 1990 and 2010 and WEC likewise sees an increase of 50% between 1990 and 2020. (Fig.8) Most of this increase will occur in the developing countries and one must recognize the importance which development in China and India with 1/3 of the world's population will have for the rest of us.

Such scenarios, naturally, also take into account savings which are deemed feasible to achieve. It may be worthwhile to mention that in the industrialized world there has already been a saving of primary energy use of about 30% since the first oil price shock in 1973 in comparison with what would have been used if these countries had followed earlier trends in a "business as usual" scenario (Fig.9).

Both IEA and WEC are pessimistic about solar, wind and other new renewable energy resources. IEA estimates that only 1% of electricity will be generated from such sources in 2010 and WEC gives 1.5 - 2% of total energy supply in 2020. WEC has stated that "it is unlikely that, in the foreseeable future, renewables will be able to offer economically viable alternatives to fossil fuels of such magnitude that they will have a significant impact on the world's environmental or overall energy balance." The reason for this pessimism is the poor characteristics and systems problems which work against economics.

Neither IEA nor WEC have found that it will be possible to stabilize CO_2 emissions even if they have investigated several possible energy mixes to supply the demand. The aim of some countries to contain emissions at 1990 levels is characterized by WEC as simply unrealistic. The most optimistic scenarios with the lowest emissions are in both cases based on a much expanded use of nuclear power.

THE NUCLEAR POWER OPTION

Nuclear power now provides about 6% of the world's energy supply and 17% of the electricity which is only slightly less than we get from hydro power. In a number of countries the fraction of nuclear power is very much more (Fig.10).

In fact, if the currently operating nuclear power plants had been coal-fired the total emissions of CO_2 would have been higher by 7%.

In France the decision was taken in 1973 to launch a major nuclear power programme, not for any environmental reasons but because the government wanted to reduce the dependence on imported oil by diversification of energy sources and there existed confidence in the French nuclear power technology. In 1980 the first power plants of this new programme started to make an effect and the development in regard to emissions since then has been remarkable (Fig. 11).

One response to the need to take decisions in the face of uncertainty is to opt for the decision which will give benefits anyhow. The French example may be worth considering at least in industrialized countries. It has not only brought a degree of energy independence and stable and low electricity prices but also major environmental benefits.

Besides in France there are strongly expanding nuclear power programmes also in the "tiger" economies in the Far East, in Japan, South Korea and China. Otherwise nuclear power appears stagnating. There are in many cases good reasons for this, such as too much generating capacity having been constructed in the past. Still, the main reason is that nuclear power is hampered by a serious lack of public and political acceptance in a large number of countries. The two major accidents at Three Mile Island in the USA in 1979 and in Chernobyl in 1986 certainly are a major reason for this. Even where nuclear power is an important contributor and the safety record has been excellent, public opinion still will not permit more plants to be built. Sweden has had a moratorium for new plants since 1980 and there is a decision to phase out all nuclear plants by 2010. In Finland, where a new plant is needed soon and the alternative to nuclear is a coal fired plant, parliament last year decided not to permit building the nuclear plant. In Spain, a few weeks ago, the government decided not to complete five power reactors which had been under construction until a few years ago. The reason is no doubt a deep seated mistrust among the public against nuclear power and the potential radiation risks from it. Such a mistrust must be taken seriously and only education over a longer period of time can help to alleviate it. Arguments of environmental advantages in normal operation will not likely make any significant change. If we are to see a more general revival of nuclear power there are at least four basic conditions which must be fulfilled:

- Governments must demonstrate their confidence in the technical solutions to high level waste disposal and start construction of real pilot disposal plants as will be done over the next decade in Sweden.

- Safety must be demonstrated by continued safe operation of all nuclear power plants everywhere. New plants must be built to even stricter safety standards, e.g. to meet the criterion that no evacuation of the surroundings should ever be necessary in the case of even very severe accidents - a criterion which some countries consider they have already fulfilled by backfitting existing plants.

- Nuclear power plants must demonstrate their economic viability so that they can be chosen in economic competition with alternatives. When we arrive at methods to set costs on environmental and health impacts of different energy sources this should favour nuclear power, but until then nuclear power must make the race without consideration of its environmental benefits.

- The spectre of further proliferation of nuclear weapons must be banned, production of further weapons material in the weapons states must be stopped and there must be concrete and visible steps towards nuclear disarmament.

It is by no means impossible to meet these conditions. We are already seeing positive effects in disarmament and arms control and individual states can point to success in meeting some or all of the conditions. To obtain general progress everywhere, and to persuade the public that this is the case, may take some time, however. There are reasons for optimism as more and more of the opinion shaping institutions recognize the need for nuclear power. The Club of Rome is certainly one such institution which in the beginning was very skeptical about the benefits of nuclear power. In a report two years ago it stated that "the use of coal and oil is probably more dangerous to society, because of the carbon dioxide they produce, than nuclear energy. There are therefore strong arguments for keeping the nuclear option open ...". Clearly the incentives for nuclear power are strong but more than statements of learned men will be needed to revitalize the option. The public and the politicians must accept it.

RADIOISOTOPE AND RADIATION TECHNIQUES AND THE ENVIRONMENT

The most essential contributions to environmental improvement would undoubtedly come from a more extensive use of nuclear power worldwide but one should not disregard the importance of radiation, radioisotopes and nuclear techniques in monitoring and protecting the environment. A few examples may show this.

The present inadequacy of our knowledge of the behaviour of the greenhouse gases and of the effects of the gases and the poor calculation models we have to predict the greenhouse effect have already been mentioned. There is a possibility to study the earth's past climate history through isotopic analysis of small air bubbles included in the ice of, e.g., the antarctic polar cap or the Greenland ice cap at various depths. Such measurements on drilling cores of ice have - with very complex interpretations - given a clear correlation over the past 160,000 years between the contents in the atmosphere of methane and CO_2 and the temperature (Fig.12). However, this does not show what was the cause and what was the effect.

Climate change will depend not only on the atmosphere and its content of greenhouse gases. The atmosphere must be seen as part of an overall system which also includes the land, the oceans, the ice caps and the biosphere. So far, we have known little about exchanges, e.g., between the atmosphere and the vast masses of water in the oceans, which certainly delay and possibly could avoid global warming altogether. Studies of radioisotopes appearing in nature at various locations can help to give answers. It is first carbon-14 which exists in nature, always being produced by cosmic radiation in the atmosphere. Secondly, there is tritium which was formed in the atmospheric nuclear weapons tests in the 1950s and 1960s. These tests also increased the amounts of carbon-14 in the atmosphere, giving a signal in time for increased carbon-14 contents. Through sampling and measurements it is hoped that it will be possible to learn more about how water circulates in the ocean and how CO_2 is exchanged between the water and thge atmosphere. This would be important in our efforts towards learning more about the greenhouse effect. It is worth mentioning that IAEA's Marine Environment laboratory in Monaco recently was awarded a scientific award for research in this area.

In the Mediterranean the lack of sewage treatment plants and increasing pollution along several coastlines are a cause for increasing concern. To study the behaviour of the waste until it finally deposits on the seabed a radioisotope of gold has been used as a tracer in French experiments. In the Adriatic part of the Mediterranean we have seen occurrences over the last several years of unusual increases in the fertilization of the sea, giving rise to rapid growth of algae. It was believed that this was due to fertilizer run-off from the fertile Po valley and isotope techniques are now giving us a chance to verify if this is correct. There is a problem here in Egypt with the silt outside the Nile delta which is slowly drifting east and not any more replaced by the Nile. I do not think that this phenomenon can be studied without the use of isotope techniques.

The isotopic composition of petroleum has shown significant differences between different oil fields which gives a chance to determine the source or sources for significant oil spills at sea. Isotope techniques were used by the IAEA Marine Environment Laboratory to study the extent of contamination of the Gulf marine environment following the massive oil spillage during the Gulf war.

The use of agrochemicals has been essential for the "green revolution" which now has made it possible - at least in theory - to provide adequate nourishment to all people on the earth. They do have their negative effects, however. The example of fertilizer run-off from the Po valley has been mentioned but pesticides can be even more obnoxious. Rachel Carson started the consciousness of this when she in her book "Silent Spring" pointed to the effect of DDT on the eggs of many species of birds. Our present use of pesticide poisons is essential and effects can be very complex to evaluate. Radioisotope techniques have since many years made studies of pathways and effects possible in the land environment. We now have learnt that pesticides also can reach the coastal waters, where there have occurred large kills in shrimp and fish farms attributed to pesticides. Again, it is isotope techniques which give the possibility to study how pesticides behave in the marine environment, notably in tropical lagoons which have proven sensitive.

Fresh water resources and their judicious use are a priority issue in many areas of the world. Isotope techniques are essential for any hydrological investigation to determine, e.g., the age and replenishment rate of a subterranean source to avoid overexploitation. Here in the Nile valley they have been indispensable in studies of fresh water resources and have given us answers to such questions as if a fresh water resource is replenished from the Nile or runs the risk of drying up, if there is infiltration of Nile water into adjacent groundwater and the contribution of irrigation to replenishment of groundwater.

The IAEA has been involved in a major ecological investigation of the Amazon region in view of the deforestation which is going on. Through use of isotope techniques it was possible to determine that about half of the rain water which falls in the area originates there. Extensive deforestation could bring with it a risk of not only a local climate change but probably also cause less rain in adjoining, drier regions.

