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DEVELOPMENT AND INTERNATIONAL ECONOMIC CO-OPERATION: ENVIRONMENT

Progress made towards sustainable and environmentally sound development

Addendum

Report submitted by the International Atomic Energy Agency

THE INTERNATIONAL ATOMIC ENERGY AGENCY'S CONTRIBUTION TO SUSTAINABLE DEVELOPMENT

1. INTRODUCTION

1.1 Background

1. In United Nations General Assembly resolutions 42/187 and 42/186, the report of the World Commission on Environment and Development was welcomed and the Environmental Perspective to the year 2000 and Beyond was adopted.

2. In these resolutions the General Assembly, inter alia, called upon the governing bodies within the United Nations system "to review their policies, programmes, budgets and activities aimed at contributing to sustainable development", "to take account of the analysis and recommendations contained in the report of the World Commission in determining their policies and programmes" and "to report regularly to the General Assembly on the progress made in achieving the objectives of environmentally sound and sustainable development...". At its thirty-second regular session, the Agency's General Conference, in resolution GC(XXXII)/RES/494, requested "the Director General to submit to the Board of Governors in February 1989 information on the contribution of the Agency's programme activities towards achieving the objectives of environmentally sound and sustainable development as a basis for a report to be submitted to the forty-fourth session of the General Assembly".

3. Some major conclusions in the World Commission's report and in the Environmental Perspective are summarized in the following sub-sections of the Introduction to this paper. Section 2 contains some general comments on the two documents by the Agency's Secretariat, and Sections 3 through 7 give information on Agency programmes relevant to sustainable development, including point-by-point information on questions about nuclear energy raised by the World Commission. Section 8 gives information about the significance these programmes have in the overall Agency budget.

1.2 The report of the World Commission on Environment and Development

General considerations

4. The central message of the World Commission's report is that economic growth needs to be revived and that, in the long run, there can be no sustainable development unless environmental concerns are taken into account. More

should be done to integrate environmental concerns into the development activities of the United Nations system, and more emphasis should be placed on preventive rather than clean-up activities. "Sustainable development" is defined as development which "meets the needs of the present without compromising the ability of future generations to meet their own needs."

5. The report lists, in its Part II, the common challenges under the following headings:

- -- Population and Human Resources
- -- Food, Security: Sustaining the Potential
- -- Species and Ecosystems: Resources for Development
- -- Energy: Choices for Environment and Development
- -- Industry: Producing More with Less
- -- The urban challenge.

Energy

6. The World Commission's treatment of the energy question is, of course, of primary interest to the Agency. There are, however, many programmes of the Agency which address problems which fall under other common challenges presented by the World Commission, e.g., the excessive use of fertilizers and pesticides in agriculture and water resource development.

7. Summarizing its treatment of energy the World Commission states: "A safe and sustainable energy pathway is crucial to sustainable development; we have not yet found it." The World Commission concludes that "It is clear that a low energy path is the best way towards a sustainable future. But given efficient and productive uses of primary energy, this does not mean a shortage of essential energy-services. Within the next 50 years, nations have the opportunity to produce the same levels of energy-services with as little as half the primary energy supply currently consumed..."

8. The World Commission points out that no form of energy -- not even new and renewable ones -- is without environmental consequences and risks. It highlights the risks of increased reliance on fossil fuels - due to the greenhouse effect, air pollution and acidification of the environment.

9. The World Commission sees some major unsolved issues in the use of nuclear energy and gives a catalogue of items on which international agreement must be reached. The report concludes that "The generation of nuclear power is only justifiable if there are solid solutions to the presently unsolved problems to which it gives rise". The World Commission stresses "that every effort should be made to develop the potential for renewable energy, which should form the foundation of the global energy structure during the 21st Century".

1.3 The Environmental Perspective to the Year 2000 and Beyond

10. As regards energy, the Environmental Perspective gives the goal as "The provision of sufficient energy at reasonable cost, notably by increasing access to energy substantially in the developing countries, to meet current and expanding needs in ways that minimize environmental degradation and risks, conserve non-renewable sources of energy and realize the full potential of renewable sources of energy".

11. The recommended action as regards nuclear energy is as follows: "International co-operation should aim at the creation of a regime for the safe production and use of nuclear energy, as well as the safe handling of radioactive waste, taking into account, through appropriate mechanisms including prior consultations, the interests and concerns of countries that have decided not to produce nuclear energy, in particular concerns regarding the siting of nuclear plants close to their borders. This regime should extend globally to encompass observance of comparable standards and procedures on management of reactors and the sharing of information and technology for nuclear safety. The Convention on Early Notification of a Nuclear Accident and the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency should be complemented by bilateral and subregional agreements and should also lead to technical co-operation among countries on environmental management of nuclear energy."

2. GENERAL COMMENTS

12. The common challenges listed by the World Commission are of outstanding importance for humanity. To the extent that they lie within the Agency's statutory mandate, the Agency's programme has been responding to them for many years. Thus:

- While focussing on nuclear power as one means of providing energy for economic development, the Agency has developed energy planning techniques which, based on comparisons between different ways of producing electricity, define an economically optimized expansion of electricity systems (see Section 3.3);
- A significant part of the Agency's overall programme is the Joint IAEA/FAO programme on nuclear techniques in food and agriculture, which is almost entirely devoted to increasing food production while reducing the environmental impact of fertilizer and pesticide use (see Section 6.4);
- Nuclear techniques have become routine tools for resource development - for example, hydrological investigations for water resource assessment and development are now hardly ever performed without isotope techniques (see Section 6.3);
- The supply of energy for economic growth in a sustainable and environmentally acceptable manner is a central activity in the Agency's programme (see Sections 3 and 5);
- Environmental monitoring and assessment using nuclear techniques are important in the context of the urban and industrial environments (see Section 5.4.2 and 6.1).

13. The General Assembly's request that United Nations bodies "take account of the analysis and recommendations contained in the report of the World Commission..." does not mean accepting them uncritically.

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14. A general comment on the World Commission's discussion of nuclear power is that it does not adequately take into account the radiation protection and nuclear safety measures already taken in order to protect the environment, the public and persons working at nuclear facilities from radiological hazards. ICRP's work on principles for radiation protection started in 1928.[1] The Agency's safety standards, guidelines, recommendations, data and procedures have all been arrived at through considerable international collaboration, not only among experts from Member States, but also, depending upon the exact subject matter being considered, with organizations such as FAO, ICRP, ILO, IMO, NEA/OECD, UNEP, UNSCEAR, WHO and WMO. These are dealt with in Sections 5.1, 5.2 and 5.3.

15. One objective of efforts in the field of radiation protection is to protect not only present but also future generations from harmful effects of ionizing radiation. The ICRP dose limitation system can be applied to all radiation exposures of individuals and of populations at whatever time and place the exposure is received. That is to say that the dose received through the release of radionuclides is taken into account, whether it is received by a known individual at the time and near the place of release, or by some future individual, say 1000 years in the future and halfway around the world. The consideration of future as well as present exposures enters into decisions on regulation of such activities as releases from nuclear power plants and management of waste disposal facilities. Other industries could well emulate such an approach.

16. The essential characteristics of standards for radiation protection, which are the basis for nuclear safety, are thus compatible with the World Commission's definition of sustainable development (see para. 4 above) which has not been noted by the World Commission in its statement on nuclear energy.

17. The "low energy path" urged by the World Commission is not defined in its report. The World Commission appears not to have considered what is likely to occur in the near-intermediate future or the importance of the different contributions to the world energy supply mix. These subjects are discussed in Section 3 below. The World Commission's major issues concerning nuclear energy are dealt with in Section 4, while the radiation protection and safety aspects of nuclear power are dealt with in Section 5.

18. The non-nuclear problem areas considered by the World Commission where nuclear techniques are making a significant contribution to the study or mitigation of environmental problems and thereby to sustainable development are described in Section 6. Problem areas related to human health have not been included.

19. The Environmental Perspective does not question the basic radiation protection and nuclear safety standards, but recommends the creation of an international régime for their application. To the extent that this is within the Agency's mandate, efforts to create such a régime are dealt with in Section 5.

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[1] For a list of abbreviations used, see the last page.

3. ENERGY DEVELOPMENT

3.1 "The low energy path"

20. The World Commission does not give any general directions for future energy supply except the desirability of a "low energy path" and a recommendation for more research into renewable energy forms. In order to assess the viability of the general directions which it does give, one should perhaps review the basis which seems to have been used in the discussion of the world's energy future.

21. The World Commission's energy scenario appears to be based on "An End-Use Oriented Global Energy Strategy" by J. Goldemberg, T.B. Johannson, A.K.N. Reddy and R.H. Williams published in 1985 (Annual Review of Energy 10:613-688), which presents a possible future scenario for 2020. This is at considerable variance with the conclusions of studies of energy demand and supply over the next 20-30 years made by the World Energy Conference (WEC), the International Energy Agency (IEA) of the Organisation for Economic Co-operation and Development (OECD), the Commission of the European Communities (CEC) and the International Institute for Applied Systems Analysis (IIASA) - see Table 1.

