NUCLEAR EDUCATION AND RESEARCH IN BRITISH UNIVERSITIES

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Foreword

We thank those people who provided information. If there is an error, any omission or the data needs updating then please inform us at the address below.

We would also be grateful to receive ideas on generating student interest in nuclear subjects or information on existing initiatives.

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EXECUTIVE SUMMARY

Concerns about the decline in nuclear education have been expressed for some time but it was only with the publication of the OECD/NEA (Nuclear Energy Agency of the Organisation for Economic Co-operation and Development) report "Nuclear Education and Training: *Cause for Concern?*" in July 2000 that quantitative information first became available. Whilst the data provided by most countries, the UK included, was acknowledged as being incomplete, it did not detract from the findings of the report since the focus was more on trends than specifics. This report complements the OECD one by providing a comprehensive and detailed picture of nuclear education in the UK today, including a summary of the research links that the industry has with universities. It is hoped that it will be a valuable aid in shaping the future of nuclear education in this country so that an adequate supply of appropriately qualified staff for the future safe and economic operation of the industry will be assured.

For this study, 22 universities were approached and responses obtained from 21, including the 9 that had responded to the OECD survey carried out in 1998. As far as is known, this covers all of the universities that are involved in teaching nuclear subjects; there are over 130 colleges and universities in the UK. In addition, one institution was surveyed, the Ministry of Defence establishment, HMS Sultan.

Today, there is not one university undergraduate course with any significant nuclear content to it. Half of the nuclear modules are optional and the majority constitute less than 5% of the degree. In short, nuclear education at the undergraduate level has been reduced to taster modules within mainstream science degrees. With universities now run on a business footing, under-subscribed nuclear courses have been replaced by those pertinent to other industries where there is a demand. HMS Sultan offers a wide range of stand-alone training courses but these are not part of a first degree, although some are at that level.

The three masters courses possibly most relevant to the industry have a combined uptake of about 24 students a year. These are in the areas of Nuclear Reactor Technology and Applied Radiation Physics. A further 15 masters courses have some nuclear content but in most cases it comprises only a small percentage of the degree. As a consequence of recent funding changes some of these courses are at risk. Already one has had to be rescued from closure through a Partnership of the university, the Regulator and the industry.

The OECD survey found a common story among member countries of ageing faculty members who were not being replaced when they retired and ageing facilities that were not being renewed. Whilst this study did not address personnel issues, it did confirm that most of the university facilities for nuclear teaching in the UK are over 25 years old. There are some new laboratories and equipment and some laboratories have been refurbished and kept up to date but quite a few are in their original state. There is now only one civil research reactor in the country and in the last two years the only two hot cell facilities in universities have closed.

Comparing the results of this study with those of the OECD survey does not show any decrease in the extent of nuclear teaching in the UK over the last two years. Indeed, there are probably more students taking nuclear options now than then. All of the respondents were optimistic about the prospects for nuclear teaching in their institutions over the next five years; most anticipated that the status quo would remain, a few envisaged a slight expansion with several universities proposing new courses. A further significant development is that the Ministry of Defence courses, previously only available to the military, have recently been made available to civilians.

Of the 9 organisations that were approached to provide details of their research contracts, 8 responded. The nuclear industry currently has over 250 contracts with some 54 British universities worth about £10M a year. Generally, a university that has nuclear teaching has good research links with the industry. However, some universities have extensive research links but do not teach nuclear subjects.

The manner in which research contracts are established may have a beneficial effect on nuclear teaching. Hitherto, most contracts have been placed on an ad-hoc basis to meet specific short-term needs. Like many other companies, those in the nuclear sector are beginning to cluster their research contracts in specific disciplines at specific universities as a way of underpinning core competencies. Not all of the centres so formed are in nuclear subjects. But unlike the ad-hoc approach to placing contracts, the centres engender a long-term relationship and the movement of staff between each other's facilities. Although established for research purposes, the wider understanding of each other's cultures and needs that will ensue could be capitalised on to develop teaching courses and training modules.

