NUCLEAR AND RADIOLOGICAL SKILLS STUDY

Report of the Nuclear Skills Group

PART 1

Full Report

Issue 1

5 December 2002

AUTHOR: TONY COVERDALE

Project Manager
Nuclear Skills Study
Tel: 020 7215 6599
email: tony.coverdale@dti.gsi.gov.uk

NUCLEAR AND RADIOLOGICAL SKILLS STUDY

The Chairman of the Nuclear Skills Group would like to thank all those who have contributed to the Nuclear Skills Study, including members of the Nuclear Skills Group, employers and employees in the nuclear and radiological sector who contributed to the nuclear skills audit and all those who took part in Foresight Workshops.

The Group are grateful for the excellent support provided by the DTI, especially Tony Coverdale, Manager of the Nuclear Skills Study and author of this report.

Professor John Chesshire

CONTENTS

PART 1

PART 2

ANNEXES

NUCLEAR AND RADIOLOGICAL SKILLS STUDY

1 EXECUTIVE SUMMARY

The ability to apply nuclear and radiological technology has a key role in the health sector (approximately 30 million radiology examinations are carried out every year), plays a principal part in national defence, is essential for the continued operation of existing nuclear power stations (which currently make up approximately 23% of the UK's generating capacity), is essential to nuclear and radiological clean up, and is needed to support a wide spectrum of research, development and manufacturing activity. The recent PIU Energy Review also spoke of "good grounds for taking a positive stance to keeping the nuclear option open"; the availability of skilled people being key to such a policy.

Concern exists, however, that a shortage of people with the skills needed to apply nuclear and radiological technology is developing. Prompted by assessment of the international situation by the OECD/NEA, a survey of the national nuclear skill base has been conducted under the direction of the Nuclear Skills Group, chaired by Professor John Chesshire. The skills study has been a good example of effective joint working between a number of Government departments (the study being co-sponsored by DTI, HSE, MoD, DH, and DfES), industry, academia and professional institutions.

The survey has identified that the health sector currently has a shortage of people with radiological skills and although the nuclear sector does not have an immediate overall shortage, a number of 'hot spots' exist in disciplines such as safety case production and radiological protection. Postgraduate education and apprentice training are also in a fragile state, raising concerns about future workforce development.

Conservative estimates suggest that the sector will require around 50,000 recruits over the next 15 years, excluding potential demand from new build, equivalent to just under 60% of the current skilled population, and this demand must be satisfied from the wider engineering and physical science sector at a time when:

> *"The 'disconnect' between the strengthening demand for graduates (particularly in highly numerate subjects) on the one hand, and the declining numbers of mathematics, engineering and physical science graduates on the other, is starting to result in skills shortages."*[1]

This report outlines the measures that have been taken to quantify the problem, looking up to 15 years into the future, and sets out a number of recommendations to avert potential skill shortages developing in the future.

The key issues are:

Promotion of the Skill Sector: Engineering and physical sciences are unpopular fields of study and unpopular career choices for young people; and nuclear and radiological technologies are unpopular choices in this unpopular field. Action to encourage more young people into these sectors is urgently needed.

Underpinning of Essential Learning Pathways: The learning pathways required to develop the skills needed by the sector must be defined and a means devised of underpinning those pathways.

Underpinning Education Institutions: The education and training institutions, colleges and establishments needed to service the above learning pathways must be identified and a means of ensuring their viability established, otherwise the infrastructure to deliver essential training will be lost.

[1] SET for success: The supply of people with science, technology, engineering and mathematics skills. The report of Sir Gareth Roberts' Review. April 2002

BACKGROUND

1.1 The ability to apply nuclear and radiological technology has a key role in the health sector, plays a principal part in national defence and is fundamental to the operation of the United Kingdom's existing nuclear power stations. It is also essential for nuclear and radiological clean up and is needed to support a wide spectrum of research, development and manufacturing activity. The ability to manage the technology is also fundamental to keeping the option open for construction of new nuclear power stations, as considered in the recent PIU Energy Review. Concern exists, however, that a shortage of skilled people is developing that could undermine the ability of the nuclear and radiological sector (defined below) to operate, the potential shortage lying in all roles: practitioners, educators, trainers and regulators.

1.2 This concern has been expressed both nationally and internationally. International concern is articulated in the OECD report "Nuclear Education and Training: *a cause for concern?*" (2000), and evidenced by the recent IAEA Senior Level Meeting on the 'Management of Nuclear Knowledge" (June 2002). Nationally, the NII's report "Education and Research in British Universities" (2001, revised 2002) assessed the strength of one element of the UK sector and identified a situation of "ageing academics, ageing facilities and no undergraduate courses with significant nuclear content".

1.3 The OECD report contained the recommendation that "Governments should engage in strategic planning of education and manpower, integrated with human resource planning, to encourage young students into the industry". The Nuclear Skills Group (NSG) was therefore formed to assess the national situation and formulate a series of recommendations to overcome any potential shortfalls.

SKILLS STUDY

1.4 The NSG commissioned two reviews to provide evidence upon which to base their recommendations and to act as a foundation for future work:

- A skills audit to quantify the size and form of the sector today; and
- A foresight study to consider the factors that may affect the sector over the next 5, 10 and 15 years.

In addition, a wide range of individuals from within the nuclear, radiological and education fields, and from other Government departments, were consulted to ensure that the study was based on a broad consensus of opinion and that the recommendations made were consistent with more widely based initiatives.

NUCLEAR AND RADIOLOGICAL SECTOR

1.5 The sector encompasses organisations that apply nuclear and radiological technology as a primary purpose (power generation, health, defence, and nuclear clean up[2]) and also those that apply radiological technology as a secondary purpose (eg non-destructive examination, pharmaceuticals etc). The audit has identified a current (2002) population of approximately 135,000 skilled people, of which around 64% are primary users and 36% secondary users.

SKILLED POPULATION	POPULATION	%	POPULATION	%
PRIMARY USERS	86,000	64%		
HEALTH			30,000	22%
DEFENCE, POWER GENERATION, FUEL CYCLE & CLEAN UP			56,000	42%
SECONDARY USERS	49,000	36%	49,000	36%
TOTAL	**135,000**	**100%**	**135,000**	**100%**

[2] Encompassing the fields of decommissioning, waste management and environmental remediation.

1.6 Of the primary users, a distinction can be made between the health sub-sector, which comprises predominately medical diagnosticians and therapists supported by medical physicists and clinical scientists, and the power generation, defence and nuclear clean up sub-sector, which comprises engineers and physical scientists.

1.7 The Health sub-sector can be further subdivided into users of radiological techniques for diagnosis and therapy, typified by radiologists and radiographers, and the clinical scientists, engineers and technicians who design, maintain and specify how to operate radiological equipment. The health sub-sector has a population of approximately 25,000 radiologists and radiographers and around 5,000 clinical scientists, engineers and technicians.

1.8 The Defence, power generation, fuel cycle and clean up sub-sector can also be sub-divided into ‘client‘ and ‘support’ organisations, the support organisations comprising contractors, educators, researchers and regulators, the population of these groups being 46,000 and 10,000 respectively.

FUTURE TRENDS

Foresight – Primary Users

1.9 Considering Primary Users of the technology, while trends in the health sub-sector could be judged fairly readily, the main uncertainty arose from how the defence, power generation, fuel cycle and clean up sub-sectors would evolve. A range of plausible scenarios were therefore considered, the following ‘seasons’ being postulated:

- **Autumn**: Operation of extant equipment to the end of design life, but not replaced, followed by nuclear and radiological clean up.
- **Winter**: Abandonment of nuclear or radiological technology, leaving nuclear clean up as the core of the industry.
- **Spring**: The ‘autumn’ scenario, but with equipment replacement.
- **Summer**: Significant expansion of nuclear or radiological technology.