These somewhat scattered examples have been given to show that isotope techniques give an extremely powerful - and indeed indispensable - tool for environmental monitoring and investigations at all levels, local, regional and global. There are some other techniques which give the possibility to diminish the environmental impact of some of our daily activities. Two examples are in radiation processing of flue gases from power plants and of sewage sludge from cities.

When it was realized that SO_2 and NO_x emissions from power station smoke stacks caused acid rain, many countries, notably in Western Europe, imposed strict limitations on emissions. The result was that power plant owners had to equip their plants with chemical factories to clean the flue gases. These were expensive. The main product was gypsum, which in principle can be used in the building industry but in some countries it became clear that too much gypsum was produced and there was no buyer for the large quantities. Radiation can provide an alternative to the chemical process. Electron beam irradiation of the flue gases, with the addition of ammonia, can remove 95% of the SO_2 and 80-85% of the NO_x and the main product can be used as a fertilizer. The electron beam comes from accelerators. No radioactivity is used or produced by the process. It has been technically proven on a small scale corresponding to power plants of some 5 MW(e) and the economics look promising. A demonstration on a larger scale plant is now needed and IAEA would help to set up such a demonstration in Poland, if funds can be found.

Another important application of irradiation is the killing of microorganisms in sewage sludge so that it can be used as fertilizer without risk for spreading infections. In this case the sludge is irradiated with gamma rays from a strong radioisotope source. Again, no radioactivity is created through the irradiation. The technology has been proven, i.a., in a plant in Germany which treats the sewage sludge from a city of some 100,000. The hygienized sludge is sold to farmers. There is another sludge irradiator in use at Baroda in India where it treats the sewage from a community of 200,000. Sewage sludge irradiators are now available commercially in sizes which would be useful for large cities.

There are many more applications of importance in relation to the environment which could be mentioned and some will be during this session. The ones given above still show the importance of nuclear techniques for monitoring and helping to preserve our environment. As to nuclear power it must be concluded that this energy source alone will not solve the serious problems which we are facing. That will require concerted efforts by many countries over a broad range of energy supply systems, recognizing the legitimate needs of developing countries to increase their energy use. On the other hand, it does not seem possible to produce a solution without nuclear power.

SWEDEN: SULPHUR BUDGET 1989

UNIT: THOUSAND TONS AS SULPHUR

• TOTAL EMISSIONS	74
• OWN DEPOSITS IN SWEDEN	28
• TOTAL DEPOSITS	225
• EXPORTS	46
• IMPORTS	197

FIG.1

SESO2.CHT SOURCE:ECE 1991

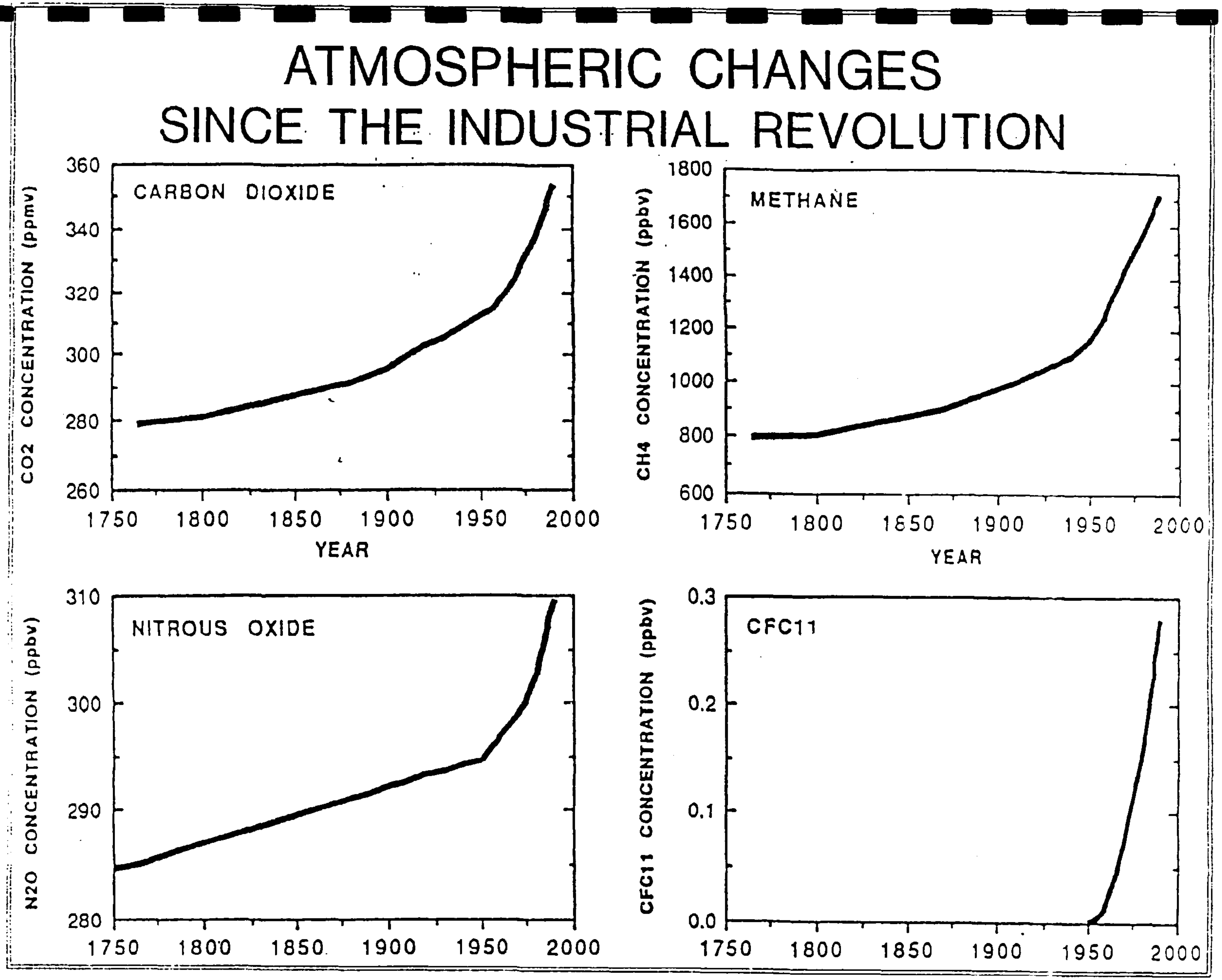
BELGIUM: SULPHUR BUDGET 1989

UNIT: THOUSAND TONS AS SULPHUR

• TOTAL EMISSIONS	178
• OWN DEPOSITS IN BELGIUM	42
• TOTAL DEPOSITS	90
• EXPORTS	136
• IMPORTS	48

FIG.2

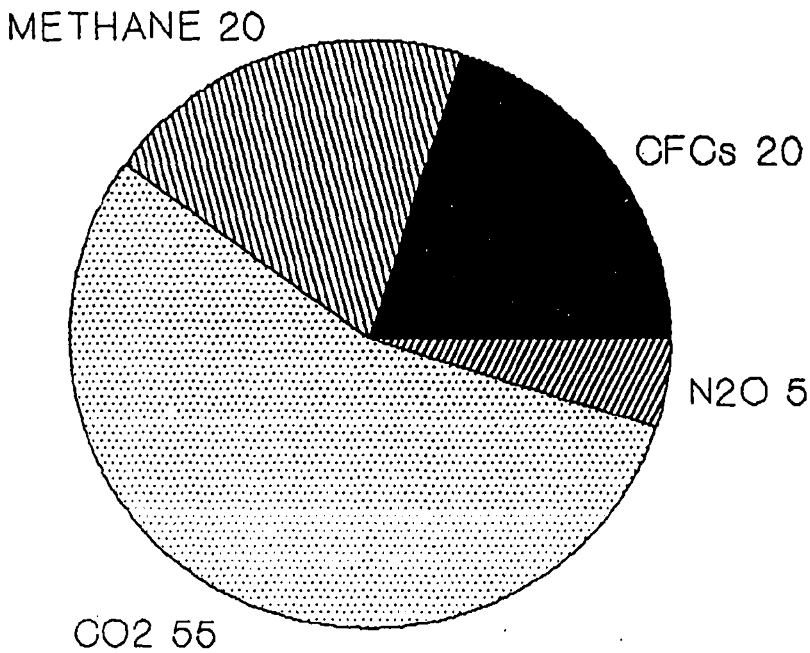
BESO2.CHT SOURCE: ECE 1991



ATMOSPHERIC CHANGES
SINCE THE INDUSTRIAL REVOLUTION
CARBON DIOXIDE
CO2 CONCENTRATION (ppmv)
360
340
320
300
280
260
1750 1800 1850 1900 1950 2000
YEAR
METHANE
CH4 CONCENTRATION (ppbv)
1800
1600
1400
1200
1000
800
600
1750 1800 1850 1900 1950 2000
YEAR
NITROUS OXIDE
N2O CONCENTRATION (ppbv)
310
300
290
280
1750 1800 1850 1900 1950 2000
CFC11
CFC11 CONCENTRATION (ppbv)
0.3
0.2
0.1
0.0
1750 1800 1850 1900 1950 2000

FIG.3

GREENHOUSE EFFECT
CONTRIBUTIONS IN % - 1980s



CFCs: SPRAY CANS, FOAM PLAST., REFRIGERATORS
METHANE; RICE PADDIES, CATTLE, FOSSIL
FUELS PRODUCTION, CARS
CO2: FOSSIL FUELS, DEFORESTATION
N2O: FERTILIZERS, CARS