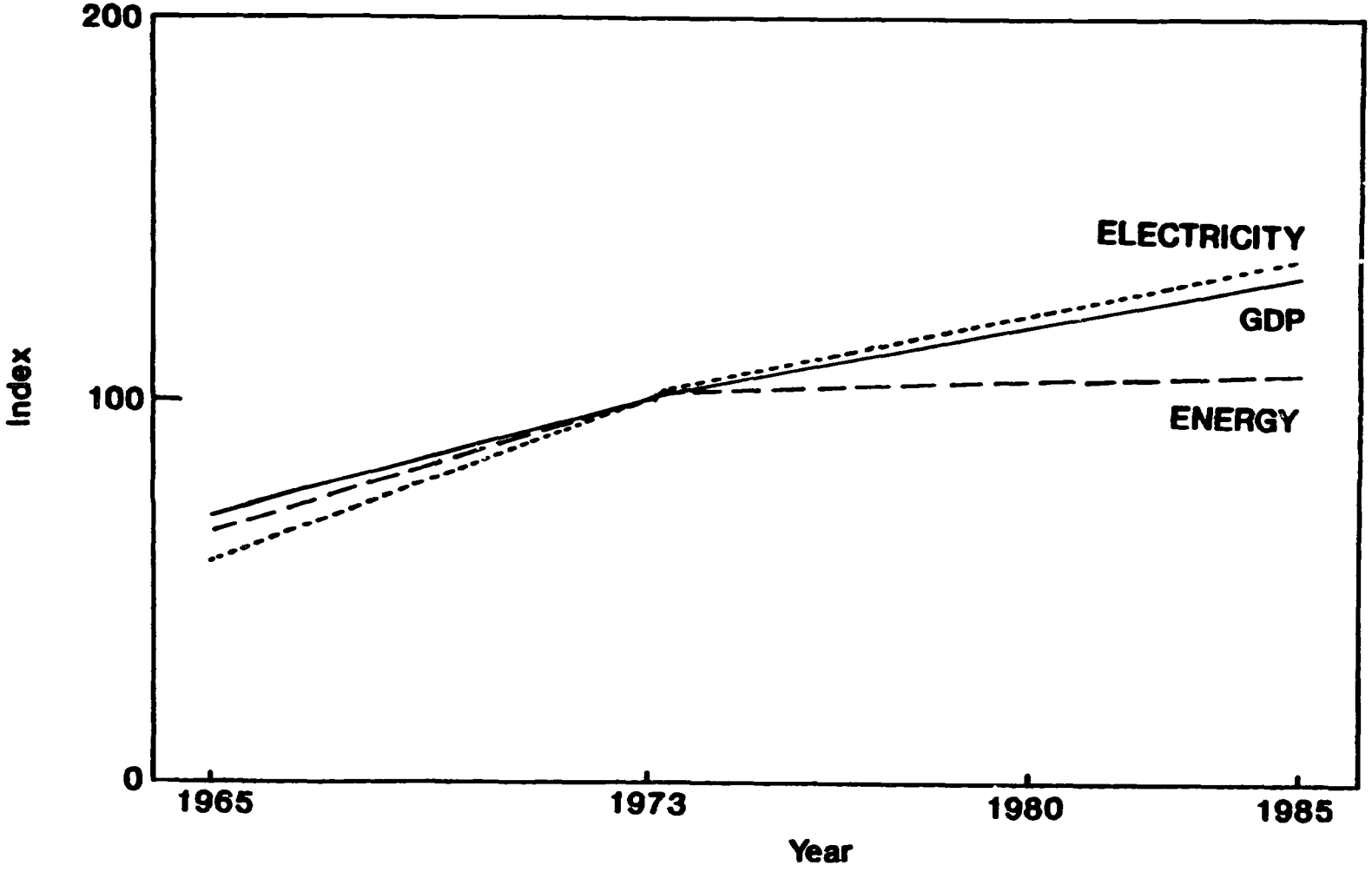
22. It is necessary to understand the background and purpose of the scenario drawn up by Goldemberg et al. The article states that "the purpose is to show that it is both technically and economically feasible to evolve an energy future compatible with the achievement of a sustainable world. Our scenario is not a forecast, but a normatively constructed energy future that we believe could evolve with appropriate public policies".

23. IEA/OECD, CEC, WEC and IIASA are almost unanimous in forecasting an increase in total energy demand from about 7000 Mtoe in 1980 to 10,000-12,000 Mtoe in 2000; also, a further increase is forecast for the period 2000-2010 and projected for the period 2010-2020. It should be noted, moreover, that the figures relating to the studies made by these organizations reflect what they consider to be low-energy scenarios, with only a moderate increase in per capita energy use in the industrialized countries and considerable increases in energy conservation and in the efficiency of energy end-use assumed.

24. The two forecasts/projections for electric energy in Table 1 suggest that the increase in the demand for electric energy will be even more pronounced than the increase in demand for primary energy. For example, although - in general - primary energy consumption has been increasing in OECD countries, since about 1973 it has not been increasing as fast as Gross Domestic Product (GDP), whereas electric energy consumption has been increasing at about the same rate as GDP - if not slightly faster (see Figure 1) - and it is expected that these trends will continue. This also reflects the role of electricity in conservation of primary energy through its higher efficiency in end uses. In this connection, moreover, it is important to bear in mind that the present per capita consumption of electric energy varies greatly from one country to another (see Table 2).

25. It should be further noted that the results of Goldemberg et al. depend heavily on a change to electricity as the end use form of energy. The scenario for 2020 involves an increase in global electricity production by more than 90% over the level of 1980, which is smaller than the increase foreseen

Figure 1: TRENDS IN GDP, PRIMARY ENERGY CONSUMPTION, AND ELECTRICITY CONSUMPTION IN OECD COUNTRIES



Source: IAEA EEDB
World Development Report, 1986 and 1987 editions

NOTE: Each curve is normalized to 100% in 1973.

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Table 1: FUTURE ENERGY DEMAND

	1980	1990	2000	2010	2020
A. WORLD TOTAL PRIMARY ENERGY DEMAND (Mtoe)[1]					
1. IEA/OECD (1982)	6900	8230-8750	10500-12100		
2. CEC (1986)	7270		10800		
3. IIASA (1985)	6800	8000	9900	11300	
4. WEC (1986)[2]	7700	9400	11100	13300	15500
5. Goldemberg et al.	7800				8400
B. DEVELOPING COUNTRIES, TOTAL PRIMARY ENERGY DEMAND (Mtoe)					
1. IEA/OECD (1982)	950	1410-1620	2320-2840		
2. CEC (1986)	1100		2270		
3. WEC (1986)	1950		3500		5500
4. Goldemberg et al.	2220				4400
C. WORLD ELECTRIC ENERGY DEMAND (TWh)					
1. IIASA (1985)	8100	11000	16200	17500	
2. Goldemberg et al.	8150				15600

Sources: IEA/OECD: World Energy Outlook (1982)
CEC: Energy 2000 (1986)
IIASA: International Energy Workshop 1985. A summary of projection responses from 70 organizations, governmental and non-governmental, national and international (1985)
WEC: Conservation Commission, position paper at World Energy Conference in Cannes, 1986

Notes: 1) Mtoe = Million tons of oil equivalent. There are differences in the data for 1980 depending on whether so-called "non-commercial energy sources in developing countries, mainly fuel wood and animal dung, have been included. Also, Goldemberg et al. use a different factor for converting hydro-, wind-, and solar-produced electric energy to primary energy; with the conversion convention proposed by WEC, the figure of Goldemberg et al. for 2020 would be increased by 7.4%.

2) This is a "plausible" hypothesis out of three considered by the WEC Conservation and Studies Committee

in, e.g., the projections of IIASA, but not greatly at variance with other projections for this particular sector. Also, Goldemberg et al. assume nuclear electricity production of more than 50% above the level of 1987, and electricity production from solar, wind power and cogeneration using biomass and fossil fuels which is slightly higher than that from nuclear in 2020.

The World Commission states that "nations have the opportunity to produce the same levels of energy services with as little as half the primary supply currently consumed". Goldemberg et al. actually assume that it will be possible to cut per capita final energy use in industrialized countries by half, while a modest increase in per capita energy use (about 10% on average) is assumed for developing countries - which is a much more restrictive formulation.

Table 2: PER CAPITA ELECTRIC ENERGY CONSUMPTION IN SOME COUNTRIES FOR 1986

Country	kWh per person and year
Norway	23,100
Sweden	16,200
USA	10,700
France	6,200
USSR	5,600
Japan	5,500
Italy	3,200
Industrialized countries average:	**7,200**
Argentina	1,460
Brazil	1,480
Mexico	1,140
Egypt	520
Thailand	480
China	420
Morocco	300
Ghana	270
India	270
Indonesia	176
Bangladesh	50
Developing countries average:	**500**

Source: IAEA Energy and Economic Data Bank, EEDB

26. It seems realistic to foresee a considerable increase in demand for energy - and particularly electricity - at least until 2010. One must then ask how the increased demand is going to be met in a sustainable manner given the increasing certainty about the existence of a greenhouse effect, which is described by the World Commission as making "heavy future reliance upon fossil fuels problematic".

27. The World Conference on the Changing Atmosphere, held in Toronto in June 1988, produced a statement which is pertinent in this context. The following are some quotations from that statement:

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"Humanity is conducting an unintended, uncontrolled, globally pervasive experiment whose ultimate consequences could be second only to a global nuclear war. The Earth's atmosphere is being changed at an unprecedented rate by pollutants resulting from human activities, inefficient and wasteful fossil fuel use and the effects of rapid population growth in many regions. These changes represent a major threat to international security and are already having harmful consequences over many parts of the globe."

"Far-reaching impacts will be caused by global warming and sea level rise, which are becoming increasingly evident as a result of continued growth in atmospheric concentrations of carbon dioxide and other greenhouse gases. Other major impacts are occurring from ozone layer depletion resulting in increased damage from ultraviolet radiation."

[An initial global goal should be to] "reduce CO_2 emissions by approximately 20 percent of 1988 levels by the year 2005. Clearly, the industrialized nations have a responsibility to lead the way, both through their national energy policies and their bilateral and multilateral assistance arrangements."