1.10 The nature of the problem in each scenario is the same: to attract recruits from the wider national pool of engineers and physical scientists at a time when engineering and physical sciences are increasingly unpopular career choices. The sector therefore faces the challenge of recruiting from a potentially diminishing pool of suitable recruits. Nuclear clean up is common to all scenarios and the rate at which it can be pursued will be limited by the availability of skilled people. The recruitment and retention challenge is also likely to be differentially affected by the season, eg the winter scenario is likely to be compounded by skilled persons being attracted out of the industry to other UK and international sectors.

Indicative Scenario – Primary Users

1.11 Indicative numbers of the accumulated total of skilled primary users likely to be demanded by the sector over the next 5, 10 and 15 years are given in Table 1 for one illustrative scenario in which:

- Health grows by 10% every 5 years[3];
- Work on nuclear clean up doubles over the 15-year period, in addition to taking on station closures;
- The current power station closure programme is implemented, but new build is not pursued; and
- Defence and the Fuel Cycle remain status quo.

[3] Noting that the Health Sector already has a 10% shortage of radiologists and radiographers. Audit Commission review of national findings – Radiology – July 2002.

Table 1

TABLE 1

INDICATIVE SCENARIO – PRIMARY USERS

SECTOR SUPPLY - ACCUMULATED RETIREMENTS

Based upon the age profile of the current Primary User population, the accumulated number of skilled people likely to retire from the sector over the next 5, 10 and 15 years are:

RETIREMENTS – LOSS OF SUPPLY	Over 5 years 2002 – 2007	Over 10 years 2002 – 2012	Over 15 years 2002 – 2017
HEALTH	3,700	6,600	9,600
DEFENCE, POWER, FUEL, & CLEAN UP	6,400	14,500	22,600
TOTAL RETIREMENTS	**10,100**	**21,100**	**32,200**

SECTOR DEMAND – ACCUMULATED RETIREMENTS, SHORTAGE AND GROWTH

Although the scenario assumes that power generation will decline, health and nuclear clean up grow, giving rise to overall sector growth. The health sub-sector already has a skill shortage and to accommodate this, sector growth and retirements, the total accumulated demand could be as high as:

PRIMARY USER DEMAND	Now	Over 5 years 2002 – 2007	Over 10 years 2002 – 2012	Over 15 years 2002 – 2017
RETIREMENTS		10,100	21,100	32,200
SHORTAGE	3,000	3,000	3,000	3,000
GROWTH		4,900	8,900	14,800
TOTAL DEMANDS	**3,000**	**18,000**	**33,000**	**50,000**

The breakdown of the above, accumulated, demands are:

SUB-SECTOR DEMAND	Over 5 years 2002 – 2007	Over 10 years 2002 – 2012	Over 15 years 2002 – 2017
HEALTH			
Radiologists and Radiographers	8,000	13,000	18,000
Clinical Scientists	1,600	2,600	3,600
DEFENCE, POWER, FUEL, & CLEAN UP			
Professional and Associate Professional [i]	4,450	10,000	15,500
Skilled Trade, Process Plant and Machine Operator [ii]	2,250	4,900	7,850
Others [iii]	1,700	2,500	5,050
TOTAL DEMANDS	**18,000**	**33,000**	**50,000**

i. 'Professional and Associate Professional' refers to a person qualified to Level 4 and 5 in the National Qualifications Framework, typically having a minimum qualification of a Bachelors degree.

ii. 'Skilled Trade, Process Plant or Machine Operator' refers to a person with a vocational or occupational qualification at Level 3 or below in the National Qualifications Framework.

iii. Others include the remainder of the population, principally Administration and Secretariat.

Impact - Graduates

1.12 To put these figures into perspective, 15,500 graduates required by the power, fuel, defence and clean up sub-sectors over the next 15 years equates to approximately 1,000 graduates per year. Of these, 700 are replacements for retirements and 300 are a response to growth of nuclear clean up. By comparison, the sector's 2001 graduate recruitment target was approximately 560[4].

1.13 Considering the major engineering and physical science disciplines from which these graduates must be recruited (mechanical, electrical, electronic, civil and chemical engineering, physics and chemistry), in 1994 some 18,000 students were accepted to study these subjects at Higher Education Institutes. By 2001 this figure had fallen to 13,250, a fall of 26% in eight years. Noting also that these figures do not take account of students who fail to graduate or choose an alternative career on graduation, if these trends continue, of a rising demand and a falling supply, the nuclear and radiological sector may be seeking to recruit the equivalent of 10% of all UK engineering and physical science graduates in 10 years' time.

Impact – Apprenticeships

1.14 The indicative scenario also demonstrates that some 7,850 people with skilled trades skills will be required over the 15-year period, highlighting the need for apprenticeships. Such schemes are of paramount importance as they not only deliver people with the required skilled trades, but also provide an alternative entry route for people that may attain higher positions through career development. Despite their importance, a recent review of apprenticeship training led by Sir John Cassells[5] identified that:

> "England does not currently have a strong apprenticeship system. It stood in danger of not having an apprenticeship system at all following the collapse of the previous system in the 1970s and 1980s. There is a real sense in which apprenticeship remains marginal within our education and training system… The reasons it is so are that it has been inconsistently delivered; poorly managed; and poorly known about and understood."

UNPOPULARITY OF ENGINEERING AND PHYSICAL SCIENCES

1.15 Engineering and physical sciences are unpopular fields of study, both academic and vocational. However it is from this pool of students that the nuclear sector must recruit. Unless this trend is reversed, the nuclear sector will face the challenge of recruiting from a diminishing pool of potential recruits. The general unpopularity of engineering and physical science has been recognised in the recent review conducted by Sir Gareth Roberts[6], which identified that:

> "The 'disconnect' between the strengthening demand for graduates (particularly in highly numerate subjects) on the one hand, and the declining numbers of mathematics, engineering and physical science graduates on the other, is starting to result in skills shortages."

1.16 The IAEA have also recognised this issue, as identified at a recent IAEA conference on managing nuclear knowledge[7]:

> "There is a general difficulty in attracting young people into the field of nuclear engineering and physical sciences: the courses seem too difficult; upon graduation the jobs are uninteresting and the pay is too low, and there is a view that only the 'least attractive' people go into these fields. It was also pointed out "before we can educate

[4] Estimate of the number of graduates that nuclear and radiological sector employers sought to recruit in 2001.

[5] Modern Apprenticeships – the way to work. Report of the Modern Apprenticeship Advisory Committee. Chairman, Sir John Cassels. Sept 2001.

[6] SET for success: The supply of people with science, technology, engineering and mathematics skills. The report of Sir Gareth Roberts' Review. April 2002.

[7] Meeting of Senior Officials on Managing Nuclear Knowledge. 17-19 June 2002. International Atomic Energy Agency, Vienna International Centre, Austria.

new people in this field, we must first attract them to the field; and engineers themselves are lousy marketers!"

SECTOR ISSUES

1.17 People interviewed in the skills audit and foresight studies reiterated the above concerns and the research identified that while some skills shortages exist today, the greatest shortages being in the areas of medicine, science, technology and regulation, it was anticipated that these shortages would increase in coming years and would extend into the areas of operations and management. The foresight exercise identified several factors affecting this, but three recurrent themes were:

Poor Communication: The importance of communication was emphasised, both in encouraging people into the skill sector and encouraging the wider public to take a rational view of the application of nuclear and radiological technology. In particular it was emphasised that the media and public raise emotional concerns to which the nuclear and radiological sector invariably counter with logic, but rational argument often cannot counter emotional fears.