GREENH1.CHT

FIG.4

GREENHOUSE EFFECT
CONTRIBUTIONS IN % - 1980s

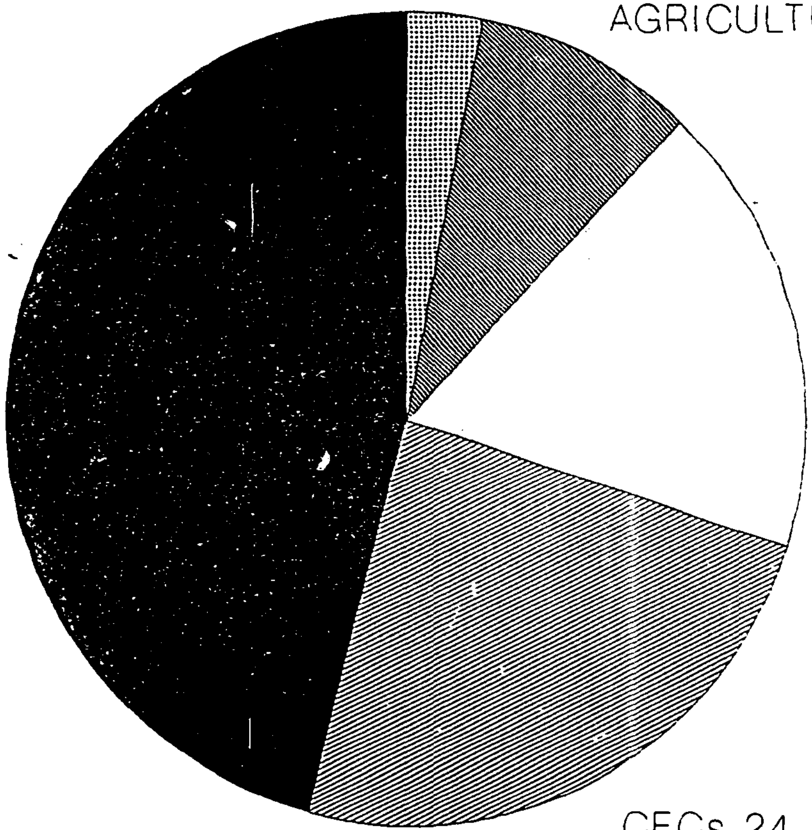


FIG.5

GREENH2.CHT SOURCE:IPCC

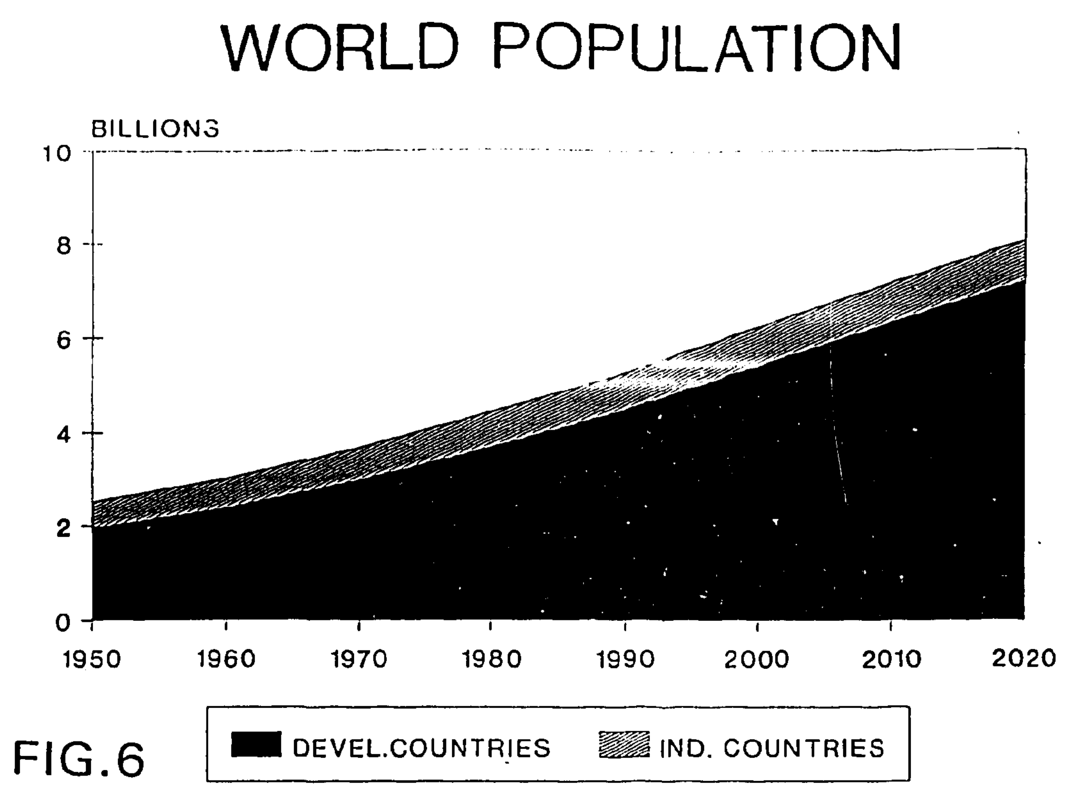


FIG.6

CE UN 1988

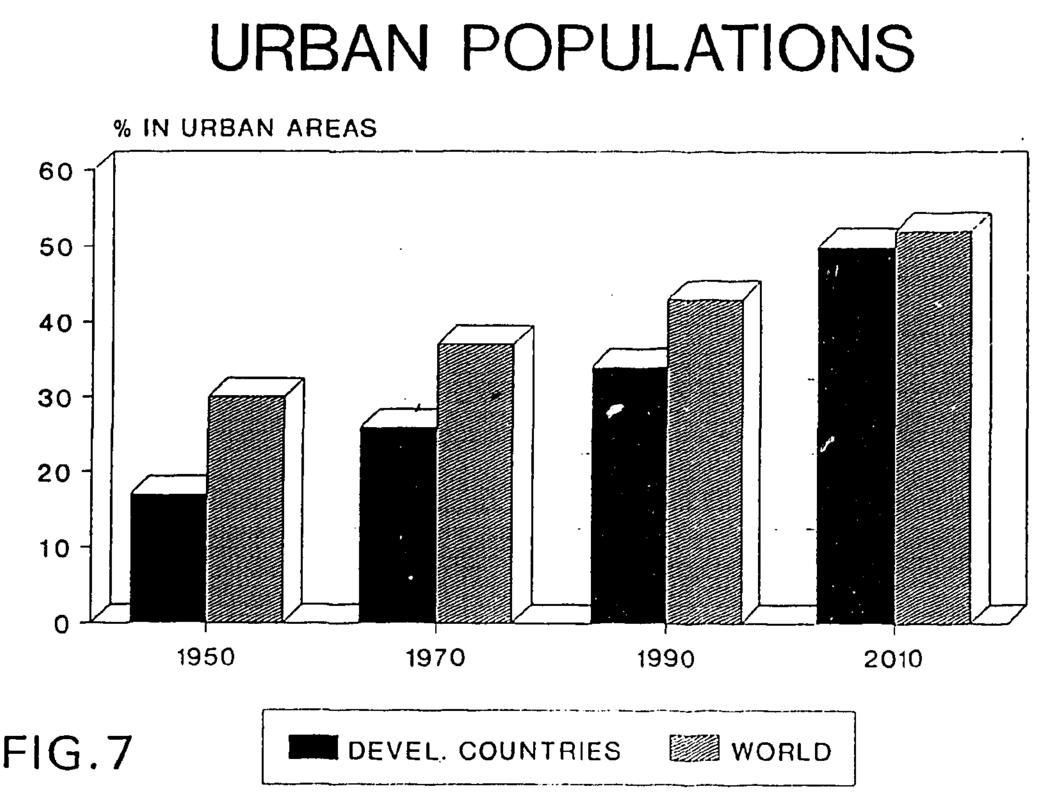


FIG.7

:CE: UN 1988

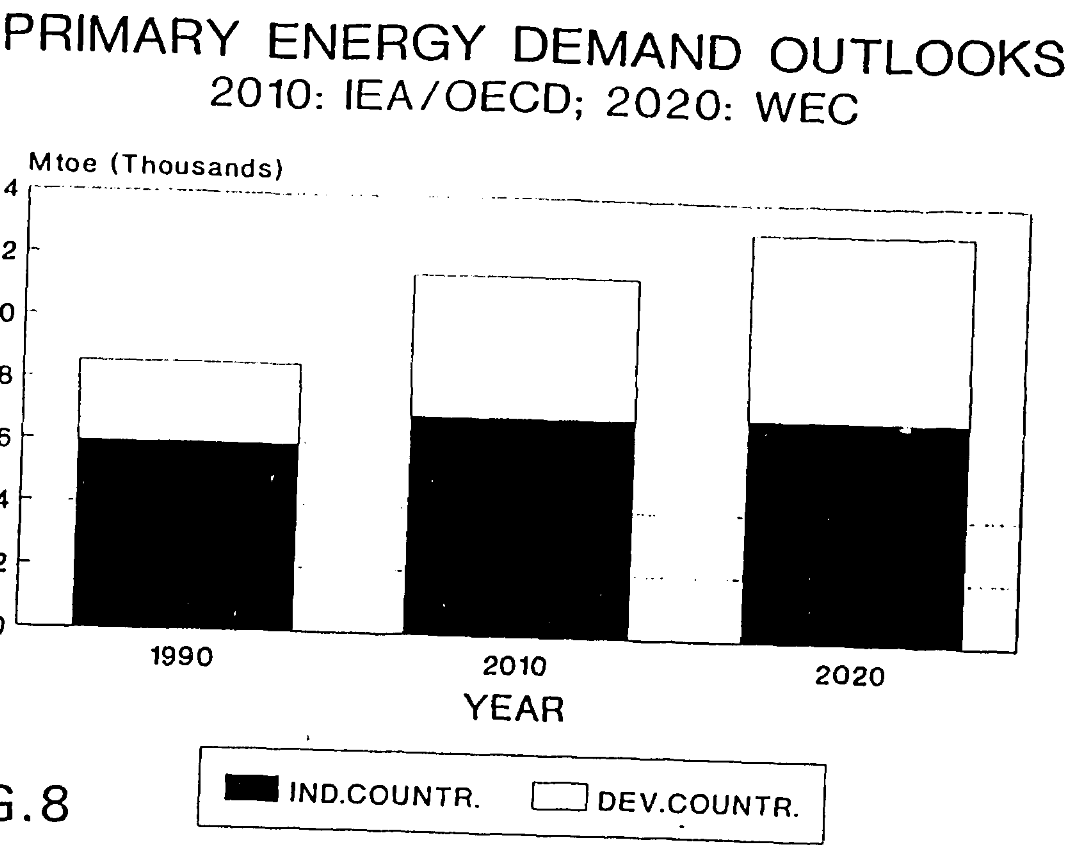