"Apart from efficiency measures, the desired reduction will require (i) switching to lower CO_2 emitting fuels; (ii) reviewing strategies for the implementation of renewable energy, especially advanced biomass conversion technologies; (iii) revisiting the nuclear power option, which lost credibility due to problems related to nuclear safety, radioactive wastes, and nuclear weapons proliferation. If these problems can be solved, through improved engineering designs and institutional arrangements, nuclear power could have a role to play in lowering CO_2 emissions."

3.2 Energy supply mixes

28. A critical question regarding sustainable future energy supplies is that of the future mix of supply options. The World Commission estimates that renewable energy sources, including hydro power, could - in theory - provide 7500-10,000 Mtoe annually (roughly the world's present total energy consumption), but this optimistic estimate is predicated on rapid technological development supported by strong policies which are not considered by the organizations already mentioned. While all of these foresee an increased use of hydro power for electricity generation (to some 650 Mtoe annually by the year 2000), IEA and WEC consider that solar energy, geothermal energy and biomass can be expected to contribute only an additional 50-60 Mtoe to the "commercial" energy balance of 2000 - i.e. less than 1% (the present share is less than 0.5%). It is expected that coal use will have increased by 36%, from 2200 Mtoe in 1986 to 3000 Mtoe annually by 2000. A French forecast of the use of coal in the OECD countries points to an increase of 45%, from 760 Mtoe in 1986 to 1100 Mtoe in 2000 (Energie, La Documentation Française, 1988). These forecasts are clearly at variance with the scenario urged by the World Commission, and they do not go in the direction of the objectives set by the Toronto Conference. Also, it must be recognized that many developing countries are at present planning to rely on coal for a major part of their future expanded energy supply (e.g., China and India).

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29. The World Commission does not mention the environmental advantages of nuclear power under normal operating conditions, despite the fact that the use of nuclear power has led to reductions in SO_2 and NO_x emissions. In France, for example, emissions of SO_2 decreased by 56% between 1980 and 1986, mainly owing to a marked increase in the use of nuclear power for electricity production, and data from Belgium and Finland also point to significant reductions in SO_2 emissions attributable to the increasing use of nuclear power. Also, France achieved a total decrease of NO_x emissions by 9% between 1980 and 1986, as the decrease in the emissions from the electric power generating sector more than offset the increase in the dominating transport sector. Nuclear power generation does not, of course, produce any emissions of CO_2. For the world as a whole, if the electricity at present being generated by means of nuclear power were being produced by coal-fired plants, around 1.6 thousand million tons of CO_2 would be emitted to the atmosphere each year over and above the present annual total of 20 thousand million tons due to energy production.

3.3 Agency activities related to electricity planning

30. In order to advise its Member States - in particular those which are developing countries - on the feasibility of introducing nuclear power plants into their electricity grids, the Agency developed, during the 1970s, methodologies for the economic optimization of electricity system expansion, taking into account all possible generating options and the current regulatory requirements of the countries in question. These methodologies have since been accepted and used by other organizations, including the World Bank. Over the next 4-6 years, the Agency hopes to study how quantified environmental and health impacts could be incorporated into these methodologies, so that environmental and health hazards are taken into account from the beginning of the planning stage.

31. Widely differing views are at present being expressed about the potential contribution which an expanded use of nuclear power could make to reducing CO_2 emissions. Policy-makers would be assisted by objective information comparing the risks and environmental effects of different energy systems for electricity production.

4. THE WORLD COMMISSION'S MAIN ISSUES CONCERNING NUCLEAR ENERGY

32. As mentioned in para. 9 above, the World Commission raises four issues concerning the development of nuclear power: (1) costs, (2) health and environmental risks, (3) nuclear accident risks, and (4) radioactive waste disposal. In addition, it points to a concern about the proliferation of nuclear weapons.

4.1 The proliferation concern

33. The World Commission concludes that "Among the dangers facing the environment, the possibility of nuclear war is undoubtedly the gravest". The dangers of proliferation associated with the use of nuclear energy are stressed in the report, where it is stated that "Co-operation is needed ... among suppliers and buyers of civilian nuclear facilities and materials and

the International Atomic Energy Agency, in order to provide credible safeguards against the diversion of civilian reactor programmes to military purposes, especially in countries that do not open all their nuclear programmes to IAEA inspection", and that "We therefore recommend in the strongest terms the construction of an effective international régime covering all dimensions of the problem. Both nuclear weapons states and non-nuclear weapons states should undertake to accept safeguards in accordance with the statutes of the IAEA".

34. It is clear that, if more States were to have nuclear weapons, more States would be in a position to trigger warfare that could threaten mankind. It is a moot question, however, whether the development of nuclear power for electricity production increases the risk of proliferation. Conversely, the absence of nuclear power development is no guarantee against proliferation. The reality is that the transfer of peaceful nuclear technology has been used as a means of obtaining commitments to non- proliferation and verification thereof through safeguards. The maintenance of credible safeguards is one of the primary tasks of the Agency. So far, the Agency's safeguards have been successful in giving assurance that material under safeguards has not been diverted to non-peaceful uses.

4.2 Nuclear energy costs and financing

35. The World Commission concludes that "Nations should look very closely at cost comparisons to obtain the best value when choosing an energy path."

36. The Nuclear Energy Agency (NEA) of OECD and the IAEA continuously monitor the actual and projected costs of nuclear and fossil-fired power plant construction and operation, with and without environmental protection measures. The most recent study, published by NEA in 1986, concludes that in OECD countries nuclear power plants built with reasonable construction times (6-10 years) would be competitive with coal-fired plants everywhere except near coal mines in Western Canada and the central USA.

4.3 Health and environmental risks

37. While recognizing the value of the ICRP's recommendations and the Agency's Nuclear Safety Standards (NUSS), the World Commission points out that they are not binding on governments and that different permissible levels of radioactive contamination are set by individual governments, causing disruption in markets and confusion among populations. The environmental aspects of the Agency's programmes in the area of nuclear energy are discussed in Section 5. The particular concerns mentioned in the present paragraph are discussed in Sections 5.1 and 5.2.

4.4 Nuclear accident risks

38. Stating that "... although the risk of a radioactive release accident is small, it is by no means negligible ...", the World Commission makes a number of recommendations related to nuclear safety.

39. Virtually all of these recommendations are covered in the Agency's programmes on the "Safety of nuclear installations" and "Radiation protection" (see Sections 5.2, 5.5 and 5.1).

4.5 Radioactive waste disposal

40. The World Commission notes that "nuclear waste technology has reached an advanced stage of sophistication" but, nevertheless, holds that "the problem of nuclear waste disposal remains unsolved". This opinion is not shared by knowledgeable scientists and engineers (the subject is dealt with in Section 5.3).

4.6 Recommendations of the World Commission relating specifically to nuclear energy

41. In its conclusions on nuclear energy, the World Commission gives a list of items on which "international agreement must be reached". The text of each item and a brief description of the present situation are given in this section, and reference is made to where a discussion may be found in Section 5.

(a) "Full governmental ratification of the conventions on "Early Notification of a Nuclear Accident" (including the development of an appropriate surveillance and monitoring system) and on "Assistance in the Case of a Nuclear Accident or Radiological Emergency" as recently developed by IAEA" (Section 5.6.1)

(b) "Emergency response training for accident containment an for decontamination and long-term clean-up of affected sites, personnel and ecosystems" (Section 5.6.2 and Section 5.3.4)

(c) "The transboundary movement of all radioactive materials, including fuels, spent fuels, and other wastes by land, sea, or air" (Section 5.1.2 and Section 5.3.5)

(d) "A code of practice on liability and compensation" (Section 5.6.1)

(e) "Standards for operator training and international licensing" (Section 5.2)

(f) "Codes of practice for reactor operation, including minimum safety standards" (Section 5.2)

(g) "The reporting of routine and accidental discharges from nuclear installations" (Section 5.4)

(h) "Effective, internationally harmonized minimum radiological protection standards" (Section 5.1)

(i) "Agreed site selection criteria as well as consultation and notification prior to the siting of all major civil nuclear-related installations" (Section 5.2)

(j) "Standards for waste repositories" (Section 5.3)

(k) "Standards for the decontamination and dismantling of time-expired nuclear reactors" (Section 5.3.4)

(l) "Problems posed by the development of nuclear powered shipping" (Section 5.7)

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5. ENVIRONMENTAL ASPECTS OF NUCLEAR ENERGY

42. The present document does not go into the details of the many and varied programmes of the Agency that relate to the concerns of the World Commission. These concerns involve complex issues that cannot easily be discussed in non-technical language.

43. A cross-sectoral look at the Agency's programmes in the area of nuclear energy from the point of view of

- environmental monitoring and assessment,
- environmental impact diminishment,
- environmental impact prevention, and
- resource development

indicates that the environmental perspective is an integral part of these Agency programmes. A brief summary of the programmes in the nuclear energy area is given in Table 3. Activities relating to nuclear fuel minerals exploration and assessment are discussed in the section on the application of nuclear techniques (Section 6), along with other resource development activities.

5.1 Radiation Protection

44. With regard to the World Commission's specific recommendation on radiation protection standards (para. 41(h)), radiological protection has long had effective, internationally accepted standards. The ICRP considers and publishes the basic principles upon which radiation protection should be based. The implementation of the ICRP principles was left to national authorities. In 1962, the Agency published the first edition of the Basic Safety Standards for Radiation Protection (Safety Series No. 9), based on ICRP principles. When the second edition was published in 1967, the Board of Governors recommended that all Member States conform their own regulations to the Standards. The third edition was published in 1982 and was jointly sponsored by WHO, ILO, NEA/OECD and the Agency. A fourth edition is foreseen for 1991.