I. INTRODUCTION

i) Background

In the Spring of 1998 the Nuclear Energy Agency of the Organisation for Economic Co-operation and Development (OECD/NEA) convened an Expert Group, comprised of representatives from 17 Member countries, to quantify the concerns raised by those countries about the perceived decline in nuclear education. Two delegates represented the UK: one from the Nuclear Installations Inspectorate and the other from BNFL.

The findings of the Expert Group were published, in July 2000, as an OECD report: "Nuclear Education and Training: *Cause for Concern?*"[1] The report confirmed what many had long suspected: "In most countries there are now fewer comprehensive, high-quality nuclear technology programmes at universities than before…….. The ability of universities to attract top-quality students to those programmes, meet future staffing requirements of the nuclear industry and conduct leading-edge research in nuclear topics is becoming seriously compromised…… There currently appear to be enough trainers and quality staff in industry and at research institutes. However, the provision of suitable trainers in the near future is becoming a concern because of the university situation."

The report concluded that, "Nuclear education and training are not yet at crisis point, but they are certainly under stress in many of the OECD/NEA Member countries…. The needs of the industry, in both recruitment and research, have declined as it has reached maturity and seeks to be more competitive in a deregulated energy sector. However, a sufficiently robust and flexible nuclear education is crucial to support the industry as it evolves." That it may not be able to do so is evidenced by a common story of ageing faculty members and facilities combined with a decline in the number of students taking nuclear subjects and a decline in and dilution of, nuclear courses available.

The first recommendation of the report is for immediate action – given that human resources do not appear instantly and a minimum of 4 to 5 years of higher education is needed to train the experts that will be needed. Another is that the nuclear industry and universities work together to market nuclear programmes to the younger generation. Governments are exhorted to engage in long-term strategic energy planning and, through a number of mechanisms, to encourage young people onto nuclear courses in order to ensure that "human resources are available to meet necessary obligations and address outstanding issues."

The findings and recommendations of the report, are, by their nature, generalisations that embrace 17 countries with markedly different cultures and institutions. Nevertheless, they are pertinent to the UK as can be seen from the UK Country Report, at Appendix 3, which is a summary of the situation based on the responses from the universities and nuclear companies surveyed.

[1]A summary of the report is available free of charge from the OECD or on their website at http://www.nea.fr/html/pub/ret.cgi?id=new#2428. The full report, which contains the country reports, is available from the OECD price 210FF or at http://www.nea.fr/html/ndd/reports/2000/nea2428-education.pdf.

ii) Objectives of this study

- To update the OECD information.
- To widen the data to cover all universities involved in nuclear teaching.
- To provide more detailed information on courses.
- To summarise research links with universities.
- To provide a body of information which can be used to determine the way forward in nuclear education.

Groundbreaking though the OECD work was, the information is becoming dated and, as far as the UK is concerned, is by no means comprehensive.

In 1998, of the 13 universities that were approached because they were known to be teaching nuclear subjects, 9 responded to the OECD questionnaire. As these were the ones pre-eminently involved with nuclear education it was possible to establish what the trends in nuclear education were. However, the picture was incomplete because of those that did not respond, as well as others that were not approached but were subsequently found to be teaching nuclear subjects.

The OECD report was confined to education and training; it did not address research sponsored by the nuclear industry at universities. Good teaching and good research often go together and it may be that the wider understanding of each other's cultures and needs that ensues from research collaborations could provide the opportunity for industry and academe to jointly develop teaching courses and training modules.

It is recognised that the future safe operation of nuclear facilities in the UK is dependent on the continued availability of appropriate skills and knowledge. Historically, universities have made a significant input to meeting these requirements through the provision of nuclear-specific education opportunities and hence the supply of suitably qualified technical graduates. This report provides a body of information, which can be used to help determine the way forward in nuclear education so that it will remain sufficiently robust and flexible to support the industry as it evolves.

iii) Methodology

The study was carried out between March and June 2000.