PRIMARY ENERGY DEMAND OUTLOOKS
2010: IEA/OECD; 2020: WEC
Mtoe (Thousands)
14
12
10
8
6
4
2
0
1990
2010
2020
YEAR
IND.COUNTR.
DEV.COUNTR.

FIG.8

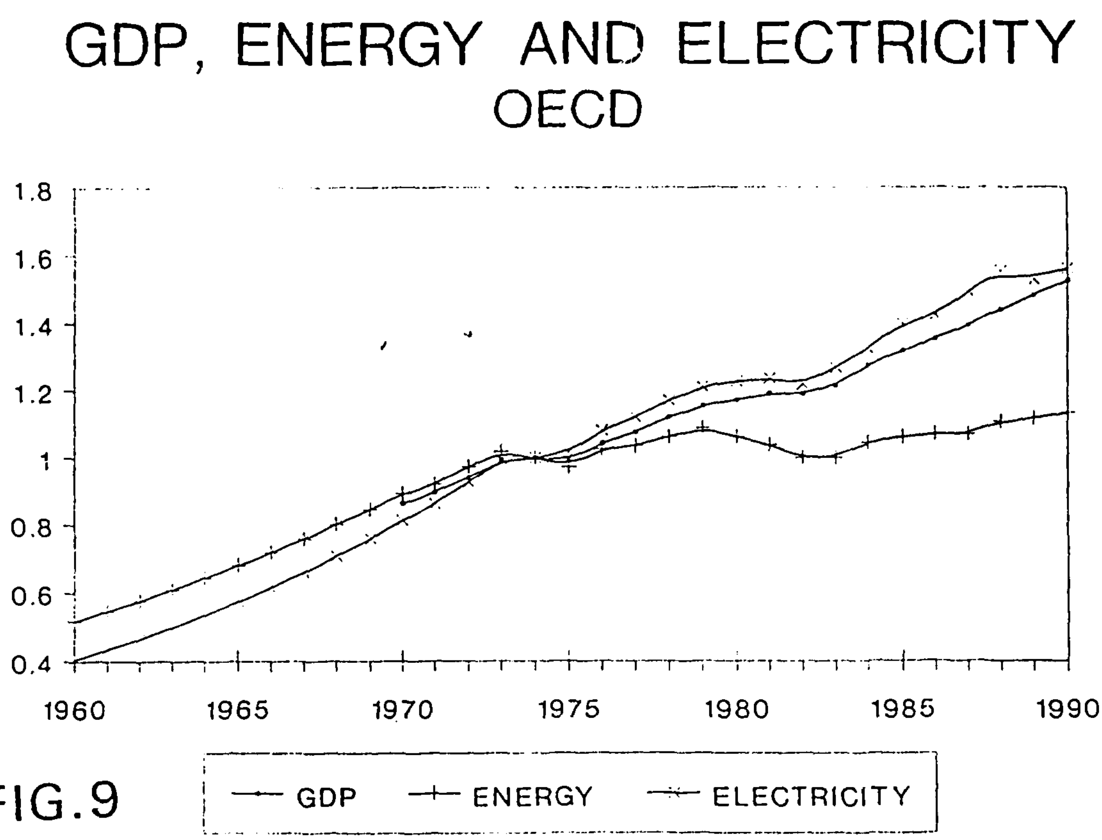
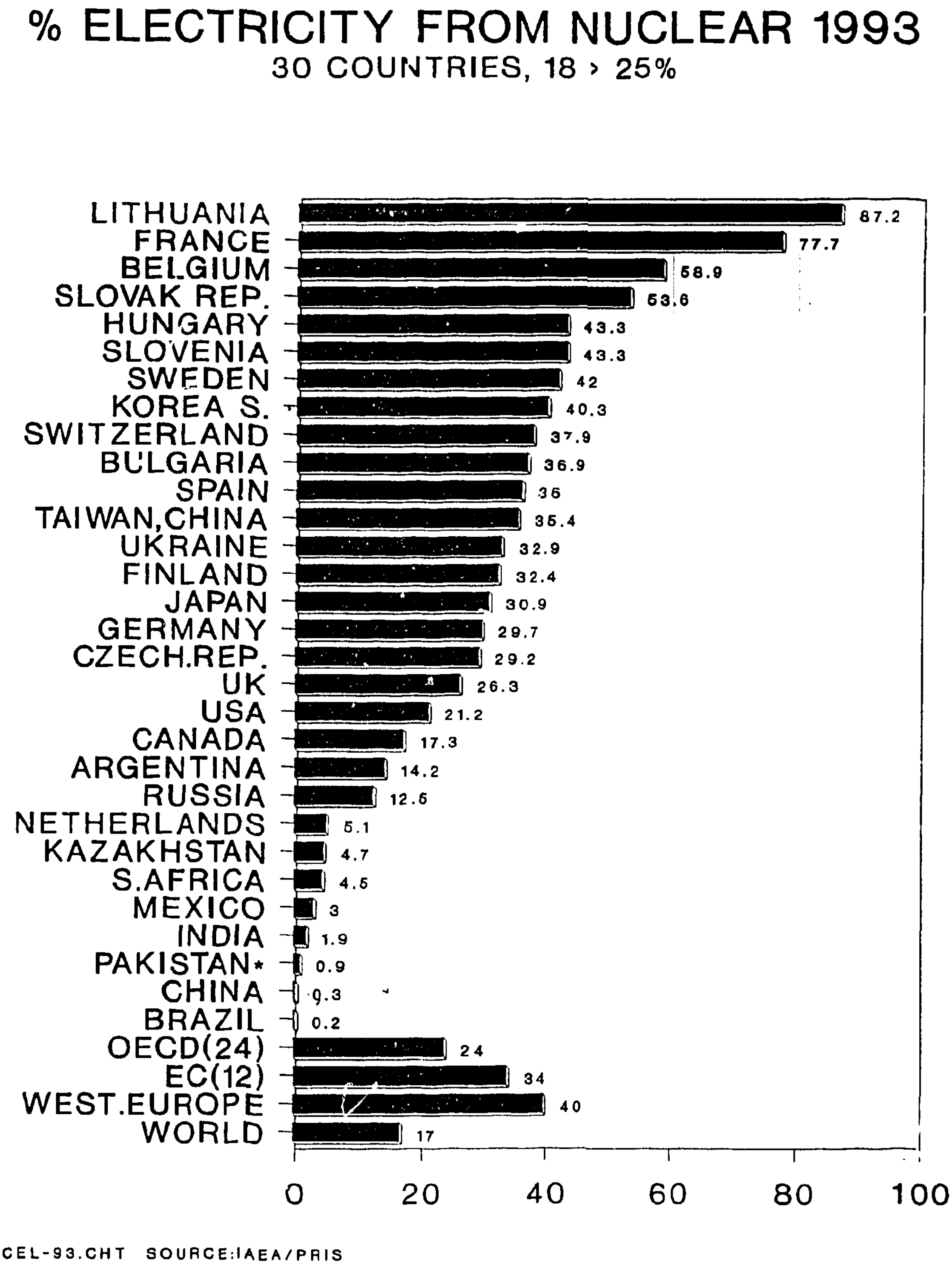
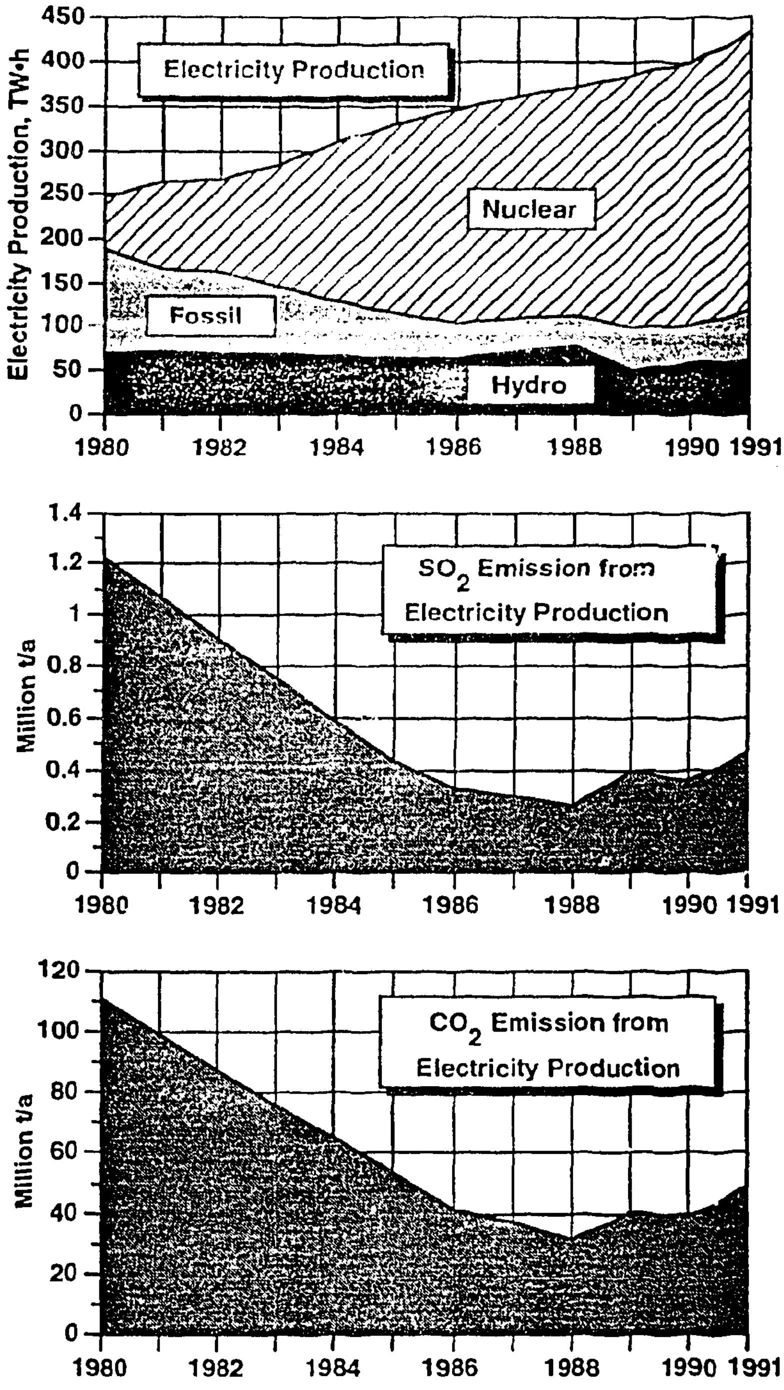