5.1.1 Intervention levels

45. The above-mentioned standards apply to controlled sources of radiation and therefore are not applicable to accident situations, where the only way in which exposures may be limited, if needed, is by some kind of intervention. The concept of "intervention levels" came into being after the fire at the Windscale reactor in 1957. A summary of the intervention levels for specific nuclides in air and foodstuffs and on pasture in different countries is given in Safety Series No. 55, "Planning for off-site response to radiation accidents in nuclear facilities", published in 1981. Guidance on setting intervention levels was provided by the Agency in 1985 as Safety Series No. 72, and on derived intervention levels in 1986 as Safety Series No. 81. Much of the confusion after the Chernobyl accident arose from the widely varying response actions, particularly the levels at which protective measures were initiated. This prompted the governing bodies of a number of international and intergovernmental organizations to request that the existing guidance be reviewed with the purpose of seeking better harmonization. Since that time,

the relevant organizations, particularly the Agency, WHO, FAO, NEA/OECD and the CEC, have been working in close co-operation. A revised version of Safety Series No. 72 is expected to be published in 1989. Since the guidance given in Safety Series No. 81 will need to reflect these changes also, it too will be revised and broadened.

Table 3: SUMMARY OF SOME NUCLEAR ENERGY PROGRAMMES WITH ENVIRONMENTAL COMPONENTS

AREA	Environmental monitoring & assessment	Environmental impact diminishment	Environmental impact prevention
Radiation Protection			
• Basic standards & criteria	X	X	X
• Intervention levels		X	X
• Transport regulations			X
Nuclear Safety			
• NUSS* standards		X	X
• Staffing of power plants			X
• OSART* missions			X
• Siting of facilities	X	X	X
Radioactive Waste			
• Radioactive waste management			X
• Low-level waste disposal		X	X
• High-level waste disposal		X	X
• Marine disposal		X	
• Decontamination		X	
• WAMAP/WATRAP*		X	X
Monitoring and Assessment			
• Standards and criteria	X	X	
• Monitoring	X	X	
• Assessment	X	X	
• Measurements	X		
Risk Management	X	X	X
Emergency Response			
• Conventions		X	
• Training		X	

* See the last page for an explanation of abbreviations.

46. The World Commission's concern about differing standards for levels of radioactive contamination (Section 4.3) is valid. The Chernobyl accident pointed out a widespread unpreparedness to cope with international trade in contaminated food products. With the Agency acting as a consultant to FAO and WHO, recommendations were submitted to the Codex Alimentarius Committee in July 1988 on recommended levels of radionuclides in foods moving in international

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trade. These recommendations are to be circulated to countries for comment through the Codex contact points so that a revised version may be reviewed and accepted by the Committee in 1989.

5.1.2 Transport regulations

47. In 1959, the Agency began to develop safety regulations for the transport of all radioactive materials, covering all modes of transport; one of the main objectives was the prevention of environmental pollution. In developing these regulations, the Agency worked in close co-operation with other international bodies such as the Central Commission for the Navigation of the Rhine, the Central Office of International Railways, the European Atomic Energy Community, IMO, IATA, ICAO, ILO, ISO, UPU and WHO. The first edition of the Agency's Regulations for the Safe Transport of Radioactive Materials (Safety Series No. 6) was published in 1961; revised editions were issued in 1964, 1967, 1973 and 1985. One of the current areas of review is the requirements for packaging plutonium shipments by air, the aim being to determine whether they are sufficiently stringent.

48. The IAEA's regulations have been adopted by or are the basis for the national regulations of essentially all Member States of the Agency, and have been incorporated into regulatory documents issued by a number of international organizations, including IATA and ICAO for air transport, IMO for transport by sea, and UPU for transfer by post. The safety record in the shipment of radioactive materials over a period of more than 35 years is exemplary. More than 10 million packages of radioactive materials are transported each year with minimal risk. This good safety record has not, however, given rise to complacency. The Agency's regulations have been further improved. Better packages have been developed and Safety Series No. 6 will continue to be updated and revised to reflect these improvements.

49. It is recognized that even the best regulations are of little value unless their provisions are complied with. For this reason, the Agency also provides advisory material on the proper application of the Transport Regulations, and has encouraged the development of effective programmes of quality assurance for packaging and assurance of compliance with regulatory requirements. In addition, the Agency has prepared recommendations on the development of emergency services and emergency response plans to minimize the consequences of any accident that may occur, and is helping Member States and international organizations to make provision for such events.

50. Physical protection to prevent the theft or sabotage of materials to be transported is also important, inter alia in guarding against contamination of the environment. Responsibility for the physical protection of dangerous goods is a matter of national sovereignty, but international co-operation and consensus in this field are vital. In 1972, the Agency published "Recommendations for the Physical Protection of Nuclear Material", which were revised in 1975 and 1977. Between the years 1977 and 1979, 58 countries and the European Atomic Energy Community negotiated, under the aegis of the Agency, a Convention on the Physical Protection of Nuclear Material, establishing standard measures of physical protection during international transport. The contracting parties are required to provide for punishment for a number of defined criminal offences and to co-operate in preventive measures and information exchange on such acts as theft, sabotage and extortion involving nuclear material. The Convention entered into force in 1987 and now has 47 signa-

tories and 23 parties. In 1988 the Agency's General Conference, in resolution GC(XXXII)/RES/492, expressed the hope that the Convention would obtain the widest possible adherence. The Agency is now examining the question whether a revision or expansion of the 1977 version of its physical protection recommendations would be desirable.

5.2 Nuclear Safety

51. The risks to health and the environment from a nuclear power plant depend on the design, siting, construction and operation of the plant. Approaches to minimizing the risks include the development of safety standards, the review of operations, and information exchange. The concern of the World Commission mentioned in Section 4.4 is considered in this section.

5.2.1 NUSS: Nuclear Safety Standards Programme

52. Under the NUSS programme, the Agency issued five codes of practice in 1978; it subsequently issued 55 safety guides to accompany the codes. In 1988, a revised set of codes was approved by the Agency's Board of Governors. The codes establish a common approach and cover the areas of governmental organization, siting, design, operations and quality assurance (see Table 4 for a listing of all NUSS documents). The codes include one on "Safety in nuclear power plant operation including commissioning and decommissioning". Many States have already promulgated or may desire to set standards more detailed or stringent than the NUSS standards, which reflect an international consensus. Even standing alone, however, the NUSS codes provide an adequate level of safety conforming to radiation protection principles, and several countries have adopted them in part or as a whole as national regulatory standards. In the World Commission's report, the need for such standards was mentioned (para. 41(f)).

Table 4: GUIDES ISSUED FOR THE NUCLEAR SAFETY STANDARDS (NUSS) CODES

Governmental organization	Siting	Design	Operation	Quality assurance
Training, qualification	Earthquakes	Safety functions	Training, qualification	Programme
Licence applications	Seismic analysis	Fire protection	In-service inspection	Records system
Application review	Atmospheric dispersion	Protection systems	Limits and conditions	Procurement
Inspection, enforcement	Population distribution	Internal missiles	Commissioning	Construction
Emergency preparedness	Man-induced events	Man-induced events	Radiation protection	Operation
License content, format	Hydrological dispersion	Ultimate heat sink	Emergency preparedness	Design
Regulations and guides	Hydrogeology	Emergency power	Maintenance	Organization
	Foundations	Control systems	Surveillance	Manufacture
	Site survey	Radiation protection	Management	Auditing
	River floods	Fuel handling	Fuel handling	Fuel assemblies
	Coastal floods	Safety principles	Plant wastes	
	Extreme meteorology	Containment		
	Tropical cyclones	Reactor coolant		
		Core design		

53. In 1987, to assess the variations in regulatory régimes worldwide, the Agency sent a questionnaire to countries with developed or developing nuclear power programmes. The results from this questionnaire were discussed in 1988

at a symposium jointly organized by the Agency, NEA/OECD and the Federal Republic of Germany. The possibility of evaluating, on a voluntary basis, the regulatory practices of individual countries in light of the NUSS codes and other good practices adopted in various countries is one outcome of that symposium. Member States have also been asked to provide information on whether the relevant requirements of their national legislation and regulations are consistent with the revised NUSS codes, an action which has been supported by the Agency's General Conference (in resolution GC(XXXII)/RES/489).

5.2.2 Nuclear facility siting

54. Paragraph 41(i) refers to the World Commission's recommendation about siting. Symposia on the siting of nuclear facilities were held in 1963, 1967 and 1974. The proceedings were published by the Agency. Technical reports on the aseismic design and testing of nuclear facilities and earthquake guidelines for reactor siting have been prepared (1968, 1972). An early Safety Series report (No. 29) on the application of meteorology to safety at nuclear plants dealt also with site selection. The siting of radioactive waste disposal facilities is covered in Section 5.3 on waste management A code of practice, "Safety in Nuclear Power Plant Siting", has been published under the Agency's NUSS programme, along with a number of supplementary safety documents (see Table 4).

55. Consultations on and prior notification of plans to site a nuclear facility are sometimes requested by individual States located in proximity to a proposed site. Bilateral and multilateral arrangements are often the mechanism for consultations.

5.2.3 Staffing of nuclear power plants

56. The World Commission recommends that action be taken on the training and licensing of reactor operators (para. 41(e)). In 1979, as part of its NUSS programme, the Agency issued a safety guide on "Staffing of nuclear power plants and the recruitment, training and authorization of operating personnel" (see Table 4). There is also a programme to review requirements of and criteria for qualification standards for nuclear power plant operating personnel and to appraise related training programmes. A guidebook on qualification of nuclear power plant operations personnel was published in 1984 and is scheduled for updating in 1989. There is no international licensing of reactor operators; the examination of the qualifications of such personnel is the responsibility of national authorities. The Agency has, however, through its technical co- operation programme, helped to establish national training centres for plant operating personnel.