Details of nuclear courses were obtained by sending a questionnaire, at Appendix 4, to individuals who had been identified as being involved in teaching nuclear subjects and with whom the objectives of the study had been discussed. Twenty-two universities were approached and responses received from 21, including the 9 that had responded to the 1998 OECD survey. As far as is known, all of the universities that are involved in teaching nuclear subjects have been included; there are over 130 universities and colleges in the UK. In addition, information was obtained from one institution, the Ministry of Defence establishment, HMS Sultan.

Details of the nuclear industry's research contracts with universities were obtained by directly approaching those in each company who were responsible for monitoring or

controlling them. Of the 9 organisations that were approached, 8 provided details: British Energy, BNFL, BNFL Magnox, HSE, MoD, NIREX, NNC and UKAEA. Most of the companies did not have a centralised system for recording the details of their university research contracts and consequently the majority of the information was provided on an ad-hoc basis. As a result, occasionally, some detail was not obtainable. Hence, where the name of a department is not known it is listed as “Not categorised”.

II. SUMMARY OF NUCLEAR EDUCATION

i) Masters and post graduate courses.

Table 1, overleaf, is a summary of the masters courses having some nuclear content.

As a consequence of recent changes in funding arrangements, some masters courses are at risk. EPSRC (Engineering and Physical Sciences Research Council) funding is now only given to new masters courses, and only for a five-year period. In other words pump priming. As a result of losing EPSRC funding, one long established course at the University of Birmingham, the Physics and Technology of Nuclear Reactors, faced closure. However, thanks to the intervention of the Regulator (HSE – NII), a Partnership has been established comprising the industry, the university and the Regulator that assessed the value of the course and put in place arrangements, including financial support, to secure its future. Other courses are facing difficulties. The Advanced Radiation Physics course at Birmingham loses its Research Council support in 2001 and the Partnership is discussing the viability of replacing it with a MSc centred on Waste and Decommissioning. Queen Mary and Westfield College (QMW) have applied for Research Council support for a masters courses based on the QMW/UCL (University College London) course in Radiation Physics that has been in operation since 1957. At the University of Surrey, Research Council funding for the MSc in Radiation and Environmental Protection is guaranteed only until 2000/1.

To widen their appeal and make them more flexible, masters courses are increasingly being offered on a modular basis. As well as enabling students to take individual modules to meet specific training needs, there are also the options of combining modules to obtain a Postgraduate Certificate or Diploma, or of obtaining a masters degree over several years of part-time study. The era of the one-year, intensive, full-time course is disappearing.

The Physics and Technology of Nuclear Reactors course at Birmingham has been updated and re-written in a modular form that will also be available electronically for distance learning. The MSc in Environmental Diagnosis at Imperial College contains modules on Neutron Activation Analysis and Instrumentation, which are offered as stand-alone short courses. At the University of Liverpool, fourteen one-week modules are offered. Masters level CATS[1] points are awarded and the modules may be taken singly or in sufficient numbers to constitute a MSc, Pg.Cert or Pg.Dip. As well as its MSc in Nuclear Reactor Technology, HMS Sultan also offers a Pg.Dip in Nuclear Reactor Technology, a Pg.Dip in Nuclear Radiological Protection and a PgDip in Nuclear Plant Engineering.

Apart from existing courses that are being restructured to meet funding requirements, only one new MSc of relevance to the nuclear industry is being proposed. This in Safety Engineering at Lancaster University, and is scheduled to start in 2001. In addition to modules associated with generic safety engineering, students will take

[1]CATS – Credit Accumulation Transfer Scheme – enables students to study modules at different universities acquiring points as they do so until they have accumulated enough for the qualification.

modules relating to one of three industrial areas. One of these will be Nuclear Engineering and Remote Handling Concepts. There will also be a six-month project. For students choosing a nuclear subject for their project the nuclear content of their degree will be over 75%.