GDP, ENERGY AND ELECTRICITY
OECD
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
1960
1965
1970
1975
1980
1985
1990
GDP
ENERGY
ELECTRICITY

FIG.9



% ELECTRICITY FROM NUCLEAR 1993
30 COUNTRIES, 18 > 25%
LITHUANIA 87.2
FRANCE 77.7
BELGIUM 58.9
SLOVAK REP. 53.6
HUNGARY 43.3
SLOVENIA 43.3
SWEDEN 42
KOREA S. 40.3
SWITZERLAND 37.9
BULGARIA 36.9
SPAIN 36
TAIWAN,CHINA 35.4
UKRAINE 32.9
FINLAND 32.4
JAPAN 30.9
GERMANY 29.7
CZECH.REP. 29.2
UK 26.3
USA 21.2
CANADA 17.3
ARGENTINA 14.2
RUSSIA 12.6
NETHERLANDS 5.1
KAZAKHSTAN 4.7
S.AFRICA 4.5
MEXICO 3
INDIA 1.9
PAKISTAN* 0.9
CHINA 0.3
BRAZIL 0.2
OECD(24) 24
EC(12) 34
WEST.EUROPE 40
WORLD 17
0
20
40
60
80
100
NUCEL-93.CHT SOURCE:IAEA/PRIS

FIG.10



Role of Nuclear Power in Reducing Emissions in France, 1980 – 1991

FIG.11

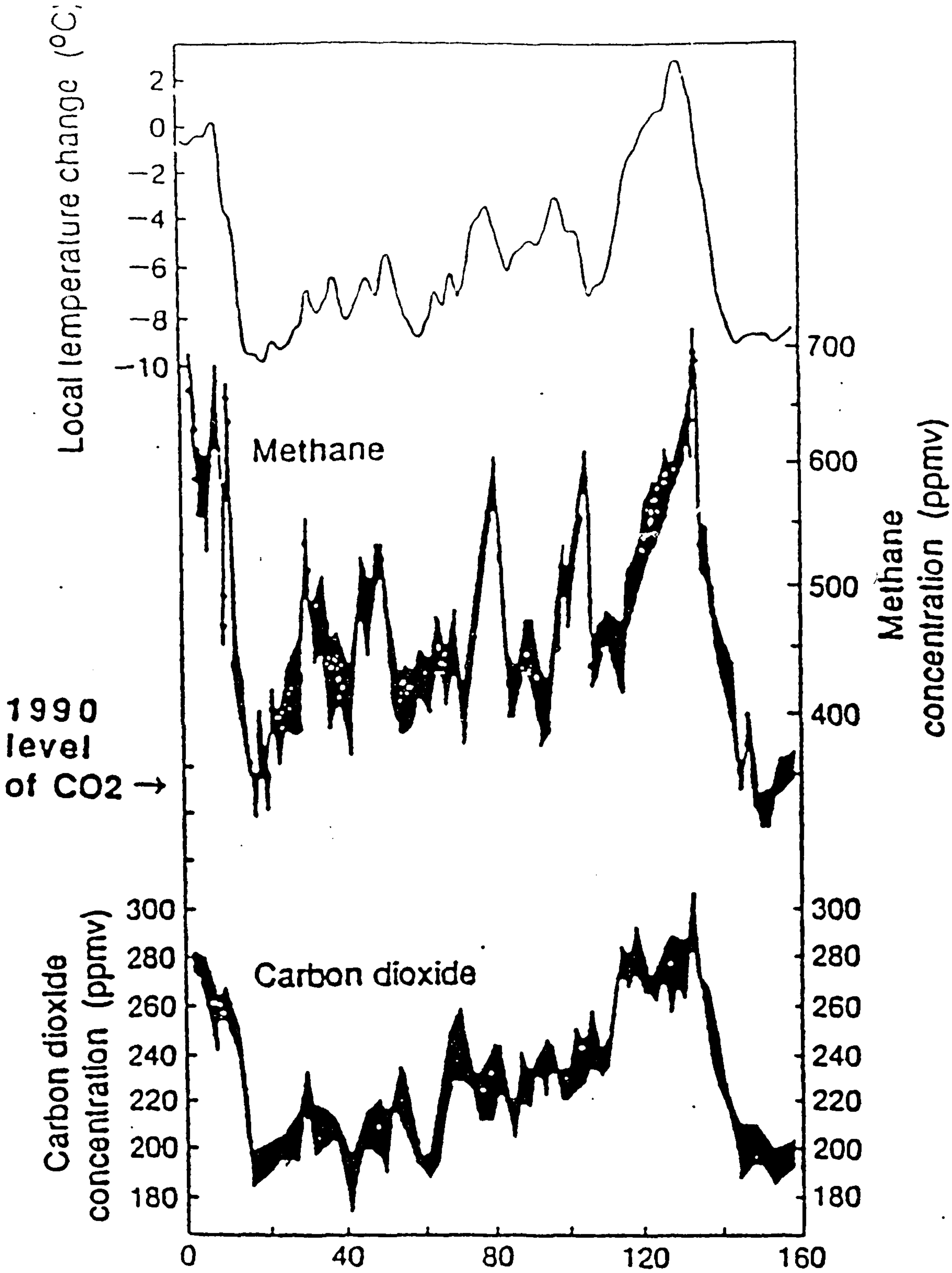

Local temperature change (°C)
2
0
−2
−4
−6
−8
−10
Methane
700
600
500
400
Methane concentration (ppmv)
1990 level of CO2 →
Carbon dioxide
Carbon dioxide concentration (ppmv)
300
280
260
240
220
200
180
0
40
80
120
160
Age (thousand years before present)

FIG. 12

15 June, 1994

ROBERT SKJOELDEBRAND

Swedish citizen, b. 1930

1951	Graduated in technical physics from the Royal Institute of Technology in Stockholm.
1950-1962	Worked in the Swedish atomic energy development programme as project engineer for research reactors. Project chief for the materials testing R2 reactor.
1962-1965	IAEA, Reactors division.
1966	Project chief for nuclear part of the first Swedish nuclear power plant.
1967-1990	IAEA. Among the positions held: Head of Reactor Engineering Section Technical coordinator for contribution to International Fuel Cycle Evaluation. 1986-90 Special assistant to Director General concerned with technical and scientific questions.
1990-	Independent consultant in questions concerning energy and environment. Currently consultant to IAEA's Department of Technical Cooperation.