5.2.4 Operational Safety Review Teams: OSARTs

57. The Agency has traditionally provided advice and assistance to Member States through expert missions. In 1982 the OSART (Operational Safety Review Teams) programme was set up to make in-depth three-week long reviews of operational safety practices at nuclear power plants. Although the programme was initially planned for developing countries, its value soon became apparent also to industrialized countries. OSART teams had up to the end of 1988 reviewed operations at 29 plants in 20 Member States. For 1989, some 10 missions are planned.

5.3. Radioactive Waste Management and Disposal

58. The objective for the management and disposal of radioactive waste is control, containment and isolation from the biosphere so as to protect the environment and avoid health hazards. Although the World Commission statement that "the problem of nuclear waste disposal remains unsolved" (Section 4.5) reflects a commonly held public perception, scientists and engineers meeting under Agency auspices have for a number of years held that no additional breakthrough in technology is needed for the safe disposal of any radioactive waste, including high-level waste such as spent fuel.

59. A characteristic of radioactive waste in comparison with wastes from other activities (industrial, agricultural, etc.) is that it arises in small quantities and that the associated hazard decreases with time. To illustrate the point: a coal-fired power plant will probably set free - apart from huge quantities of CO_2, SO_2 and NO_x - a larger amount of toxic heavy metals than the total amount of spent fuel arising from a nuclear power plant producing the same amount of electric energy. Moreover, these metals will remain toxic forever.

60. In the early 1960s a number of Safety Series documents were prepared on the disposal of radioactive waste into the sea, in the ground and into rivers, lakes and estuaries and on the management of wastes at nuclear power plants and from radioisotope users. In addition, the treatment of low- and intermediate-level radioactive wastes was considered in a number of early technical reports. In the 1970s, however, the increased concern about environmental issues led many countries to place greater emphasis on the management of radioactive wastes, and the Agency responded with increasing emphasis on waste management issues. Over the years waste management subjects have been the topics of a number of conferences and symposia held at frequent intervals starting in 1959. In Table 5 is a listing of the topics covered, together with an indication of the year and any co-sponsoring agency.

Table 5: RADIOACTIVE WASTE MANAGEMENT SYMPOSIA/CONFERENCES
Co-operating agencies and year are given in brackets

Waste disposal (1959)
Treatment of low- and intermediate-level wastes (ENEA, 1965)
Disposal into seas, oceans and surface waters (1966)
Disposal into the ground (ENEA, 1967)
Treatment of airborne wastes (USAEC/Harvard University, 1968)
Management of low- and intermediate-level wastes (NEA, 1970)
Management of nuclear fuel cycle wastes (NEA, 1976)
Underground disposal (NEA, 1979)
Management of gaseous wastes (NEA, 1980)
Management of alpha-contaminated wastes (CEC, 1981)
Management of uranium mining and milling wastes (NEA, 1982)
Radioactive waste management (USDOE, 1983)
Conditioning of wastes for storage and disposal (CEC/NEA, 1983)
Siting, design and construction of underground repositories (1986)
Management of low- and intermediate-level wastes (CEC, 1988)

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5.3.1 Standards and criteria for low-level waste disposal sites

61. The World Commission's recommendation on criteria for disposal (para. 41(j)) is discussed in the next three subsections. In 1977, work began on the development of an integrated approach to the preparation of standards and criteria for the disposal of radioactive wastes into geological formations. The resulting Safety Series reports for low- and intermediate-level wastes are listed in Table 6. The guidebook on shallow ground disposal has a companion technical report on "Site investigations for repositories for solid radioactive wastes in shallow ground", which covers the earth science and other studies required for the selection and confirmation of an underground repository site.

Table 6: LOW- AND INTERMEDIATE-LEVEL WASTE SAFETY SERIES
Safety analysis methodologies (1984)
Disposal in rock cavities (1983)
Site investigations, design, construction, operation, shutdown and surveillance (in rock cavities and shallow ground) (two in 1984)
Criteria for underground disposal (1985)
Acceptance criteria (1985)
Performance assessment (1985)
Guidance on underground disposal (1981)
Disposal in shallow ground -- a guidebook (1981)

62. At the present time, the coverage of this area is considered up-to-date and emphasis is being placed on providing practical assistance to Member States. In support of this assistance a technical document is being prepared for publication in 1990 with guidelines for safety assessment procedures. In addition, attention is being focused on the problems of wastes with chemical as well as radiological hazards (so-called "mixed wastes"). A number of reports are under preparation in this area. In 1989 the Agency, in co-operation with NEA/OECD, is planning a symposium on safety assessments of radioactive waste repositories.

63. Uranium mining and milling wastes, if not properly managed, can have important ramifications for health and the environment. In 1987, the Agency published a code of practice on this subject. In 1981, a technical report was published describing current practices and options for the confinement of uranium mill tailings.

5.3.2 High-level waste disposal

64. A publication on "Safety principles and standards for the underground disposal of high-level radioactive waste' is expected to be approved and published in 1989. It should assist in the implementation of a number of high-level waste repository projects being planned in several countries. Other recent publications on high-level waste in the Agency's Safety Series or Technical Reports Series are listed in Table 7.

65. It is planned to issue safety codes and guidelines for radioactive waste management and disposal in a coherent format similar to that of the NUSS codes.

Table 7: HIGH-LEVEL RADIOACTIVE WASTE PUBLICATIONS
SAFETY SERIES
Safety principles and standards (in preparation)
Safety analyses for deep repositories (1983)
Safety assessment for underground disposal (1981)
Regulatory procedures (1980)
TECHNICAL REPORTS SERIES
Handling and storage of conditioned wastes (1983)
Site selection factors (1977)
Site investigations for deep repositories (1982)
Near-field effects (1985)
Site investigation techniques (1985)

5.3.3 Marine waste disposal

66. Radioactive waste has been disposed of into the marine environment since the 1940s. This practice was, in fact, continued until a moratorium took effect in 1985. Since there was concern about the transboundary implications of such disposals in the late 1950s, specifically at the United Nations Conference on the Law of the Sea in 1958, the Agency commissioned a scientific panel to examine the problem and recommend measures to ensure that such activities would not lead to unacceptable hazards to man. This resulted in Safety Series No. 5, "Radioactive waste disposal into the sea", published in 1961. That document was in continuous demand until it was replaced in 1981 by Safety Series No. 61. The entry into force in 1975 of the Convention on the Prevention of Marine Pollution by the Dumping of Wastes and other Matter (London Dumping Convention, 1972) gave the Agency specific responsibilities for the definition of high-level radioactive wastes unsuitable for dumping at sea, and for making recommendations to national authorities in matters concerning the issuance of special permits for the ocean dumping of radioactive wastes not falling within this definition. The Agency prepared the first "Definitions and Recommendations" in 1975, and revised them in 1978 and 1986 in the light of technical advances. Considerable technical documentation on this subject exists, and the subject is kept under continuous review. For example, a document published in 1988 on the potential impacts on marine organisms of dumping under conditions near the limits set as unacceptable has indicated that the current "Definitions and Recommendations" would have to be revised taking such impacts into account. However, in light of the current de facto moratorium on dumping, there is no urgency to initiate such a revision.

5.3.4 Decontamination and decommissioning

67. Contrary to public perception, practical experience does exist from the decommissioning and dismantling of a number of smaller nuclear power stations. Since the financing of decommissioning and waste disposal is often cited as an issue or as a barrier to nuclear power development, several Member States have introduced a kilowatt-hour charge on electricity to take care of the future costs of radioactive waste disposal and the decommissioning of nuclear power plants. One of the World Commission recommendations relates to

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decommissioning activities (para. 41(k)). The Agency published, in 1980, Safety Series No. 52, entitled "Factors relevant to the decommissioning of land-based nuclear reactor plants". Technical reports on aspects of decommissioning nuclear facilities were published in 1983, 1985 and 1986. Current work involves the development of technical and regulatory guidance and reviews of the status of selected technologies and management systems.

68. A new area was added to the radioactive waste management programme after the Chernobyl accident to address questions of the decontamination of facilities and the environment after large-scale accidents. It is intended to issue during the 1989/1990 period two technical reports on the safe transport, disposal and stabilization of very large volumes of contaminated material from the clean-up of large areas after a nuclear accident and on the rehabilitation, decommissioning and disposal alternatives for a nuclear reactor after a serious accident, based on the experience from Chernobyl (see World Commission recommendation 41(b)).

5.3.5 Current issues and future directions

69. The needs for the management of radioactive wastes in developing countries vary with the level of use of radioactive materials, the existence of a uranium mining industry or the existence of power or research reactors. In order to meet the needs of developing countries for advice on practical approaches to the integrated development of radioactive waste management systems, the Agency initiated a Waste Management Advisory Programme (WAMAP) in 1987. Assistance is given in the establishment of regulations, the development of a regulatory framework for licensing and inspection, the analysis of problems and the selection of solutions, and the design, construction and operation of waste management facilities.

70. The Agency has also been exploring mechanisms for providing international peer review assessment services in the area of radioactive waste management. The concept of a Waste Management Assessment and Technical Review Programme (WATRAP) has recently been proposed to help Member States in the evaluation of the technical, operational, and performance features of planned or existing waste management systems. This programme is directed towards those States which have well established waste management programmes. Developed Member States requesting these services would be expected to cover the cost of the review. The programme is expected to begin early in 1989.

71. Regulations or conventions on the export of toxic wastes are being developed by both OECD and UNEP. Radioactive wastes are expressly excluded in this work. There is at present no international regulation or convention covering the export of radioactive wastes. In 1988, the General Conference adopted a resolution condemning "all nuclear waste dumping practices which would infringe upon the sovereignty of States and/or would endanger the environment or public health of other countries" (GC(XXXII)/RES/490). A code of practice for international transactions involving radioactive waste is to be developed by the Agency as one of the actions resulting from the resolution.