Poor Co-ordination: The potential for skills shortages is generally recognised and several initiatives exist to address the problem, but these tend to be uncoordinated, hence their collective effect is not as great as it should be.

Apparent Indecision: Indecision in an industry will discourage recruitment and having many policies under consideration will appear to potential recruits as indecision, eg 'keep the nuclear power option open' or 'implement safe-store and defer decommissioning'.

CURRENT 'HOT SPOTS'

1.18 A number of skill 'hot spots' have been identified in the sector now, including:

- **Health Sub-Sector**: Shortages currently exist in all health sub-sector occupations, with a national shortage of radiologists and radiographers of 10% being identified[8] and local shortages as high as 30% being reported in some disciplines. A number of Health Service workforce development plans exist, including 'The Cancer Plan' and the 'Strategy for the Professions in Healthcare Science'. These place emphasis on diagnosticians and therapists, but equal attention must be paid to the workforce development of clinical scientists, engineers and technicians.

- **Radiological Protection**: Health physics describes the skill sets needed to apply techniques and procedures to protect people from the effects of radiation and is an essential function for all primary and secondary users of radiological technology. Health physicists have been recognised as a shortage category for many years but evidence suggests that poor marketing of career opportunities is hampering recruitment. Career development paths also encourage people to leave their specialisation, principally into higher management, so compounding shortages. But good people with drive are unlikely to remain in a field where people from another discipline hold key management positions.

- **Radiochemistry**: Radiochemistry is essential for the production of radioactive samples used in countless medical procedures and is an important building block in nuclear and radiological clean up. BNFL's support for the Manchester radiochemistry department has corrected, in part, a decline in radiochemistry research but the question remains about what is required: a focal point upon which radiochemistry research is concentrated or a centre of excellence supporting satellite departments that achieves diversity across the research sector?

- **Regulation**: The age profile of NII inspectors exhibits a definite age skew, which, if unchecked, will result in a skill shortage within 5 to 10 years. This is due to NII's need to recruit people with significant nuclear experience. Most recruits will be over 35, so automatically skewing the age profile, and NII are faced with a perpetual

[8] Audit Commission review of national findings – Radiology – July 2002: Identifying a mean vacancy rate for radiologists and radiographers of 10%.

challenge of how to attract a small cadre of experienced people from within the sector.

- **Nuclear Education in HEIs**: A common view amongst employers is that they need generalist engineers and physical scientists who can be given specialist in-house training in nuclear technology. As a consequence, there is a low demand for specialist nuclear education in HEIs. This has two effects:
  - The ability to deliver postgraduate nuclear education is diminishing and will be lost if corrective action is not taken.
  - The ability to deliver nuclear modules in undergraduate education is diminishing; hence few undergraduate students are exposed to the challenges a career in the sector may offer.
- **Modern Apprenticeships**: Vocational education not only provides the skilled trades required by the sector, but also provides an alternative entry route for professionals and associate professionals through continuous professional development, many engineers in the sector today having entered through the apprenticeship route. However, vocational education has declined in recent decades, which is detrimental to the sector.
- **Safety Case Writing**: The nuclear sector has always had a strong safety culture and has evolved comprehensive safety practices including the application of written safety cases. The adoption of written safety cases is becoming more widespread in industry and, as a result, there is increased competition for good safety case authors. This is an example of skills developed in the nuclear sector being deployable in other sectors but without reciprocal transfer.
- **Criticality Assessment**: Criticality assessment is unique to the nuclear sector but, with the decline of nuclear research, fewer faculties exist to educate such people and there is less incentive for individuals to acquire those skills.
- **Nuclear Safety Research**: There is increased reliance on expertise and facilities abroad, especially on water reactor technology.
- **Control and Instrumentation**: Control and Instrumentation is key to all process engineering; hence the nuclear sector experiences stiff competition for such skilled people.
- **Numerate Graduates**: There is a migration of people with high quality mathematical modelling skills to the finance and insurance sectors, or to scientific consultancies, which have the ability to pay high salaries for those skills.
- **Project Management**: A decreasing number of people have both the skills to project manage a major development and an appropriate appreciation of nuclear issues.
- **Corporate Capabilities**: A number of corporate capabilities exist in only limited numbers, eg the design and manufacture of nucleonic detectors or the design and manufacture of large pressure vessels.

FUTURE PROGRAMME

1.19 The future programme must focus on three strategic issues:

Promotion of the Sector: Promotion of engineering and physical science in general, and of nuclear and radiological technology in particular, to encourage recruitment into the skill sector.

Underpinning of essential Learning Pathways: Definition and underpinning of the essential learning pathways needed to develop the skills required to apply nuclear and radiological technology.

Underpinning of Education Institutions: Measures to underpin the education and training establishments needed to support the above learning pathways.

1.20 Three closely linked functions, but with subtly different aims, are training, education and research. In addressing the required learning pathways and educational institutions a distinction must be made between these three functions and measures taken to ensure a correct balance is maintained. In this report the distinction is considered thus:

Training: The development of skills that enable people to perform predictable tasks.

Education: The advancement of an individual's fundamental understanding of a discipline, enabling that person to develop processes or consider situations beyond predictable limits.

Research: The expansion of fundamental understanding of a discipline to enable the person to explore new possibilities within a field to produce new diagnostic techniques, more efficient processes, or safer operations.

2 CONCLUSIONS

SKILL SHORTAGES – SHORT AND LONG TERM

2.1 The health sub-sector is experiencing a skill shortage now, while other sub-sectors exhibit a definite age skew meaning that, unless corrective action is taken, a growing skill shortage will develop over the next 5 to 10 years. With the exception of the health sector, Human Resource managers report that they have been able to satisfy recruitment demands to date, but the problem of finding suitable candidates is becoming increasingly difficult. It is conservatively estimated the overall sector will require approximately 50,000 new entrants over the next 15 years to satisfy anticipated demand. But worryingly, this demand must be satisfied from the engineering and physical sciences sector, which is diminishing in size due to its unpopularity as a field of academic study and career choice. A significant skill shortage is likely to develop over the next decade unless action is taken now.

ENGINEERING AND PHYSICAL SCIENCE

2.2 The nuclear and radiological sector is a sub-sector of engineering and physical science but, as Roberts identified: "the declining numbers of mathematics, engineering and physical science graduates is starting to result in skills shortages." The challenge facing the nuclear and radiological sector is therefore two fold:

- To collaborate with other sectors to jointly increase the size of the engineering and physical science skilled population; and
- To recruit those people needed by the nuclear and radiological sector from the engineering and physical science skilled population.

FACTORS

2.3 Key factors that hinder recruitment and retention are:

- **Short-termism**: Employers tend to plan between 3 and 5 years ahead, whereas the lead-time for skill development is often between 5 and 10 years, or more.
- **Communication**: The sector has a difficult communication challenge inherent with the language used in the sector, emotional fears of the effects of the technology and a defensive stance brought about by hostile media.
- **Profile**: The profile of engineering and physical sciences in general, of nuclear and radiological technology in particular, and the state of the sector (winter, spring etc) has a significant impact on recruitment and retention.
- **Pay**: Relative pay is both a disincentive to joining the sector and a lure to leave, eg to the finance and insurance sectors. The relationship between remuneration and attraction is not a simple one however, and issues such as status, stimulation and career development influence people's choice of career.
- **Indecision**: Potential recruits to the sector perceive an industry fraught with indecision, which is detrimental to recruitment, eg: 'no new build but keep the option open', 'consider safe-store and defer decommissioning', 'long consultation periods are necessary before commencing decommissioning'.
- **Transferability**: Skills developed in the nuclear and radiological sector are readily transferable to other sectors but the reverse invariably requires significant additional training. Transferability compounds recruitment and retention as skilled people can be easily redeployed, either individually or by employers, in response to perceived poor remuneration or indecision in future programmes.