Universities now operate as businesses and they cannot afford to run expensive, post-graduate courses that are undersubscribed. The decline in nuclear related masters courses in the last decade is evidence enough. To widen their appeal and to be more flexible, courses are increasingly offered on a modular basis but the current funding arrangements send a very clear message that, beyond the initial pump-priming period, if industry wants it then industry will have to pay for it. And if industry does not pay then courses will atrophy. On the other hand, if industry can specify what it wants, then it is very likely that its needs will be met in a flexible manner.

ii) Undergraduate courses

From Table 2, overleaf, it can be seen that there is no longer any university undergraduate course with any significant nuclear content to it. Where there is a nuclear content, it constitutes typically less than 5% of the degree; only two universities suggested a figure of 10% for their courses. Of the modules identified, half are optional. In short, nuclear education at the undergraduate level has been reduced to "taster" modules within mainstream science degrees.

HMS Sultan offers a wide range of stand-alone courses, lasting from a day to a year, but these are not part of a first degree, although some of them are at that level. The emphasis is more on training than scholarship and the courses cater for those already in the industry rather than those that might be encouraged to join it.

Only one university, De Montfort, is contemplating a new undergraduate course with any significant nuclear content. This is only at the early planning stage but it is hoped that it will have a nuclear content of about 20% and the word "nuclear" in the title.

Undergraduate teaching - the principal purpose of universities - is financed on a block-funding basis; to get the maximum funding universities have to enrol the maximum number of students. With empty seats meaning a loss of income, universities literally cannot afford to run courses for which there are few takers. The result has been that under-subscribed nuclear courses have been replaced by those pertinent to other industries where there is a student demand. At the masters level it may be a case of if industry wants it then industry pays for it but, for a number of reasons, funding mechanisms included, this approach does not readily translate to the undergraduate level. However, that is not to say that the industry cannot lend support in any way practicable to retain and strengthen existing modules and try and introduce new ones. In other words, to try and increase demand so that supply will follow naturally.

iii) Facilities

The age and expected lifetime of the different types of experimental facilities varies from university to university and Table 3, overleaf, shows the current situation. Most facilities are over 25 years old and many are over 30 years old. There are some new laboratories and equipment and some of the old laboratories have been refurbished and kept up to date but quite are few are in their original state. There is only one civil research reactor left in the country, the Imperial College CONSORT reactor at Silwood Park and in the last two years the only two hot cell facilities in universities have closed (at Salford and UCL).

iv) Comparison with the OECD Survey of 1998

Based on 9 responses from 13 universities the best estimate for the number of students taking masters courses in 1998 was 78 a year. From the data in Table 1 the number of students on the three courses possibly most relevant to the nuclear industry, Applied Radiation Physics, Physics and Technology of Nuclear Reactors and Nuclear Reactor Technology is 21 – 30 a year. By including the other courses and allowing for the fact that they contain less than 100% nuclear content, a figure of 78 full-time equivalent students a year may be arrived at but it seems an optimistic total.

At the undergraduate level, the number of students having a nuclear component to their education showed an increase from 364 in 1990 to 427 in 1998. The figures in Table 2 indicate that the total could exceed 1300, without counting the 400 attending the HMS Sultan training courses. Unfortunately, with the majority of courses showing a nuclear content of 5% or less, the suspicion articulated in the OECD report that it was unlikely that any undergraduate programme in the UK could now claim any appreciable nuclear content has been proved to be true.

The rather pessimistic portrayal of ageing facilities given by the OECD report is confirmed by the information gathered in the course of this study. In addition, since 1998, the only two hot cell facilities in universities have closed (at Salford and UCL).

III. SUMMARY OF NUCLEAR INDUSTRY RESEARCH LINKS WITH UK UNIVERSITIES

The nuclear industry currently has over 250 contracts with some 54 British universities worth about £10M a year; a summary on a university department basis is shown at Appendix II.