5.4 Environmental Monitoring and Impact Assessment

72. Of great importance in the quantification and assessment of the state of the environment are environmental monitoring and assessment activities.

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The Agency's programmes on the monitoring and assessment of environmental radioactivity involve the radiation protection, waste management and agrochemicals programmes, and also the work of the Agency's laboratories at Seibersdorf and Monaco. To set the stage for a discussion of the Agency's work in matters of environmental radioactivity, it is useful to review the symposia and conferences held over the years. Table 8 lists the subjects of some meetings, often co-sponsored by other interested organizations.

Table 8: SYMPOSIA ON RADIONUCLIDES AND THE ENVIRONMENT

Assessment of radioactive contamination in man (WHO, 1964, 1971, 1984)

Assessment of airborne radioactivity (1967)
Physical behaviour of radioactive contaminants in the atmosphere (WMO, 1973)

Environmental contamination by radioactive materials (FAO/WHO, 1969)
Rapid methods for measuring radioactivity in the environment (FRG, 1971)
Transuranium nuclides in the environment (USERDA, 1975)
Behaviour of tritium in the environment (NEA, 1978)
Environmental migration of long-lived radionuclides (CEC/NEA, 1981)

Radioactive contamination of the marine environment (1972)
Impacts of nuclear releases into the aquatic environment (1975)
Techniques for identifying transuranic speciation in aquatic environments (CEC, 1980)
Impacts of radionuclide releases into the marine environment (NEA, 1980)

Environmental behaviour of radionuclides released in the nuclear industry (NEA/WHO, 1973)
Environmental surveillance around nuclear installations (1973)
Environmental effects of cooling systems at nuclear power plants (UNECE, 1974)
Combined effects of radioactive, chemical and thermal releases to the environment (NEA, 1975)

73. A number of safety standards, guides, recommendations, procedures and data and relevant technical reports published over the years give a clear idea of the direction the Agency has gone in the area of environmental monitoring and impact assessment. Only more recent documents are referred to in the following selective discussions.

5.4.1 Environmental standards and criteria

74. Releases to the environment from routine operations of nuclear power plants are very small. Standards and criteria exist for setting limits to such releases, in order to assure protection of the public. In 1978, the Agency published guidance for use by national authorities on concepts and principles for planned environmental releases of radioactive material. This was completely revised in 1986 with the publication of Safety Series No. 77, "Principles for limiting releases of radioactive effluents into the environment". In essence this document provides a procedure for limiting the dose to the most exposed population (the "critical group") from a particular source. The limit, called a "source or release upper bound", will be considerably lower than the primary dose limit for the general public recommended by ICRP and the Agency in the Basic Safety Standards. This is so because the primary dose limit applies to exposure of the individual from all sources,

not just the one being considered. In 1988, the Agency published "The application of the principles for limiting releases of radioactive effluents in the case of mining and milling of radioactive ores." The question of limiting releases of effluents is receiving continuing attention and a new safety guide is planned for 1990/1991. A technical document establishing source upper bounds for specific practices will be issued in 1990.

75. Releases of transboundary significance are covered by the document "Assigning a value to transboundary radiation exposure", published in 1985 as Safety Series No. 67. The document sets forth the principle that "policies and criteria for protecting populations outside national borders from releases of radioactive substances should be at least as stringent as those for protecting the population of the country in which releases occur".

76. Since an individual member of the public may also be exposed to sources of radiation resulting from widespread regional or global releases, upper bounds (i.e. fractions of the primary limit) are also needed for sources with regional or global impact. A Safety Series document on the "Establishment of upper bounds to doses to individuals from global and regional sources" is in publication. The global and regional upper bounds differ from the source upper bound in that they apply to the sum of doses from many sources, not to the dose from one particular source, and they must be implemented through international agreements, rather than by national authorities alone.

77. Work is also continuing to establish internationally agreed principles for the exemption of sources of trivial levels of radiation from regulatory control. International consensus on exemption levels was reached in 1988. Work to apply these levels to specific problems should be completed in 1991.

5.4.2 Environmental monitoring

78. "Environmental monitoring" is a term used in two different senses. The first is monitoring for surveillance and compliance with authorized procedures and the second is monitoring for research, to collect information relevant to assessing the behaviour and pathways of radionuclides in the environment. Both are important in Agency programmes. Three Safety Series documents have been prepared on the subject: "Objectives and design of environmental monitoring programmes for radioactive contaminants" (1975), "Monitoring of airborne and liquid radioactive releases from nuclear facilities to the environment" (1978) and "Radiation monitoring in the mining and milling of radioactive ores" (1988). These are complemented by a number of technical reports (see Table 9).

Table 9: TECHNICAL REPORTS ON ENVIRONMENTAL MONITORING
Reference methods for marine radioactivity studies (1970 and 1975)
Radiotracer experiment design in marine biological systems (1975)
Partition coefficients and concentration factors in the marine environment (1985)
Particle size analysis in airborne contamination assessment (1978)
Tritium in some typical ecosystems (1981)
Measurement of radionuclides in food and the environment (1988)

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79. The World Commission made a recommendation on the reporting of releases (para. 41(g)). Discharges of both a routine and an accidental nature are reported to national authorities. Bilateral and multilateral arrangements also exist for the reporting of certain releases. The reporting of discharges to international organizations is done retrospectively and selectively for assessment purposes. These kinds of assessments are done on a recurring basis by UNSCEAR. The licensing of routine discharges is done by national authorities, as is surveillance for compliance with discharge limits.

80. The reporting of accidental discharges having potential transboundary consequences, on the other hand, falls under the Convention on Early Notification of a Nuclear Accident. A communications system designed to rapidly notify responsible national authorities about such accidents is being established by the Agency pursuant to its responsibilities under that convention. Demonstrations, including the use of the Global Telecommunication System of the World Meteorological Organization, which has been supporting the Agency's work under the Convention, have been conducted. The system is now fully operational. However, it should be noted that the primary responsibility for notification and emergency planning and preparedness remains with national authorities.

81. Reporting mechanisms for marine discharges of regional importance have been developed for the Baltic, through the Helsinki Commission, and the Northeast Atlantic, through the Paris Commission. Upon request, the Agency does provide technical advice on marine radioactivity to regional conventions and to Regional Seas programmes sponsored by UNEP, but it has no role in their operations (see subsection 5.3.3 for a discussion of the London Dumping Convention). For airborne releases of radionuclides no similar conventions exist.

82. Work for the near future includes the preparation of a new safety guide. In co-operation with FAO, WHO, WMO and UNEP, an international symposium will be held in 1989 on environmental contamination following a major accident.

5.4.3 Environmental assessment

83. In the area of environmental impact assessment, there are two Safety Series publications: "Generic models and parameters for assessing the environmental transfer of radionuclides from routine releases" (1982) and "Environmental assessment methodologies for sea dumping of radioactive wastes" (1984). Work is proceeding on methods for assessing individual and collective doses in connection with the guidelines for limiting releases to the environment, and a document on the subject will be published in 1989. A coordinated research programme on validation of models for the transfer of radionuclides in the terrestrial, urban, and aquatic environments initiated in 1987 will be completed in 1992. Technical reports dealing with assessment and effects are listed in Table 10.

Table 10: TECHNICAL REPORTS ON ENVIRONMENTAL ASSESSMENT AND EFFECTS
Effects on aquatic organisms and ecosystems (1976)
Methodology for assessing impacts on aquatic ecosystems (1979)
Modelling impacts of deep sea disposal on living marine resources (1988)
Assessment methods for regionally and globally dispersed radionuclides (1985)
Environmental effects of cooling systems (1980)

5.4.4 Radionuclide measurements in environmental samples

84. The Chernobyl accident demonstrated the need for national laboratories to be able to handle large numbers of samples of food and other environmental samples in a short period of time. In addition, information on reference methods for the measurement of radionuclides needed to be updated in the light of the simpler and more reliable methods introduced since the FAO/WHO/IAEA publication in 1966 on methods of radiochemical analysis. To respond to these needs, the Agency introduced a programme on "Fallout Radioactivity Monitoring in Environment and Food" (MEF). A document with a comprehensive list of reference methods for key radionuclides and a section on the instrumentation and space requirements of a proper radioactivity measurement laboratory has just been prepared and will be published as a technical report entitled "Measurement of radionuclides in food and the environment". This document will soon be complemented by one dealing with rapid methods of analysis for emergency situations.

85. The Agency's Analytical Quality Control Services (AQCS) programme has been in operation since 1959. Reference materials are prepared and distributed to various laboratories in Member States not only for the assessment of low levels of radioactivity, but also for the determination of minor and trace elements and the analysis of certain organic compounds. Recently bulk environmental and foodstuff samples containing elevated levels of radioactivity have been collected in order to prepare materials for intercalibration studies. The first of these, a milk powder, is available for distribution.

5.5 Risk Management and Comparative Assessments

86. In Sections 4.3 and 4.4, mention is made of the World Commission's concerns about risks from nuclear energy. The health risks and environmental effects of different energy technologies have been aspects of the public debate concerning energy systems. Developing a common basis to compare risks and effects has not been an easy task and is far from complete. Much effort has gone into the development of models for transport through atmospheric, aquatic and terrestrial pathways and the incorporation of pollutants into food chains. The understanding of the effects of radioactivity in man is generally good. However, relationships between the amounts of material present in air, water and foodstuffs; the amounts incorporated into the human body; the relationship between chronic and acute exposures; and the effect of such exposures are at best poorly known for non-radioactive pollutants. Comparative studies involving radioactive and non-radioactive pollutants therefore entail very large uncertainties. In addition, some environmental effects do not involve man, but rather some aspect of the environment, such as climatic changes (carbon dioxide increases) or ecosystem disruption (dying forests or barren lakes from acid rain) that are not directly related to human health.