LECTURE 7

National Seminar On

"NUCLEAR ENERGY IN EVERYDAY LIFE"

Cairo, Egypt

28-29 June 1994

Nuclear Techniques in Medicine and Human Health

by

Prof. Dr. Mohamed M. Nofal

Former Director, Division of Human Health, IAEA

Professor Emeritus, Nuclear Medicine

Alexandria University

Ladies and Gentlemen;

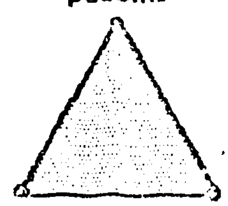
I would like to thank the organizers of this seminar on Nuclear Energy In Everyday Life for inviting me to address this distinguished audience about Nuclear Techniques in Medicine and Human Health.

May be it is time for me to say some plain, simple words of wisdom which I acquired during my exile in the wilderness of Vienna where I had the opportunity to step aside from the hurry and worry of the day to day clinical practice of nuclear medicine and reflect on wider international issues.

I have few questions which I would like to ask and try to find an answer to them. The first question that arises is whether nuclear techniques in medicine are necessary in a developing country? Are nuclear medicine and radiotherapy a luxury for a general hospital in such countries? Is a nuclear reactor as much of a status symbol in a newly emerging nation as a steel mill or new international jet airline ...

In many cases, nuclear medicine for example has been conceived to ease the conscience and justify to some extent the investment in nuclear energy. To conceive the role of nuclear medicine in the health care has been easy, but to deliver it to local hospitals is most often a case of obstructed labour.

Especially in nuclear medicine in a developing country, a triangle can be established to illustrate the case. Assuming that they have the qualified personnel, the triangle comprises patients, radiopharmaceuticals and instruments.



If you have the radiopharmaceutical, the instruments do not work, if the instruments are in order, the right kind of radiopharmaceuticals are not delivered on time; when both are available, the patient is not there, not waiting for the test and being subjected to treatment or may have died! There is also a reverse square law about nuclear medicine; the further away the hospital is from the main centre of nuclear energy in a country, the problems and difficulties increase by a square of the distance.

Not only nuclear medicine is a multidisciplinary science, it has also the property of tagging itself to some departments in a hospital; be it radiology, radiotherapy, internal medicine or even some laboratories. It will be wrong to put nuclear medicine under the aegis of any other department in a hospital, it should be established as an independent clinical department.

We must recognize that nuclear medicine is a high technology medicine and that certain infrastructure is required for successful institution of nuclear medicine in a country. It should be in a hospital where facilities like radiology and clinical pathology are well established. Nuclear medicine procedures should try to answer specific questions, not to get inconfirmable results which do not lead anywhere as far as management of the patient is concerned. One should wonder, is there any point in putting a mirror in front of the blind! If there is no coronary bypass surgery, what use is the thalium perfusion study?

Ladies and Gentlemen;

In the early 20s, von Hevesey introduced the practice of the radiotracer theory in biology by using a natural radioisotope of lead. Soon, the chemists gave birth to biochemistry by applying this principle and the use of other natural radionuclides. But the breakthrough for medicine did not occur until the period between 1938 and 1950 when the production of artificial radionuclides became feasible in nuclear reactors and cyclotrons and the GM tube was developed. Physicians started using radioisotopes of iodine and phospherous in chemical salts to investigate thyroid and blood physiology. Soon, they translated their basic research into the first practical clinical tests with radioiodine in thyroid tissue to treat hyperthyroidism and for the non-surgical destruction of functioning metastases of thyroid malignancies.

Nuclear medicine began to take shape in 1954 with the use of external scintillation probes to register the time vs. activity curves in a given organ after the intravenous administration of relatively complex compounds labelled with ^{131}I (generally known as radiopharmaceuticals) and with the development of the first "rectilinear scanner" for the acquisition of a ^{131}I [illegible] image of the spatial distribution in the thyroid gland of orally administered ^{131}I. These images depicted the magnitude of thyroid function in every region of the gland, presenting the physicians with the first opportunity to analyze the quality of regional function in an organ, in a similar way that X-rays make possible the study of organic morphology and structure. By 1960, the rectilinear scanner allowed the functional imaging of most organs in the human body, completing the first revolution in medicine produced by radioactivity.

A quantum leap in the progress of nuclear medicine imaging occurred in the 60's. The invention of the gamma-camera in its analogic version improved image quality and reduced acquisition time, granting the analysis of the transit of a radiotracer inside the body through a series of sequential images, adding the dimension of time to imaging. With this, nuclear medicine gave a long step from static imaging to dynamic studies. During the 70s nuclear medicine became quantative. First, by coupling a dedicated computer to the analogue gamma-camera to improve image quality, to record fast dynamic processes like the beating of the heart, and to rescue quantative data always hidden in the nuclear images; later, by developing the digital gamma-camera with an integrated computer in its design. Finally, during the 80s, the digital gamma-camera was provided with one to four rotating detectors to reconstruct tomographic images representing the distribution of the radionuclide in several slices of the organ. This new system is better known a single photon emission tomography (SPET). These slices could also be summed up to generate a tridimensional image of the organ, so all its volume and surfaces could be explored increasing notably the sensitivity of nuclear imaging.

Radioactivity created a second revolution in medicine by connecting the extraordinary sensitivity of the radiotracer methodology and the unique specificity of the immunological processes. Radioimmunoassay (RIA) introduced a new concept for measuring in a test tube ("in-Vitro") the tiny concentrations in blood of multiple immuno-reactive substances of biomedical interest, without exposing the patients to ionizing radiation. All of a sudden, medicine suffered a change in dimensions, from the usual measurements in milligrams (10^{-3}g) and micrograms (10^{-6}g), to less known nanograms (10^{-9}g), picograms (10^{-12}g) and femtograms(10^{-15}g). Together with immuno-radiometric assays (IRMA), RIA has influenced a wider spectrum of medical fields by measuring hormones, drugs and enzymes, and by detecting in blood or tissues a growing series of tumor markers.

Cancer diagnosis and therapy:

Cancer is major health problem of our times. Expectations that a single conservative agent -and thus a single cure- would be identified, have now been dispelled and current medical opinion favours the view that each cancer is unique and needs an individual approach. Recently the possibly vital role of "cancer risk genes" (oncogenes) which are aberrant forms of normal genes, has been noted.

Nuclear techniques have made very significant contributions to the diagnosis of cancer. They provide convenient means to detect tumor markers and to visualize tumors by in-vivo and in-vitro tests using radionuclides.

Tumor markers comprise a number of substances expressed by many, but not all tumors. They are released into the circulatory system where their presence or concentrations may indicate the existence of the tumor itself. The elevated blood levels of these materials may indicate the presence of malignancy.

The greatest value of tumor markers measurement lies not in initial or early diagnosis. Rather, it lies mainly in the assessment of prognosis, post-therapy follow-up, detection of early recurrences and when used in combination with organ imaging methods, in monitoring tumor burdens or size.

The radionuclides that are attached to tumors in I.V. administration are very few and are probably confined to ^{131}I to differentiated thyroid cancer after removal of the gland itself, as well as the use of Gallium and MIBG.

More efficient systems for delivery of radionuclides to tumors have been developed as monoclonal antibodies to tumor associated antigens, became available. The sites of antibody deposition may be visualized by external imaging. This procedure is called radioimmunoscintigraphy. The technique itself is quite non-invasive. It consists of I.V. administration of labelled antibody to a patient and imaging after a suitable interval. It is best applied for detection of recurrent cancer of the GI, GU and gynaecological systems especially when using SPECT.

The most recent development in the use of radionuclides for detection of malignant lesion is PET, a sophisticated method using short lived radioisotopes such as ^{18}F, ^{15}O and ^{11}C that are produced in a cyclotron. PET does not merely localize a tumor but provides information on its functional or metabolic status which can be the key to its characterization as being malignant. Brain tumors, epilepsy, stroke and dementia can now be diagnosed and managed much better than formerly through SPECT and PET. PET technology is expensive and needs an initial investment of over US $ 6 million. It is a matter of science/fiction: science in the developed countries and fiction in the developing world.

Before we talk about cancer treatment, it is necessary to remove a simple misconception in the minds of even some responsible authorities, that cancer is not a serious health problem in the third world. The real situation is the other way. Cancer is of increasing concern in the developing countries. Presently available means of control of communicable and parasitic diseases have reduced the problems of their treatment to a problem of availability and delivery of proper health care. Timely vaccination, improvement of sanitation and personal hygiene, maternity and child care as well as the introduction of new curative agents, all these have improved the life expectancy in many developing countries and thus made their population cancer prone.

Young or old, rich or poor, every cancer patient has a right to proper treatment aimed either at cure or towards amelioration of its course. In countries where there is no, or inadequate radiotherapy facilities, we are denying an effective mode of treatment to a large group of patients.

When faced with cancer, the physician in the developing world may not have much to offer. It is estimated that up to 75% of cancer patients in developing countries are in a non-curable stage when first diagnosed. There, surgeons are scarce, chemotherapy is too expensive and radiotherapy is so much depending on machines which are costly to purchase and not easy to maintain. Egypt, with the assistance of IAEA, is proceeding with a technical cooperation project to manufacture a simple, robust prototype of a cobalt machine which would fit the conditions prevailing in developing countries.