Hitherto, many contracts were placed on an ad hoc basis to meet specific short-term needs and the contracts were managed individually as part of planned and budgeted programmes of work. Like many other companies, those in the nuclear sector are now beginning to manage their university contracts collectively as an investment portfolio. Part of this strategy is to underpin core competencies by clustering contracts in specific areas at specific universities. An inherent advantage of this approach for both parties is the comparatively long-term funding involved, enabling both the university and the company to plan ahead. Having secure funding for a number of years is also essential in attracting good quality researchers, particularly at the post-doctoral level where there is a high mobility.

BNFL, for example, has sought to underpin its core competence in radiochemistry by establishing a centre of excellence in the subject at Manchester University. The company will invest £2M over 5 years in staff and students, the university will provide the laboratories and the infra structure and it is envisaged that the centre will be self-supporting after the initial five year period. Manchester will link to the other radiochemistry centres in the UK and abroad to form a network. The future of radiochemistry in the UK should thus be assured and BNFL will have access to academic expertise in this area for years to come. Other such centres are planned in the areas of Particle Technology and Non-Destructive Testing. Another company, AEA Technology, is establishing similar centres in Advanced Materials at Oxford and Chemical Engineering at Cambridge.

Not all of these centres are in nuclear specific subjects but unlike the ad hoc approach to placing research contracts, they engender a long-term relationship and the sharing of facilities. The movement of researchers between industry and university and vice versa results in a better understanding of each other's cultures and needs that could be capitalised on to develop teaching courses and training modules.

Where there is teaching there is also research, though not necessarily vice versa. All of the universities listed in Tables 1 and 2, with the exception of Middlesex and Plymouth, are known currently to have research contracts with the industry. Generally, a university with strong teaching has strong research links. However, some universities have extensive research links with the industry but do not teach nuclear subjects eg Bath, Bristol, Leicester and UMIST.

This picture of nuclear teaching and research may be explained by the evolution of both the industry and the university system. Where teaching exists it has generally existed for some time and so have the links with the industry. As demand has reduced over the years, so has the number and content of the courses and what remains today is the rump of what existed in the heyday of the industry. In contrast, research contracts offer industry funding and the possibility for departments to improve their

Research Assessment Exercise status and so get a bigger slice of government funding. In such an environment, those departments that feel capable of conducting research will bid for it from any sector, the nuclear one included. Unlike the majority of teaching, research is less confined to those universities that have traditionally had links with the industry. If there is to be resurgence in nuclear teaching, then this diversity could be of benefit.

TABLES

Table 1. Summary of masters courses relevant to nuclear education.

UNIVERSITY	TITLE OF COURSE	NUMBER OF STUDENTS PA	NUCLEAR CONTENT OF COURSE
BIRMINGHAM	Applied Radiation Physics	10 – 16	100%
	Physics and Technology of Nuclear Reactors	8 -10	100%
	Medical and Radiation Physics	10	55%
CITY	Energy Technology and Economics	16	5%
	Information Engineering	25	5%
	Radiation Protection*	6 – 10	17%
IMPERIAL	Environmental Diagnosis	12	15%
LIVERPOOL	Radiometrics	50 – 60**	100%
LOUGHBOROUGH	Analytical Chemistry	12	4%
	Medicinal Chemistry	10	4%
MIDDLESEX	Occupational Health and Safety	30	1%
PLYMOUTH	various	45	5%
QUEEN MARY AND WESTFIELD	Radiation Physics	12 – 15	5 – 10%
HMS SULTAN	Nuclear Reactor Technology	3 – 4	100%
SURREY	Radiation and Environmental Protection	20	100%
	Medical Physics	25	50 – 75%
SWANSEA	MRes	15	5%
UNIVERSITY COLLEGE LONDON	Radiation Physics	20 –25	20%

* Radiation protection is an optional module in the MSc programme for medical radiographers.

** the number of students taking modules, not necessarily the MSc