87. The Agency is therefore placing new emphasis on comparative assessments of the health and environmental impact of nuclear power. Work will concentrate on compiling and evaluating the available information and developing ways of presenting comparative data in a more meaningful way, taking account of the uncertainties involved. Also, the Agency has joined with UNEP, UNIDO and WHO in a joint project on assessing and managing health and environmental risks from energy and other complex industrial systems. The project has four main objectives: to develop a guide for risk management and hazard control

procedures; to establish and operate an information system on health and environmental effects; to train personnel in risk management and hazard control; and to promote a risk management hazard control approach to energy and other complex technology planning and use.

5.6 Emergency Response

5.6.1 Convention on Early Notification of a Nuclear Accident (including the development of an appropriate surveillance and monitoring system) and Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency

88. With regard to the World Commission's recommendation in paragraph 41(a), it should be noted that both conventions were adopted by consensus in 1986 and are both in force. By the end of 1988, 72 States had signed and 32 ratified the Convention on Early Notification, and 70 had signed and 28 ratified the Convention on Emergency Assistance. The subject of the development of an appropriate surveillance and monitoring system is discussed in subsection 5.4.2. The Agency's General Conference, in resolution GC(XXXII)/RES/493, called upon those States which had not done so to become parties to the two Conventions as soon as possible.

5.6.2 Emergency response training

89. The establishment of appropriate and adequate emergency planning and preparedness programmes in support of nuclear facilities depends heavily on the availability of people trained to do the job. Technical guidance alone will not suffice. Interregional training courses on "planning, preparedness and response for radiological emergencies" were held in 1982, 1984 and 1987.

90. Since an actual emergency is a rare event, the most realistic way of testing, maintaining and improving the effectiveness of emergency response capabilities is through drills and emergency exercises. In 1981, the Director General wrote to all Member States offering to send special assistance missions to help in the development and improvement of emergency plans by reviewing existing plans and evaluating emergency exercises. Since that date the Agency has responded to some 15 requests for such missions.

5.7 Legal and Other Issues

91. There are at present two international conventions on civil liability for nuclear damage, the Paris and Vienna Conventions. In order to establish a link between the two Conventions, a Joint Protocol was adopted on 21 September 1988 at a diplomatic conference held in conjunction with the thirty-second regular session of the General Conference. The Joint Protocol was signed on that day by 19 States. Once in force, the Joint Protocol will extend the benefits of the Paris Convention to the States party to the Vienna Convention and vice versa, and eliminate problems arising from simultaneous application of both Conventions. In resolution GC(XXXII)/RES/491, adopted on 23 September 1988, the General Conference requested the Board of Governors to convene an open-ended working group in 1989 to study all aspects of liability for damage as part of its ongoing consideration of the question of nuclear liability.

92. In 1960, the Agency and IMO jointly held a symposium on nuclear ship propulsion. In 1968, the Agency published, on behalf of itself and IMO, a

Safety Series report on "Safety considerations in the use of ports and approaches by nuclear merchant ships" (Safety Series No. 27). A Code of Safety for Nuclear Powered Merchant Ships was updated in 1981 by IMO. Civil nuclear-powered shipping has so far proven to be less promising than expected. There are at present no operating nuclear merchant ships; therefore, no effort on the part of the Agency in this area is currently warranted. There are existing nuclear-powered military vessels and ice breakers. These ships are covered under the Convention on Early Notification and, in fact, the Agency was advised in 1986 of the sinking of a damaged Soviet nuclear submarine, even though no releases of radioactive material occurred.

5.8 Technical Co-operation in Nuclear Energy and Safety

93. Assistance to developing countries by means of experts, equipment and training is a major part of the Agency's work. In the area defined as "safety in nuclear energy", which includes radiation protection, waste management, safety, environmental monitoring and assessment, there have been 275 projects since 1980. Most of the assistance in this area concentrates on the establishment of radiation protection regulations, licensing and inspection procedures, occupational radiation protection, and radiation protection of the public. Assistance relating to the safety of nuclear installations includes nuclear plant safety assessments and operational safety reviews for research and power reactors. Missions in waste management have concentrated on improving regulatory infrastructures and control over spent radioactive sources. The training of personnel is discussed in Section 7.

6. APPLICATION OF NUCLEAR TECHNIQUES

94. Nuclear and isotopic techniques were used to study natural processes long before the Agency existed. From the late 1940s, radioactive as well as separated stable isotopes became readily available. The use of such isotopes and the development of analytical tools, including tracer methods, neutron activation analysis, X-ray fluorescence and atomic absorption spectrometry, have added to the techniques available for the study and detection of environmental pollutants such as pesticides and toxic metals. In addition, these tools have become standard methods for assessing water and mineral resources. The use of nuclear techniques to help solve pollution problems is well known and is an important contribution to the concept of sustainable development.

95. Table 11 gives examples of nuclear techniques used for different purposes.

6.1 Environmental Monitoring and Assessment for Non-radioactive Pollutants

96. The Isotope Hydrology Unit has been collecting, analysing and publishing information on environmental isotopes in precipitation since the Agency's foundation. The samples are collected by meteorological services in 70 countries and territories. A series of publications entitled "Environmental Isotope Data No. 1 - No. 8: World Survey of Isotope Concentration in Precipitation" gives meteorological data, tritium compositions, and deuterium and oxygen-18 isotopic concentrations from 1953 to 1983.

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Table 11: NUCLEAR APPLICATIONS -- EXAMPLES

Environmental Monitoring and Assessment

1. Food and Agriculture
   - -- Studies of nitrogen fixation in crops and trees to optimize the use of nitrogenous fertilizers
   - -- Nuclear techniques for the improvement of fertilizer and water management practices
   - -- Monitoring pesticide residues in food and the environment and development of controlled-release pesticides
2. Nuclear Techniques in Pollution Studies
   - -- Early work on isotope data in precipitation
   - -- Analysis of non-radioactive pollutants with nuclear techniques
   - -- Nuclear techniques in flue gas monitoring and pollutant transport studies

Diminishing Environmental Impacts

1. Food and Agriculture
   - -- Radiotracer studies to reduce or eliminate pesticide residues during food processing
   - -- Sterile Insect Technique (SIT)
2. Physics and Chemistry
   - -- Electron beam processing of combustion flue gases to remove SO_2 and NO_x

Resource Development

1. Hydrology
   - -- Studies of origin and flow of water
2. Minerals
   - -- Nuclear techniques for mineral exploration and assessment
3. Food and Agriculture
   - -- Plant breeding and genetics
   - -- Animal production and health

97. With regard to monitoring for non-radioactive pollutants, the Agency has been assisting WMO in the Background Air Pollution Monitoring Network. The Agency was requested to provide laboratory services at its own laboratory in Seibersdorf, Austria, in cases where no or insufficient national facilities were available.

98. Nuclear analytical techniques are being proposed and used to determine toxic elements in food, solid wastes and atmospheric aerosols. A recently initiated programme is aimed at using nuclear techniques to assess pollutants from coal burning, e.g. in studies of how pollutants are leached from coal ash.

99. The Agency's laboratory in Monaco has a long-standing programme for the analysis of non-radioactive pollutants of the sea. Working for UNEP, the laboratory has published standards for the measurement of hydrocarbons and heavy metals in marine samples.

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6.2 Mitigation of impacts

100. Recent work has indicated that electron accelerators can be used for cleaning flue gases from fossil-fuelled power plants, without the major chemical installations now needed for SO_2 and NO_x removal. The primary effort is aimed at investigating whether the promising results obtained at small plants can also be obtained at plant sizes of the current power plant generation.

6.3 Resource Development

101. Resource development in a sustainable manner is a common theme throughout the World Commission's report. Water resource investigations and development are now unthinkable without techniques using radioactive and stable isotopes. The Agency has assisted Member States with technical co-operation projects in hydrology since its beginning. There are at present some 70 projects in 60 Member States.

102. A technical report on "Isotope techniques in the hydrogeochemical assessment of potential sites for the disposal of high-level radioactive wastes" (1983) and a report on "Nuclear techniques in groundwater pollution research" (1980) are examples of the value of nuclear techniques in water pollution studies as well as in resource assessment determinations.

Table 12: URANIUM GEOLOGY AND RESOURCES
<u>Uranium Geology and Resources</u>:
Africa (1979)
Latin America (1981)
Wet tropical environments (1983)
South America (1984)
Correlation between South America and Africa (1987)
Asia and the Pacific (1988)
<u>Exploration and Assessment Methods</u>
Evaluation and mining techniques (1980)
Remote sensing (1981)
Borehole logging (1982, 1986)
Recognition of uranium provinces (1988)
Geochemical exploration (1988)
<u>Uranium Deposit Types</u>
Rocks younger than Proterozoic (1982)
Sandstone and related host rocks (1983)
Volcanic rocks (1985)
Pine Creek geosyncline (1980)

103. Nuclear techniques are used also in the development of non-nuclear energy resources. In 1975 and 1981, meetings were held by the Agency on the Application of Nuclear Techniques to Geothermal Studies. The papers were published in special issues of the journal "Geothermics" in 1977 and 1983. A co-ordinated research programme, started in 1984, is studying isotopic and geochemical techniques in geothermal exploration in Latin America.

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104. Uranium geology, exploration and resource assessment have been a part of the Agency's programme since its inception. Geological exploration techniques are not confined in their use to the search for any particular mineral, and the expertise gained in the exploration for uranium has applications in the exploration for other energy minerals, such as coal and petroleum, and for non-energy mineral resources. The techniques used in surveying large areas of land are useful in background radiation surveys and in surveying areas after large-scale accidents. Table 12 lists the subjects of some of the more recent Agency publications in the uranium geology/ exploration area.