Putting all these aside, there is the trained manpower behind these machines. The individual is the single most important factor in the whole process of medical care. We need a person who is well versed in one of the branches of medicine, who is a seeker and is capable of learning a new discipline and teaching it to others. Preparing such a person requires time and patience. Once Confucius said: "If you plan for a year, plant rice; if you plan for ten years, plant trees; but if you plan for hundred years, train men."

Ladies and gentlemen, despite all the difficulties I have mentioned, nuclear techniques in medicine and health in the third world have achieved considerable progress in technology transfer; thanks to the kind assistance of IAEA. One thing I have come to realize, that it is better to light even one candle than to curse the darkness.

LECTURE 8

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USE OF NUCLEAR TECHNIQUES IN FOOD, AGRICULTURE AND PEST CONTROL

Björn Sigurbjörnsson

Introduction

The so-called Nuclear Techniques used in agriculture are of two distinct types but both based on the special characteristics of radio-isotopes which give off radiation or on isotopes which are heavier than the normal element.

One type of application uses the radiation given off by isotopes to enable the detection of individual atoms in infinitely small amounts of matter. With this technique we can e.g. follow the travels of fertilizer elements in the soil, into and throughout the crop plant or the travels of animal nutrient atoms throughout the animal and their deposition in milk and meat. This has resulted in enormous advances in crop and livestock research.

Very minute traces of pesticides and their residues can be detected in food, in plants and animals and in the environment enabling the development of measures to reduce harmful effects.

The other type of application makes use of the unique ability of ionizing radiation - x-rays, gamma-rays, electrons and neutrons to penetrate all types of matter and produce changes within living cells. These changes in cells induced by radiation can do three things: (1) can kill the cell; (2) render it incapable of reproducing itself (sterilize); or (3) cause changes in its genetic make-up, called induced mutations.

This is made use of to kill microorganisms in food, prevent sprouting of potatoes and onions, breed better crop plants or sterilize insects for control Some of this can be accomplished by chemicals, but in some cases the chemicals used leave residues dangerous to health or are themselves dangerous to workers because of their mutagenicity or carcinogenity. No chemical can compete with radiation in penetrating packaging material or living tissues, flesh, bones and seeds. Therefore these nuclear techniques have become highly successful tools in both research and processing. Radiation sources on the other hand are normally in self-contained and completely shielded cells with no radiation hazard. Electronic accelerators of course can be turned on and shut off at will like any electronic appliance.

Use of Nuclear Techniques and their Impacts

A. Radiation

There are three main types of uses:

1. To sterilize insects for eradication

2. To induce mutations for plant breeding

3 To kill or sterilize microbes and pests in food and food ingredients to improve quality, shelf-life and wholesomeness.

1. Insect Sterilization

This application is used in the so-called Sterile Insect Technique (SIT). The technique is based on an elegant and simple technique, discovered by the American entomologists Knipling and Bushland: an insect infestation is eradicated by releasing into the infested area sterile insects in a ratio of 10 - 15 times the number of the wild insects found in the area. It should be obvious that if the sterile flies are 10 times as many as the wild flies, the chance of a fertile mating is only 10%. Therefore, the next generation of the wild population is much smaller. If we again release the same number of sterile flies and repeat this over a few generations, we end up with no flies left. As I said, this is an elegant and smart theory but the exciting part is that it works in practice. Using this technique it was possible to totally eradicate the enormously devastating pest, the New World Screw Worm from the USA and Mexico. To do this big factories had to be built capable of producing billions of flies which are all sterilized by gamma rays. You may recall in 1989 when this pest was found in Libya posing a potentially disastrous threat, not only to Libya and North Africa, but possibly to all of Africa, threatening its wildlife, livestock as well as its human population.

Through an emergency programme costing tens of millions of dollars and requiring the transport of 40 million sterile flies per week from a factory in Mexico to Libya. The cases of miasis - the disease caused by the flies - had reached 12,000 in addition to hundreds of cases of human miasis before the release of the sterile flies resulted in the total disappearance of the Screwworm from the continent of Africa.

Another success story concerns the Mediterranean Fruit Fly. The Medfly is undoubtedly the most damaging insect pest of citrus and stone fruits worldwide, resulting in enormous loss in fruit quality and thus of marketable products as well as huge costs for pesticide treatments. The Medfly originated in the Mediterranean area and was first found across the Atlantic some 30 years ago. When it invaded Mexico and threatened its valuable citrus crop, the Mexican Government took immediate steps. With advice from the Joint FAO/IAEA Division and the Seibersdorf laboratory, the Government built a factory in Southern Mexico capable of producing 500 million sterile Medflies per week (about 5 tons). Shortly thereafter systematic releases were started in the infested area with sterilized flies in overwhelming numbers. A few years later the Medfly disappeared from the country of Mexico.

Now there are factories in Guatemala, Chile, Argentina, Peru and Hawaii and it is hoped that the result will be a drastic reduction in the damage caused by this pest in the New World.

Now let us look at the place of origin of the Medfly, here in this area. The damage caused by this fly to fruit production in Egypt and other countries around the

Mediterranean is also enormous. One tries to control the pest by pesticide applications, but there is growing opposition to the use of pesticides due to their secondary effects on wildlife, food supplies and human health. Yet there are no facilities in Mediterranean countries for mass rearing and sterilizing Medflies. Therefore the IAEA together with FAO are advising and assisting Mediterranean countries on the feasibility of using the SIT in this area.

A recent breakthrough in mass rearing the Medfly has made the use of SIT much cheaper, many times more effective and completely harmless to marketable fruit. This breakthrough was achieved in the FAO/IAEA laboratory and enables the killing of all female eggs by simply raising the temperature of the solution containing the eggs by some 10 degrees.

We are working with the Maghreb countries and are running a pilot test in Tunisia. We are also responding to a request for assistance from Portugal for using SIT to eradicate the Medfly from the island of Madeira. At the end of May we held a consultation of plant protection officials from Syria, Lebanon, Jordan, Israel, Gaza and Cyprus in order to consider the technical feasibility of eradicating the Medfly from the whole region, including Egypt. I should add that an Egyptian scientist was invited but was unable to arrive in time

All these countries suffer from the Medfly and all use pesticides extensively to protect their fruit from the Medfly. The outcome of the consultation was very positive. As a result we are now helping the countries of the region prepare plans for a Middle East regional project for complete eradication of the Medfly betwen Turkey and Libya. The plan is to build a mass rearing factory to be located on Cyprus. It would produce 1 billion flies per week. The flies would be sterilized by gamma rays and released by aircraft, following a carefully prepared plan, in the participating countries. We estimate, if sufficient funds can be found, that the fly could be eradicated from the whole region in 5 - 7 years.

The Medfly cannot survive in low temperatures and does not travel over long distances without suitable hosts. This is why the Medfly will not survive north of Naples or move over the Sahara or east of Amman and Damascus. Thus it would be tempting to eradicate this pest once and for all from all the countries around the Mediterranean. FAO and IAEA are considering the calling of a meeting with technical people from all the countries concerned to look into the feasibility of a Pan-Mediterranean Medfly Eradication Project.

2. Irradiation of Food

Ionizing radiation has the unique ability to penetrate any type of food packaging and the food itself, specifically killing or sterilizing living and active cells in microbes or insects while having minimal effect on the food itself.

Until recently, a variety of chemical fumigants have been used to disinfest fruits and grain or preventing sprouting. Now a number of these fumigants have been found to be harmful, carcinogenic or mutagenic. As a result, many countries have banned nearly all of them, creating great concern in the food industry. Ionizing radiation will effectively disinfest fruits, vegetables and grains without any harmful effect. Even more important is that the products can be packaged, thus preventing reinfestation as long as the package is intact. Now that the GATT accords on sanitary and phytosanitary measures in international trade have taken effect, it is essential that quarantine regulations be met. It is becoming widely recognized that radiation treatment may present not only the most effective means but also the safest way of meeting quarantine regulations and thus facilitate international trade.

It is also becoming widely known that food borne pathogens are on the increase and are causing widespread serious illnesses. WHO says that diarrhea caused by food borne pathogens is the most common cause of child death in the developing world. It is almost impossible to buy chicken in the market which is free of Salmonella or other pathogens. While Salmonella is killed with proper cooking, secondary contamination of e.g. vegetables, continues to cause outbreaks. WHO has recognized that the only effective method of treating chicken for Salmonella is irradiation treatment and indeed recommends to travellers that if possible they should buy irradiated chicken to prevent infection.

The advantages of food irradiation are many and the uses manifold. Yet, it has been difficult to introduce food irradiation into the food industry. There is surprising fear of the use of irradiation in the mind of consumers and consumer unions. For those who know how radiation treatment works and know the results of decades of extensive research into the wholesomeness or irradiated food, it is difficult to understand the basis for this fear. The reason seems to be a general fear of anything "atomic", a belief that irradiated food becomes radioactive - which is never the case - and the association of ionizing radiation with atomic bombs and atomic power plants.

Regardless of the grounds for this unfounded fear, consumers' attitudes must be taken seriously and the consumers and their associations should be given factual information about the true nature of food irradiation and the benefits food irradiation can have for improving and securing food supplies.

3. Mutation Breeding

Ionizing radiation penetrates living plant tissue and can cause changes in the cell nucleus, particularly in the active cells in the seed embryo. These changes affect the chromosomes and the genes and give rise to altered plants. These alterations, called induced mutations, can cause the plant to be shorter, early maturing and more resistant to pests and diseases. The plant breeder selects from the induced mutants those which will improve the performance of the crop.