FRAGMENTATION

2.4 Fragmentation is exhibited in a number of forms:

- **Fragmented Management**: Competition to reduce the costs has led to a fragmented sector management structure, which now comprises a matrix of 'client' and 'supplier' organisations, within which it has become unclear who is responsible for skill development. This situation has developed in both the health and engineering/scientific sectors. In the engineering sub-sectors, Government organisations, primary clients and supply chain organisations typify the layers of split responsibility. Similar layers exist in the health sub-sector: the Department of Health, the National Health Service and individual Healthcare Trusts.
- **Multiple Qualifications**: A wide variety of qualifications exist, creating confusion about which are, or should be, valued and which are not. This confusion is a disincentive to candidates pursuing certain desirable learning pathways.
- **Training & Education**: A wide variety of training and education establishments exist; hence it is unclear which are vital to the sector, and which are not.
- **Government Organisations**: A wide variety of Government organisations exist to support training and education, eg SSDA, LSC, RDA, Connexions, HEFCE and Research Councils. Funding mechanisms are therefore complex and, in many cases, do not meet the Government's education objectives.
- **Industry initiatives**: A large number of industry initiatives exist targeting schools, but in many cases these do not support the curriculum or teachers' needs; hence they do not achieve their aim.

SECTOR COLLABORATION

2.5 Skill shortages are arising, not because of the failings of specific individuals or organisations in the sector, but because of the macro failure of the national process to recruit, educate and train scientists and engineers in the changing education and employment environment. There are no simple solutions to redress this situation. Corrective action requires attention to detail to improve the overall process and the involvement of many agents within the sector acting in consort. SR2002[9] states:

"as the Roberts report made clear, ensuring a supply of scientists and engineers for the future will also require business and the private sector to play a central role. While Government can help to create the right environment throughout the school, further and higher education systems, employers have a crucial role to play in improving the prospects and attractiveness of careers in science and research."

A successful workforce development strategy must therefore address:

- Action by employers to promote the attractiveness of careers in their sector; and
- Collaboration between employers and educators to provide the right learning pathways.

2.6 Responsibility for 'creating the right environment' for skill development lies primarily with the Department for Education and Skills, and to a lesser extent the Office of Science and Technology, but this responsibility is executed through a series of expert bodies that have delegated operational authority. These include the Learning and Skills Council, Regional Development Agencies, the Sector Skill Development Agency, Sector Skills Councils, the Higher Education Funding Councils and Research Councils. An effective workforce development strategy must therefore involve collaboration between employers (demand) and the above operational councils and authorities (suppliers) in order to implement Government policy to the benefit of the sector.

[9] Opportunity and Security for All: Investing in an enterprising, fairer Britain. August 2002.

2.7 Government policy on skills development is based on employers establishing their collective demand for skilled people, jointly promoting their sector to encourage recruitment and influencing suppliers of education and training to provide courses that will satisfy their demand. The current vehicle for delivery of this policy is through a Sector Skills Council (SSC).

SECTOR SKILLS COUNCIL CHARACTERISTICS

- Must be employer led
- Must aim to reduce skills gaps and shortages by:
  - Anticipating future demand for skilled people;
  - Applying leverage on the supply of skilled people;
  - Helping people make informed career choices;
- Must aim to improve learning supply by encouraging the development of:
  - Modern Apprenticeships;
  - Higher Education; and
  - National Occupational Standards.

2.8 Development of such councils is still at an early stage and the NSG envisage difficulties relating the SSC concept to the nuclear and radiological sector. The sector is too small to form a standalone council and the economic activity of the sector is diverse, the point of commonality being skills rather than activity. The view of the NSG is:

- Since the success of an SSC is dependent on employer support, formation of an SSC must be employer led: the council must be the organisation required by the sector, not an organisation prescribed by Government.
- It is not evident what the final shape and form of the sector tapestry will be.
- Considering its relatively small size, the unique demands of the nuclear and radiological sector must not be marginalized within a broad-based SSC.
- Collaboration between employers, educators and other involved organisations is essential but it is not clear that simple engagement with a single SSC represents the right way forward.

2.9 The expectation of the Sector Skills Development Agency (SSDA) is that an SSC, or SSCs, will eventually exist to cater for the nuclear and radiological sector, albeit that the application of nuclear and radiological technology may be a cross-sector skill in relation to the final tapestry of SSCs. eg Health is likely to have its own SSC, distinct and separate from Power Generation, although benefits may be found in cooperation in the delivery of training and education. The debate is around where the skills synergies best lie and into which SSCs the sector (and SSDA) consider they best fall. The advice of the SSDA is to make strategic plans accordingly.

2.10 It is likely to be some time before a fully functioning SSC(s) exists. A principal action must therefore be to pave the way for inclusion of the nuclear and radiological sector within the SSDA's national strategy. A means is therefore required of forging collaboration between employers and promoting synergy across the sector in order to implement Government policy in this area. In advance of an SSC(s), and where appropriate, interim action is also required to co-ordinate the activity of the various organisations currently: promoting the sector to encourage recruitment; providing training and education within the sector; and underpinning educational establishments needed by the sector. By this means some early gains can be achieved in addressing skill development. The NSG's recommendations therefore lie, initially, with a task group, whose role will be to:

- Forge collaboration between employers across the sector in order to encourage formation of appropriate Sector Skills Councils; and

- In advance of an SSC, and where appropriate, encourage collaboration amongst those currently engaged in skills development in order to achieve some early improvements.

As the tapestry of Sector Skills Councils develops, responsibility should be progressively transferred to the emerging council(s) and the interim arrangements dismantled.

STRATEGIC PLAN

2.11 The cross sector nuclear skills task group must formulate a strategic plan to stimulate initiatives to address the potential skill shortages identified by the foresight exercise. That strategic plan must concentrate on three issues:

- **Promotion of the Sector**: Collaborative promotion of engineering and physical science, to enlarge the pool of competent people who could potentially be recruited into the sector, and promotion of the nuclear and radiological sector to encourage recruitment into that sector.
- **Learning Pathways**: Collaborative initiatives to ensure that the learning pathways are available to train and educate the people needed by the sector. Learning and qualifications are inextricably linked, qualifications being an auditable measure of achieved learning. With the high number of learning pathways and qualifications available to students, it is imperative that mechanisms for establishing a 'common currency' for qualifications be established, such as the adoption of National Occupational Standards.
- **Viability of Education and Training**: Collaborative initiatives to ensure the viability of the further education colleges, higher education institutes and training establishments to enable those learning pathways to function.

TACTICAL AIMS

2.12 The priority tactical aims supporting that strategy must be:

- **Science, Engineering, Technology and Mathematics Network**: Action is required to promote engineering and physical science in schools, but the sector must collaborate with other initiatives in this action and must not start an independent campaign. SETNET is the recommended vehicle for achievement of this aim.
- **Vocational versus Academic Education**: Vocational education has declined in recent decades, to the detriment of the sector. Vocational education is required, not only to provide people with skilled trades, but also to provide an alternative source of professional and associate professional people through continuous professional development. Action must be taken to promote vocational education in order to achieve a balance between vocational and academic education within the sector.
- **Nuclear Education in HEIs** Action is required to establish the right level of provision of nuclear education in HEIs that complements the in-house training provided by employers, provides a viable infrastructure of education in universities and enables an introduction to be given to undergraduates of the opportunities the sector offers. To achieve this, collaborative action is required between employers, in-house training organisations, academia and the research councils.