6.4 Food and Agriculture

105. Naturally, the most significant activities are in the Agency's programme areas related to food and agriculture. One major area of investigation within the "Soil fertility" programme area concerns optimization of the use of nitrogenous fertilizers, which would also reduce run-offs. Another programme area of interest is "Agrochemicals and residues", in which the focus is both on the investigation of the fate of pesticide residues in food, feed, soil, water and biota, and on the development and improvement of pesticide forms which could reduce environmental contamination.

106. The Agency's studies and applications of the sterile insect technique (SIT) to control and eradicate the Mediterranean fruit fly and the tsetse fly within certain geographical areas have produced significant successes -- for instance, in Central America in the case of the fruit fly. As one of the biological methods of insect control, SIT will help to minimize the use of pesticides.

6.5 The Amazon Project

107. One of the major technical co-operation projects of the Agency relates to the Amazon region in Brazil. This project is an example of the integrated use of isotope techniques in a major environmental investigation. The project concerns the effects of changing land use on the ecology and climate of the Amazon region. Questions important to many countries with tropical rainforests are being addressed in this project. The project is also one which shows how different disciplines can be joined in one major investigation. Three major Brazilian research institutes are involved under the co-ordination of the National Nuclear Energy Commission, and from outside, groups from France, the Federal Republic of Germany and the USA are participating. Sweden is providing considerable funding.

108. The clearing of tropical rainforests raises two major issues: environmental and ecological effects, and the problems of sustainable agriculture on the cleared land. About half of the rainfall in the Amazon Basin (5.8 million square kilometres) comes from recycling from the forest. There is concern that removal of significant quantities of forest will reduce rainfall not only in the Amazon region, but also elsewhere. Tropical rainforest ecosystems have often developed on fragile soils, and large-scale interventions can have very far-reaching effects, also on river systems in the region. Isotope techniques are of key importance in studies of this ecosystem.

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6.6 Technical Co-operation in Nuclear Applications

109. Over 540 projects have been undertaken in the area of nuclear applications since 1980, nearly half of them relating to resource development in food and agriculture. Another 64 projects have related to uranium exploration and assessment. The Agency has supported over 100 projects on applications of nuclear techniques in pollution measurement and resource determination, primarily through the provision of laboratory equipment and of training in the use of such equipment. Table 13 gives a breakdown of these projects by programme area.

TABLE 13: TECHNICAL CO-OPERATION PROJECTS (1980-1988)

Area	Environmental	Amelioration	Prevention	Resources
Nuclear Physics & Chemistry	103			
Prospecting, Mining & Processing				64
Nuclear Engineering and Technology	1	1	[illegible]	
Isotopes/Radiation in Agriculture		28	45	241
Isotopes/Radiation in Industry/Hydrology	36	2		51
Safety in Nuclear Energy	71	37	167	
Total	211	68	236	356
Percentage of all Agency Technical Co-operation projects	11.5%	4%	13%	20%

7. TRAINING

110. Training courses and fellowships are an important aspect of the Agency's technical assistance programmes. With a very small contribution from the Agency, benefits multiply as each trainee shares the experience, information and knowledge he or she has gained. Over the last five years, about $40 million has been disbursed for fellowships and training courses. In 1987 alone, almost 2000 professionals took part in training courses or fellowship programmes, and approximately 38% of these related to subjects considered "environmental" in this report.

111. The Agency's Laboratory at Seibersdorf has trained many scientists in analytical techniques for both radioisotope measurements and the use of nuclear techniques for the determination of non-radioactive pollutants. Training in the use of isotope and nuclear techniques for the assessment of pesticide residues, studies of soil/water problems and entomology has provided expertise to thousands of scientists from developing countries over the years. The Agency's Laboratory at Monaco has trained marine scientists and analytical chemists in analysis techniques related to marine pollution by radionuclides, and by hydrocarbons and heavy metals.

112. The role of the International Centre for Theoretical Physics (ICTP) in Trieste, which operates under the Agency's auspices, is also important in training. Theoretical physics may seem far removed from the practical study

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of environmental problems, but the role physics plays in understanding atmospheric and aquatic transport is fundamental. Physical transport mechanisms are the basis for all models. ICTP has had courses on solar energy, ecological modelling (continuing over many years), and atmospheric and ocean sciences, all of which are of direct relevance to scientists in developing countries working in areas related to the environment and resource development.

8. SIGNIFICANCE WITHIN THE AGENCY'S BUDGET

113. In total, the environment-related activities, as defined in Section 2, account for about 17% of the Agency's regular budget (see Fig. 2). Within the substantive programme areas, the percentage is much higher - 60% in Nuclear Energy and Safety and 55% in Nuclear Applications (Fig. 3).

Figure 2: TOTAL AGENCY REGULAR BUDGET 1989/1990

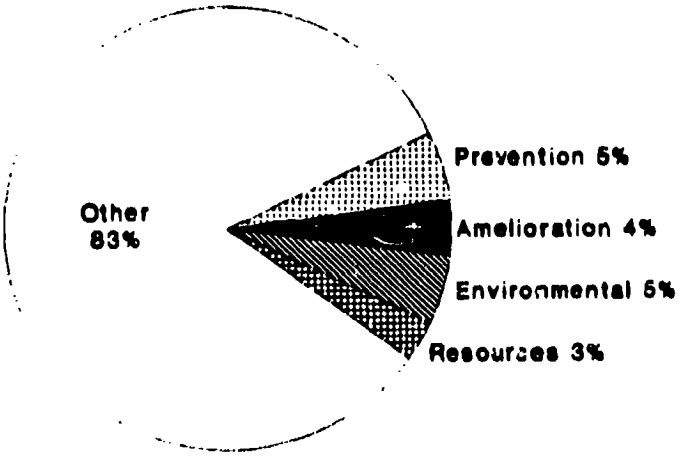
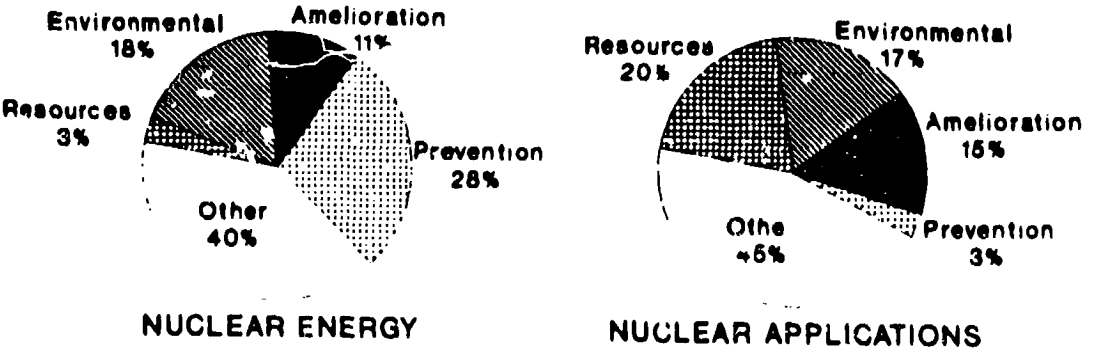


Figure 3: AGENCY REGULAR BUDGET 1989/1990



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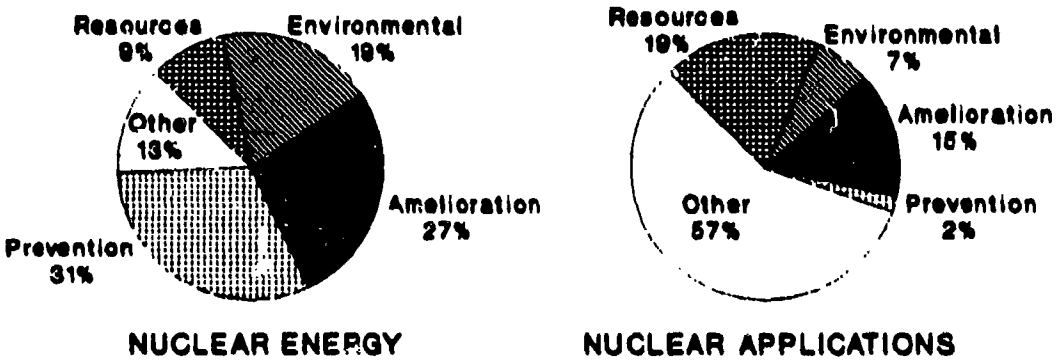
114. As regards the Agency's on-going technical co-operation projects, about 87% of these projects in the area of nuclear energy and safety may be classified as "environmental". In the area of nuclear applications, 43% of the projects may be classified as such (Fig. 4).

Figure 4: TECHNICAL CO-OPERATION PROJECTS 1989/1990



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ABBREVIATIONS

CEC	Commission of the European Communities
FAO	Food and Agriculture Organization of the United Nations
IAEA	International Atomic Energy Agency (the Agency)
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
ICRP	International Commission on Radiological Protection
IEA	International Energy Agency of OECD
IIASA	International Institute for Applied Systems Analysis
ILO	International Labour Organisation
IMO	International Maritime Organization
ISO	International Standards Organization
NEA	Nuclear Energy Agency of OECD
NUSS	The Agency's Nuclear Safety Standards for nuclear power plants
OECD	Organisation for Economic Co-operation and Development
OSART	Operational Safety Review Team
RAPAT	Radiation Protection Advisory Team
UNEP	United Nations Environment Programme
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
UPU	Universal Postal Union
WAMAP	Waste Management Advisory Programme
WATRAP	Waste Management Assessment and Technical Review Programme
WHO	World Health Organization
WMO	World Meteorological Organization