The results of the application of radiation in plant breeding have been quite dramatic. To date, nearly 1800 varieties of crops and ornamentals of induced mutant origin have been officially named and released to growers throughout the world. Induced mutations have resulted in improvement of practically all important agronomic characters and have resulted in improved varieties in all important crop species, especially in the major cereals. In some countries the induced mutants have come to represent major areas of cultivation, e.g. wheat and rice in China, cotton in Pakistan, rice in the U.S.A., durum wheat in Italy and barley in Europe.

Modern field and horticultural crops are becoming even more refined and higher yielding. In the efforts ahead to double food production in the next 30 years, we are unlikely to find the necessary qualities in existing plant germ plasm collections. The plant breeder will depend on the generation of additional genetic variability which can be induced by mutagenic agents, particularly ionizing radiation. The combination of induced mutations with modern biotechnology and molecular biology has opened up promising new possibilities for crop improvement.

B. Isotopes

1. Soil Fertility

By putting an isotopic label on a fertilizer-nitrogen applied to obtain high crop yields - it is possible to find out how best to apply fertilizers, how deep to place it in the soil, how close to the roots, at what time before or after planting and in what chemical form the fertilizer gives the best results. Many such studies were carried out by FAO and IAEA throughout the world some 20 - 30 years ago. They led to new and improved ways of fertilizer applications. The new methods have long since been incorporated into recommended fertilizer application practices in many countries and for a number of crops, e.g. all the major cereals. Documented savings to farmers and societies as a whole are enormous and may now amount to hundreds of millions of dollars.

Similarly, the use of isotopic tracers in studying the rate of nitrogen fixation by bacteria in symbiotic relation with legumes (peas and beans), it has been possible to develop more efficient ways of employing this symbiotic relationship to replace expensive nitrogen fertilizers. Isotopic techniques are by far the most exact methods of measuring nitrogen fixation rates. The use of isotopic markers in animal nutrition similarly has led to improved animal feeding practices and better utilization of locally available feeds and agricultural wastes.

2. Agrochemicals

There is increasing concern for the impact agricultural practices can have on the environment, especially the harmful effects which may result from careless use of agrochemicals, such as fertilizers and pesticides. An isotopically labelled ingredient in the effective component of such agrochemicals will reveal the presence of the chemical or its residues long after the application as they may appear in plants and animals, water and soil, food or human beings.

For this reason, one attempts with isotopic techniques to assess the impact of various agrochemicals on the environment - on the non-target fauna and flora as well as in food and water.

However, radioisotopes can only be used under experimental and closed-system surroundings since the release of long-lived isotopes emitting harmful radiation is not desirable. therefore most of these applications rely on non-radioactive or stable isotopes which can be identified and traced on the basis of their atomic weight. The IAEA together with FAO and supported by the Swedish International Development Authority is operating three large-scale research programmes to study the effect of pesticides on the fauna and flora in Africa, Central America and in various coastal waters.

3. Disease Diagnosis, Molecular Biology

Isotopic markers are widely used in a variety of basic scientific disciplines which form the basis for much work undertaken in support of food and agriculture. It can be safely stated that without the use of isotopic markers there would be no modern biotechnology, molecular biology and genetics or the myriad spinoffs off these technologies such as modern disease diagnostic techniques. DNA, the basic chemical of life on earth, containing the genetic code, consists of two strands which separate during a phase of reproduction, The basis for molecular biology and genetics lies in being able to identify one strand from the other. This can only be done by a label, in most cases a radioactive isotope (P^{32}).

Work of this nature has led to the many breakthroughs which have occurred in both basic and applied biotechnology. One such application has led to the development of chemicals which are used for the most efficient disease diagnostic method known, called ELISA. This diagnostic method supports a large programme supported by FAO and IAEA in making available diagnostic kits to veterinarians, enabling them to make reliable and quick diagnoses. The large and successful campaign to eradicate Rinderpest from Africa relies on the use of FAO/IAEA supplied ELISA kits. Many other techniques used in the fight against animal diseases rely on isotopic labels: DNA probes, monochlonal antibodies. A related immunoassay technique is based on radiation and is called radioimmunoassay. In FAO/IAEA programmes this technique is primarily used to study the level of the reproductive hormone progesterone. Such studies have given results which have led to shortening of the time interval between calves, thereby increasing markedly both meat and milk production and the grazing pressure on land.

The Role of Nuclear Techniques to Meet Food Production Challenges of the Future

FAO is now preparing a publication showing data and projections for population growth and developments in food and agriculture towards the year 2010 in order to better adjust its programmes to deal with the challenges ahead. FAO is also looking beyond 2010 to discern what really lies ahead in the next centuary. One must remember that e.g. from the time of radiation treatment of a seed to the release of a marketable, improved variety, there may be a 12 - 15 year interval, so that decisions on actions taken today may not be translated into reality until the year 2006 - 2010.

The overriding concern for future developments is the rapid population increase, one million more mouths to feed every 4 days and most of them in food deficient countries.

Another equal concern is for the 800 million souls living with us now on this earth who do not get adequate food and the 200 million children who are undernourished or malnourished and either do not survive or are left with lasting physical deficiencies.

A simple calculation projects that around 2030 there will be 9 billion people on earth, and to feed them all we must double food production.

And this must be done in the face of growing environmental concerns and demands for sustainable development.

Doubling food production would not be so difficult if we would dump ever increasing amounts of fertilizers and pesticides on our crops, have unrestricted access to water and plenty of virgin soils which could be brought under cultivation.

Unfortunately, none of this is available. On the contrary: Soils are eroding at 22 billion tons per year, the earth's soil resources have a half-life of 100 years. Over the last 30 years, cultivated land per person has shrunk some 32%. These trends must be reversed lest our food production capability is not going to deteriorate in the future.

Whatever measures will be taken. one thing is certain: we must rely on science and technology to uncover new methods and new materials, new systems and new crop varieties that will give us a chance. As reviewed above nuclear techniques provide accurate, sensitive, fast and effective tools in research and development. They seem to become more relevant in agricultural research with every year. They are based on some of the most fundamental characteristics of our physical universe, the very nature of atoms and nuclei; it is difficult to imagine technology more firmly based on natural phenomena.

The problems of food and agriculture must be resolved to meet man's most basic and essential needs: the very survival of the individual and the human species. The application of nuclear technology therefore must be problem driven, not simply a demonstration of elegant technology. Nuclear techniques in food and agriculture should not be used aside from and in isolation from the overall effort to increase and secure food supplies. It is for this reason that the International Atomic Energy Agency applies nuclear technology in food and agriculture in a joint programme with the Food and Agriculture Organization of the United Nations. It is an example which should be followed by all national and regional atomic energy authorities.

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Education: Ph.D. (Plant Breeding) Cornell University. 1960.

M.Sc. (Cytogenetics) University of Manitoba, Canada. 1957.

B.S.A. (Agriculture) University of Manitoba, Canada. 1956.

Basic education: Icelandic Grammar School
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Other training:

Training course on use of isotopes and radiation in agriculture, USA 1957 (Oak Ridge and elsewhere)

FAO training course on seed technology, Cambridge, UK 1961.

Distinctions: University of Manitoba: Gold Medal, several scholarships, elected to the Sigma Xi and Phi Kappa Phi Societies.
Honorary Professor at the Chinese Academy of Agricultural Sciences.
Honorary Member of the Board of the Swedish Seed Association, Svalöf.

Publications

95 scientific and review papers and articles, including laboratory manuals and book chapters. Lectures at numerous scientific and technical meetings.

Employment:

From 1983:	Director, Joint FAO/IAEA Division of Nuclear and Biotechnology Applications in Food and Agriculture; */
1974-1983	Director, Icelandic Agricultural Research Institute, Reykjavik;
1968-1974	Deputy Director, Joint FAO/IAEA Division
1963-1968	Head, Plant Breeding and Genetics Section, Joint FAO/IAEA Division
1957-1963	Research Officer (Plant Breeding. University Research Institute, Reykjavik, Iceland.

Other offices held (current and past)

Chairman, FAO Task Force on Biotechnology

Chairman, FAO Standing Committee on the Effects of Radiation

Chairman, Board of Directors, Nordic Gene Bank, Sweden

Chairman, Nordic Agricultural Research Council Association

Member, Nordic Committee for Plant Breeding

Chairman, National Committee for FAO, Iceland

Member, Inter-Nordic Committee for FAO matters

Chairman, Icelandic Codex Alimentarius Committee

Member, Board of Mutation and Polyploidy Section of EUCARPIA

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Chairman, Icelandic Nutrition Society

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References: M.S. Swaminathan

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*/ The Joint FAO/IAEA Division has six subject matter Sections:

- Soil Fertility, Irrigation and Crop Production
- Plant Breeding and Genetics
- Animal Production and Health
- Insect and Pest Control
- Agrochemicals and Residues
- Food Preservation

The Division operates 41 Coordinated Research Programmes with 461 contract holders in National Research Institutes. Each programme dealing with a specific research problem consists of 10 to 15 Research Contract holders who cooperate over 5 years and plan and report on their work in Research Coordination Meetings held during the period.

The Division is also responsible for 207 Technical Cooperation Projects in 60 developing countries and operates a supporting laboratory centre with research and training in soils, plant breeding, animal science, entomology and agrochemicals; with a training facility for food preservation.