3 RECOMMENDATIONS

SUMMARY OF RECOMMENDATIONS

STRATEGIC RECOMMENDATIONS

Recommendation 1: The Skills Development Strategy should focus on three issues:

- Promote the sector to encourage recruitment;
- Underpin essential learning pathways; and
- Underpin education establishments that support those pathways.

Recommendation 2: Encourage concerted industry support of education, training and research.

Recommendation 3: Establish a Nuclear Skills Task Group to:

- Forge collaboration between employers across the sector.
- Identify the right vehicle for carrying forward action in the long term.
- Take forward the NSG's recommendations and generate action.

Recommendation 4: Encourage collaboration with Regional Development Agencies and Enterprise Councils to ensure coherence of regional, national and sectoral programmes.

Recommendation 5: Raise the profile of radiological skills within the Health Sector and integrate NHS workforce development arrangements with those of the remainder of the sector.

TACTICAL RECOMMENDATIONS

Recommendation 6: Co-ordinate general promotion of the sector, employment and careers.

Recommendation 7: Remove artificial barriers to communication by use of language and openness.

Recommendation 8: Work with the Nuffield Foundation to include nuclear and radiological related material in the 2005 review of the national curriculum.

Recommendation 9: Promote sector support to continuing professional development for teachers.

Recommendation 10: Promote sector support for the promotion of science, engineering, technology and mathematics in schools.

Recommendation 11: Promote the use of Modern Apprenticeships in the sector.

Recommendation 12: Promote the use of National Occupational Standards.

Recommendation 13: Promote modular nuclear higher education courses to enable their use as:

- Taster units in undergraduate courses; and
- Building blocks to postgraduate qualifications.

Recommendation 14: Work with other sectors to lobby for increased per capita funding for undergraduate engineers and physical scientists.

Recommendation 15: Work with other sectors to lobby for collaborative development of higher education syllabi to balance employers' (vocational) requirements and academic criteria.

SKILLS DEVELOPMENT STRATEGY

3.1 The prime reason for shortages of skilled people in the nuclear and radiological sector is the inability to recruit, and subsequently retain, sufficient people into the sector, which is, in turn, dependent upon the number of people choosing engineering or the physical sciences as a career. Having recruited people into the sector, it is further necessary to educate and train those people in the unique disciplines required to manage nuclear and radiological technology in order to achieve the required skill mix within the workforce. This gives rise to the first recommendation, addressing the required strategy to increase the sector's skill base:

Recommendation 1

SKILLS DEVELOPMENT STRATEGY

The skills development strategy should focus on three principal issues:

- **Promotion of the Sector**: Collaborative promotion of engineering and physical science, to enlarge the pool of competent people who could potentially enter the sector, and promotion of the nuclear and radiological technology to encourage recruitment into that sub-sector.
- **Underpinning of Essential Learning Pathways**: Collaborative initiatives to ensure that the learning pathways needed to train and educate in the sector are available.
- **Underpinning of Education and Training Establishments**: Collaborative initiatives to ensure the viability of the further education colleges, higher education institutes and training establishments to enable those learning pathways to function.

3.2 A multiplicity of organisations are already involved in these activities, in Government, in industry, in academia and in professional institutions, but their efforts are fragmented and collectively they do not deliver the results they should. There are no simple solutions to redress this situation and the corrective action requires attention to detail to improve the overall process, with the involvement of many agents within the sector acting in consort.

Concerted Industry Support of Sector Skill Development

3.3 The Nuclear Skills Group noted that several employers in the sector carry out commendable work in support of skill development, but further effort is needed to ensure synergy across the sector and introduce diversity to defend against reliance upon single sources of support. This requires:

- Co-ordination of sector promotion;
- Harmonization of education, training and research initiatives that have common value across the sector;
- Proportionate support from all sector employers: large companies, SMEs and Government.
- Collaborative effort to develop the skilled people required by the sector, avoiding in-sector 'poaching' without contribution to commensurate sector growth.

Recommendation 2

ENCOURAGE CONCERTED EMPLOYER SUPPORT OF SECTOR SKILL DEVELOPMENT

Commitment is required from all sector employers to provide concerted support for promotion of the sector and the education, training and research needed to ensure that skill development in the sector will satisfy the future needs of all employers: large companies, SMEs and Government.

Action: Nuclear Skills Task Group / Sector Employers

Nuclear Skills Task Group

3.4 Government policy reflects the need for concerted action by employers, the accepted vehicle for delivery of which is a Sector Skills Council (SSC), licensed by the Sector Skills Development Agency (SSDA). However, the development of such councils is at an early stage and, as noted in Chapter 2, there is no obvious SSC for the nuclear and radiological sector. It is not clear at present what the best vehicle for collaborative action by the industry might be and equally it is not clear at this stage that there is total buy-in from employers to the action required to address skills issues. It is essential that these issues be addressed as soon as possible. In the meantime, a vehicle is required to pave the way for inclusion of the complete nuclear and radiological sector within the wider tapestry of developing sector skills councils and to drive forward action on the NSG's recommendations.

3.5 It is proposed that this be achieved by means of a task group, directed to promote collaboration and synergy across the sector, so seeking to implement Government policy in this area.

Recommendation 3

ESTABLISH A NUCLEAR SKILLS TASK GROUP

It is recommended that a task group be formed, the prime role of which must be to:

- Forge collaboration between employers across the sector.
- Pave the way for inclusion of the complete Nuclear and Radiological Sector within the developing tapestry of Sector Skills Councils.
- In the interim, take forward the NSG's recommendations and generate action.

Action: DTI / SSDA

3.6 It is recommended that the task group consist of:

- A steering group comprising senior representatives of sector employers and Government, charged with setting strategic objectives and monitoring progress; and
- An operational group, comprising secondees from public and private sector employers, to implement the actions arising from the recommendations made in this report and objectives set by the steering group.

3.7 The task group must work closely with:

- Sector employers;
- Deliverers of education and training; and
- Those that seek to promote and develop the sector.

3.8 This includes:

- The Sector Skills Development Agency (SSDA), who have responsibility for skills development, in particular implementation of the Sector Skills Council initiative;
- The Learning and Skills Council (LSC), at both central and regional level;
- Regional Development Agencies (RDA);
- Research Councils;
- Higher Education Funding Councils;
- The DTI Strategy and Competitiveness Unit, who are responsible for co-ordinating the DTI's response to the SSC initiative and are also responsible for implementing the DTI's response to the Roberts' recommendations;
- Providers of education and training in HEIs and FECs; and
- Professional Institutions.

3.9 As the tapestry of Sector Skills Councils develops, responsibility should be progressively transferred to the emerging council(s) and the interim arrangements dismantled.

Research

3.10 Skills development and research are closely related, exemplified by BNFL's investment in nuclear science and technology research alliances with Manchester, Leeds and Sheffield universities. Increasingly the funding of education and research is from diverse sources, which can result in conflicting demands on providers of learning pathways. The sector requires a coordinated strategy that balances the needs of employers, the requirements of academia and Government funding criteria, which should include collaboration between those organisations that fund research. This is an area in which the task group, and later the engaged Sector Skills Councils, must be involved.

Regional Development

3.11 The Regional Development Agencies (and regional Learning and Skills Councils) are key agents in skills development, as identified in SR2002:

"Consulting widely, in particular with employers, the Government will therefore undertake a fundamental review of the funding for adult learning… The review will also consider how current funding arrangements could be reformed to enable Regional Development Agencies (RDAs) to play a full and effective role in developing and implementing regional skills strategies… Increasing innovation was identified as priority by most regions… a new enhanced Higher Education Innovation Fund (will be created) to stimulate the commercialization of scientific research. The next round of this Fund will include a role for the RDAs in ensuring that universities' proposals for funding are aligned with the needs of business in the region."

3.12 Employers must engage with the relevant RDAs to ensure that regional skills related programmes reflect the requirements of the nuclear and radiological sector. It is recommended that, in the short term, the nuclear skills task group, and in the long term the relevant Sector Skills Councils, engage with the appropriate Regional Development Agencies to co-ordinate employer collaboration in skills development at the regional level. Four regions of particular interest are:

- **North West** (including Cumbria, Manchester and Risley);
- **Highlands and Islands** (including Caithness);
- **South West** (including Devonport, Bristol, Gloucester and the Severn Estuary); and
- **North East** (only limited nuclear and radiological skills are deployed in the region, but a number of employers are based in the region that are, or may become, key stakeholders in the sector).

Recommendation 4

COLLABORATION WITH REGIONAL DEVELOPMENT AGENCIES AND ENTERPRISE COUNCILS

The nuclear skills task group, and Sector Skills Councils in the longer term, should collaborate with the appropriate Regional Development Agencies, regional Learning and Skills Councils and Scottish Enterprise Councils on skills development.

Action: Nuclear Skills Task Group

Health Sector

3.13 As highlighted in the recent Audit Commission report, a shortage of people with radiological skills is resulting in the "inability to meet demand for 'round the clock' services" and "long waits for some types of examination, particularly CT and MRI scans." A higher profile must be given to radiological skills within the health sector; not only of the diagnosticians and therapists (radiographers and radiologists) but also the medical physicists and clinical scientists, engineers and technicians who provide essential support for the design and maintenance of health care equipment. The effectiveness of front line support is wholly dependent upon logistics support.

3.14 A number of health sector workforce plans already exist or are in development, including 'The Cancer Plan', 'Making the Change. A Strategy for the Professions in Healthcare Science' and 'Human Resource in the NHS Plan'. These plans propose a programme of modernising workforce planning, including:

- Bottom-up planning by stakeholders represented in Workforce Development Confederations;
- Top-down planning by the National Workforce Development Board; and
- The concept of a 'Skills Escalator', in which careers are considered as a succession of stages with their own learning requirements. Staff are encouraged to constantly extend their skills and knowledge, enabling them to move up the escalator, while roles and workload are delegated down the escalator, generating skill mix benefits. A greater variety of step-on and step-off points are created, complementing traditional entry points, such as registered professional staff, with other entry routes, such as cadet schemes and role conversion, to attract people in other careers who are seeking new challenges.

3.15 While these plans are commendable, they must be turned into action and implementation of the nuclear and radiological skills initiative must be carefully planned to ensure synergy between extant and future health initiatives.

Recommendation 5

RAISE THE PROFILE OF RADIOLOGICAL SKILLS WITHIN THE HEALTH SECTOR

The profile of radiological skills within the health sector must be raised, not only of the diagnosticians and therapists, but also the medical physicists and clinical scientists, engineers and technicians that support them. The nuclear skills task group and emerging Sector Skills Councils must work closely with the health sector skills development organisations to ensure synergy in their actions. This must:

- Take into account the radiological sub-groups within the health sector;
- Encourage action to be taken by those best placed to do so; and
- Ensure that all elements of the sector are adequately represented.

Action: Nuclear Skills Task Group / NHS National Workforce Development Board and Confederations

TACTICAL RECOMMENDATIONS

3.16 The following tactical recommendations are made to address the strategic issues.

Co-ordinate General Promotion of the Sector

3.17 Developing Recommendation 2, promoting the sector is a strategic objective of the skills initiative and helping employers and individuals make informed choices must be a principal aim of the task group and relevant Sector Skills Councils. Many organisations already promote the sector, including employers, professional institutions, careers advisers and trade associations, but their actions must be co-ordinated to have maximum effect.

3.18 Promotion of the sector must emphasise the factors that make the sector an "attractive" career option, including remuneration, career development, status, elimination of student debt and skills marketability. Collectively, it is these factors that will make individuals consider it worthwhile, or not, making the investment in time and effort to pursue an engineering or "hard" science option. Many of these factors are employer dependent and in promoting the sector both sector generic and employer specific attractions must be emphasised.

Recommendation 6

CO-ORDINATE GENERAL PROMOTION OF THE SECTOR

Many organisations already promote the sector, including employers, professional institutions, careers advisers and trade associations, but their actions must be co-ordinated to have maximum effect. Best practice must be identified and encouraged across the sector. This must address:

- The positive aspects of the sector and outputs that are in the public good, such as medical treatment or nuclear clean up.
- The attractions of working in the sector: the technical challenge, opportunities for career development and transferability of skills.
- The best vehicles for promotion: eg SET ambassadors, visitor centres, recruitment fairs, publications, websites etc.
- The nature of the message, emphasising the relevance of the work to managing the environment and the essential, exciting and stimulating nature of the work.

Action: Nuclear Skills Task Group / Sector Employers

3.19 The language used by the sector involves many technical and scientific terms, and much use is made of jargon and acronyms, all of which can alienate a lay audience. Because of its defence origins, much of the sector is also shrouded by security, not all of which is necessary. And, in an attempt to allay health and safety fears, the sector often 'dumbs down' the challenge of work within the sector. These factors create an artificial barrier with the lay public and make it difficult for potential recruits to find out about the sector or apply for entry. Success will inevitably be dependent upon the adoption of simple language and openness when promoting the sector.

Recommendation 7

REMOVE ARTIFICIAL BARRIERS - LANGUAGE AND OPENNESS

The task group must promote, encourage and motivate members of the sector to use simple language when promoting the sector and avoid the unnecessary use of jargon or acronyms. Unnecessary confidentiality must also be avoided as this inhibits communication of the challenges that exist in the sector and fosters an environment of mistrust.

Action: Nuclear Skills Task Group / Sector Employers / Trainers & Educators

SECTOR SUPPORT TO SCHOOLS

3.20 Young people are strongly influenced by their experience in schools; hence several recommendations are targeted at this period in the learning process. Much has been published recently about the teaching of science and technology, about the content of the curriculum and about the interest generated by the subjects. It is also evident that teaching staffs are under considerable pressure with changing curriculum demands and the availability of resources to deliver syllabi in a positive and effective manner. The following recommendations are made cognisant of these issues.

National Curriculum

3.21 A review of the national curriculum has been commissioned by the DfES, to be implemented in 2005; an opportunity therefore exists to influence its content. The University of York and the Nuffield Curriculum Centre are developing a science education course in support of this review, the aims of which are to:

- Communicate more clearly to students the key science explanations at the heart of scientific understanding;

- Draw young people meaningfully into engagement with science, teaching them about ideas and controversy, uncertainty and risk, as opposed to a largely uncontested body of knowledge;
- Use a range of teaching and learning activities and practical work, aimed at developing understanding of how we know about these explanations and the nature of scientific enquiry;
- Balance exact science (biology, chemistry, physics) with ideas drawn from sciences such as epidemiology and health sciences that depend upon assessment of risk and probability; and
- Use of model of core sciences, aimed at developing scientific literacy, studied by all, with additional science modules preparing students for further scientific study or pre-vocational study.

3.22 The Nuffield Foundation has contributed to the Nuclear Skills Study and has identified a number of ways in which the nuclear sector can contribute to the current review. This includes providing material on risk assessment and management, and contributing to the proposed core modules, which include: "Radiation and Life" and "Using Radioactive Materials". This is a real opportunity for employers to contribute to the development of curriculum teaching materials in ways that would address the reality of nuclear and radiological technology as well as promoting skills objectives. It is therefore recommended that the sector contribute to the curriculum review through liaison with the Nuffield Foundation.

Recommendation 8

INCLUSION OF NUCLEAR AND RADIOLOGICAL MATERIAL IN THE NATIONAL CURRICULUM

The task group should collaborate with the Nuffield Foundation in order to influence the 2005 review of the national curriculum. Material should be included that will aid the general improvement of scientific literacy, in particular nuclear and radiological technology, which is in general poorly understood. That material should be introduced in such a way that stimulates an interest in the subject that: can be understood in the context of society, seeks new ways of learning and avoids 'learning by rote'.

Action: Nuclear Skills Task Group / Nuffield Foundation

Support to Teachers and Pupils

3.23 Both teachers and pupils require strong sector support. A number of employers already work closely with schools and evidence exists of good practice in providing effective support. But there is also much evidence of the sector failing to appreciate the needs of teachers and pupils, failing to provide support or, where support is provided, it being of poor or inappropriate quality. Two recommendations are therefore made; both of which are examples of the need for employers to work with other sectors in pursuit of common objectives, taking full advantage of established national and regional schemes and initiatives.

3.24 Teachers have an important influence on young people, but they require support from employers to use that influence to the benefit of the sector. Established programmes for the Continuing Professional Development of teachers exist, but the effectiveness of that CPD is dependent on the provision of appropriate, good quality, materials and support from the sector. A number of organisations already deliver such support, but best practice must be established and implemented, and the actions of the diverse groups co-ordinated to have maximum effect.

3.25 The Council for Science and Technology has recommended that products and services should be supplied in teacher friendly ways and that government should work with key stakeholders to improve the operation of supply arrangements. A Centre of Excellence has been proposed which would act as a framework for achieving these outcomes. The Centre would be expected to develop the provision of CPD in science, working with partner organisations. DfES is currently undertaking a consultation on the establishment of such a

Centre. The task group should monitor progress of this initiative and encourage support of the Centre, once established, by employers within the nuclear and radiological sector.

3.26 Appropriate support also needs to be given to pupils to increase the propensity of people to

Recommendation 9

SECTOR SUPPORT FOR CONTINUING PROFESSIONAL DEVELOPMENT FOR TEACHERS

The task group must act as an interface between those that provide continuing professional development for teachers and those elements of the sector that can provide good quality and appropriate material to support CPD.

To be effective, Continuing Professional Development for teachers requires good quality material on subjects such as careers advice, opportunities in industry, employers' requirements and experience in industry. A number of sector organisations are in a position to deliver this support, but their actions must be co-ordinated to have maximum effect.

This should include support for the Centre of Excellence for CPD in science, once established, as recommended by the Council for Science and Technology.

Action Nuclear Skills Task Group

enter careers in science and technology. Many such initiatives exist but collectively these initiatives are not achieving the success they should. Support must be given to extant schemes that have a proven track record of delivering the right support to schools. One such scheme, supported by DTI and DfES, is the Science, Engineering, Technology and Mathematics Network (SETNET). This should be used as a vehicle to form a collaborative arrangement with teachers and other sectors to promote science and engineering to young people.

Recommendation 10

PROMOTION OF SCIENCE ENGINEERING TECHNOLOGY AND MATHEMATICS IN SCHOOLS

The task group must promote appropriate sector support, to teachers and pupils, to increase the propensity of people to enter careers in science and technology through an extant scheme or schemes that have a proven track record of delivering the right support to schools. One such recommended scheme is the Science, Engineering, Technology and Mathematics Network (SETNET). This scheme encourages:

- Use of science ambassadors to promote science and engineering to young people.
- Provision of appropriate material to support delivery of the curriculum.
- Provision of support to help put the curriculum into context.

Action: Nuclear Skills Task Group

MODERN APPRENTICESHIPS AND FURTHER EDUCATION

3.27 In November 2001, the Government announced plans to make on-the-job training for young people in England match the best in the world, calling upon employers to help achieve a target of more than a quarter of young people entering Modern Apprenticeships by 2004. Modern Apprenticeships are joint agreements between students, employers, the LSC and accrediting organisations for young people to be employed to undertake education and training, which the employer prepares for them with the aim of progression within a chosen career.

3.28 The decline in apprenticeship training has not only affected the sector's ability to train skilled trades but has also curtailed an important supply route for professional staff, many of today's professional engineers having entered the sector as apprentices. Collaborative arrangements are needed to develop a range of Modern Apprenticeships that are recognised throughout the sector, the qualifications from which are transferable throughout the sector.

3.29 The Modern Apprenticeship Advisory Committee has set out an action plan for achieving the Government's ambition. The LSC, working closely with new Sector Skills Councils and the Connexions Service, are to spearhead the delivery of this new generation of Modern Apprenticeships. In the absence of a Sector Skills Council, the task group should pave the way for implementation of this initiative. This message is reiterated in SR 2002, which states:

> "This investment will support reform in… key areas, (including) a drive to expand Modern Apprenticeships and work-relevant qualifications… From 2003, a step-change in the funding system for post-16 learning will be made, with three year budgets and 100 per cent end-year flexibility cascaded direct to local Learning and Skills Councils (LLSCs). The Government expects the benefits of these new arrangements to be passed on to colleges, allowing them to plan provision on the basis of local strategic priorities and employer needs, rather than just on the basis of short-term affordability."

3.30 This initiative must be promoted across the whole sector, including the medical sub-sector. By example, the competence standard for radiographers is currently a vocational degree but many tasks in that sub-sector could be carried out by persons qualified to an appropriately defined National Vocational Qualification. The Modern Apprenticeship scheme would be an ideal vehicle for implementing such an initiative. The NHS Consultation Document 'Human Resources in the NHS Plan' includes examples of progress made in new ways of working, which includes the use of Assistant Practitioners in Radiography, creating a new grade of assistant practitioner to undertake some tasks currently carried out by radiographers. There is much synergy between this initiative and the use of Modern Apprenticeships, which must be exploited in this and other areas.

Recommendation 11

MODERN APPRENTICESHIPS

The task group should promote the development of a range of Modern Apprenticeships that are recognised throughout the sector, including the health sub-sector, the qualifications from which are related to a common set of occupational standards to permit transferability.

Action: Nuclear Skills Task Group / Learning & Skills Council / SSDA

3.31 Investment in Modern Apprenticeships may not always meet short-term economic criteria but, in the NSG's view, is essential for the development of the nuclear skill base in the medium and long term. Action is primarily for employers. But the Task Group (and the sector skills initiative that succeeds it) should monitor progress with a view to identifying whether some form of Government support, eg training grants or tax credits, might be needed to sustain investment at the level required to ensure that skills needs are met.

National Occupational Standards

3.32 Increased use of contractors and increased mobility of the workforce places greater emphasis on the transferability of skills, which can only be achieved by the use of common occupational or competency standards. Organisations such as the Occupational Skills Council for Engineering and National Occupational Standards in Healthcare Science must be supported in developing such standards, and those engaged in delivery of further education, higher

Recommendation 12

NATIONAL OCCUPATIONAL STANDARDS

The task group must promote and encourage the development and use of National Occupational Standards that are recognised across the sector and the work of organisations such as the Occupational Skills Council for Engineering and National Occupational Standards in Healthcare Science must continue to be supported.

Action: Nuclear Skills Task Group / Sector Employers / Trainers & Educators education and in-house training must be encouraged to adopt those standards when developing course syllabi.

HIGHER EDUCATION – SPECIALIST ISSUES

3.33 Employers currently prefer to recruit good generalist engineers and scientists and provide specialist nuclear training in-house. Postgraduate higher education is therefore in competition with in-house training, with employers preferring in-house training as it is targeted and more cost effective to deliver. As a consequence, there is a low demand for nuclear education in HEIs, which has two effects:

- The ability to deliver nuclear modules in undergraduate education is diminishing; hence few undergraduate students are exposed to the challenges a career in the sector may offer; and
- The ability to deliver postgraduate nuclear education is diminishing and will be lost if corrective action is not taken.

3.34 These effects are confirmed by the HSE's survey of higher education in the United Kingdom, which identified a situation of "ageing academics, ageing facilities and no undergraduate courses with significant nuclear content." There is a need to maintain an ability to provide nuclear education in HEIs as:

- Many undergraduates obtain their first experience of nuclear and radiological technology in undergraduate courses, which, if lost, removes an opportunity for promoting the sector with the aim of recruitment;
- In conjunction with research and undergraduate education, postgraduate education is one of the elements that make HEI faculties viable; and
- Professional engineering institutes now seek a Masters qualification as the competence standard for Chartered status but, without postgraduate education, people would be unable to achieve Chartered status in a nuclear discipline.

3.35 One solution lies in modularising nuclear and radiological HE courses, and seeking equivalent recognition for in-house training. Such modules would have a transferable currency and could be used either as 'taster' units in undergraduate courses, or collectively to build into a postgraduate certificate, diploma or Masters degree. Achievement of this aim must be employer led, but requires collaboration between employers, academia, and in-house trainers. Involvement of the research councils is also required, as the funding of elements of postgraduate education is part of their remit. The task group should act as facilitator to promote the initiative, which should:

- Seek synergy in delivering: right sized modules, at affordable costs, in study periods acceptable to employers;
- Ensure the relevance of courses to employers and students; and
- Make the best use of training techniques, including higher education, in-house and remote learning.

3.36 Such an initiative would support all three strategic aims: promote the sector, underpin learning pathways and underpin the viability of education institutes. The success of such an initiative must be measured by the ability of the course to be self-sustaining, ie students must want to take the courses, employers must value the qualification and adequate funding must be available to sustain the courses. If these criteria are not met the long-term viability of such courses is unlikely to be assured.

Recommendation 13

MODULAR SPECIALIST HIGHER EDUCATION - INCLUSION IN ENGINEERING AND PHYSICAL SCIENCE DEGREES

The modularization of specialist higher education, and recognition of its equivalence with certain in-house training courses through the application of Occupational Standards for Engineering, should be encouraged. Such modules could build into a postgraduate certificate, diploma or Masters degree. The inclusion of such units in undergraduate engineering and physical science degrees, as 'tasters' for the sector, should also be encouraged.

This demand for such modules rests with employers, hence the initiative should be employer led. But alliances will be required between employers, to enable a broad basis for the modules, and with Higher Education Institutions for delivery of some of the modules. One envisaged model could be modules developed by a specialist lead university, working with employers, and franchised to other HEI's. Although the requirement must be employer led, a third party facilitator will be required to stimulate such action, a role which should be undertaken by the task group in the first instance.

Action: Nuclear Skills Task Group / Sector Employers / Educators in HE

HIGHER EDUCATION - GENERIC ISSUES

3.37 Two generic issues that apply to Higher Education are:

- The need for increased per capita funding for engineering and physical science undergraduates to ensure the viability of university faculties; and
- The development of higher education syllabi that meet employer needs.

Funding – Higher Education Funding Councils

3.38 The sector is reliant on a supply of good quality graduate engineers and physical scientists from which to recruit but, with the decline in popularity of such courses, engineering and physical science faculties are under increased financial pressure and many are closing. Evidence suggests that closures are not only contributing to the shortage of engineers and physical scientists, but also to a shortage in educational staff to educate new engineers and physical scientists. This issue is wider than the nuclear and radiological sector and was considered in the Roberts Review, which identified that:

"For laboratory-based subjects these (HEFCE) premia appear to be insufficient to allow universities to maintain their laboratories properly and to met their staff and running costs… it is very likely that this under-investment was 'frozen-in' and has resulted in a continued under-resourcing of science and engineering departments."

3.39 The funding arrangements for undergraduate engineering and physical science education should be reviewed to ensure that reliance on market forces to ensure the viability of such courses does not result in unnecessary closures. This has been addressed, to some extent, in SR2002, which states that the Spending Review will take forward the key recommendations of the Roberts Review, including:

- Modernising science and technology laboratories in schools and universities;
- Increasing Research Council PhD stipends to an average of over £13,000 a year by 2005-06 and the salaries of Research Council-funded postdoctoral researchers by an average of around £4,000; and
- Targeted funds for improving universities' capacity to recruit and retain first-rate academics.

3.40 The spending review allocates additional funding to support university faculties, but a review of the subject teaching premia for science and engineering subjects is still required. As recommended by Roberts:

"In order to ensure that in future higher education institutions can and do invest properly in science and engineering teaching laboratories, the Review recommends that HEFCE should formally review, and revise appropriately, the subject teaching premia for science and engineering subjects. The revisions should ensure that the funding of undergraduate study accurately reflects the costs – including paying the market rate for staff, as well as the capital costs – involved in teaching science and engineering subjects."

3.41 The task group must therefore collaborate with other Sector Skills Councils to establish whether a review of the HEFCE subject teaching premia for science and engineering subjects is still justified post implementation of SR2002 and, if so, jointly lobby to that effect.

Recommendation 14

INCREASE FUNDING PER ENGINEERING AND PHYSICAL SCIENCE UNDERGRADUATE

The task group should collaborate with other SSCs to review the subject teaching premia for science and engineering subjects. If evidence exists that under funding is resulting in the unnecessary closure of faculties, skills organisations should jointly lobby for increased funding.

Action: Nuclear Skills Task Group / DfES Higher Education Group / HE Funding Councils

Higher Education Curricula – Employers and Accrediting Organisations

3.42 Employers increasingly complain that graduates are poorly prepared for employment in the workplace. Employers, Higher Education Institutions, accrediting organisations, professional institutions and Government must therefore collaborate to develop courses that balance employer and academic requirements. This issue is wider than the nuclear and radiological sector and the task group must collaborate with other sectors to establish a means of developing higher education syllabi that more directly meet employers needs. This may require differentiation between HEIs that deliver vocationally biased courses and those delivering academic biased courses. This reiterates an issue considered by the Roberts Review, which states:

"the Review is concerned that a step change is needed in the skills communications between employers (particularly businesses) and HEIs. Greater business involvement in course development would give HEIs, businesses and students more confidence that students are acquiring the right skills, and would keep businesses in touch with the skills sets on offer from universities… HEIs and employers must be supported by those bodies that accredit science and engineering courses (eg the Engineering and Technology Board and professional bodies which are members of the Science Council). These bodies must work with HEIs to drive forward innovation in course design, and not allow the accrediting processes to inadvertently inhibit it."

Recommendation 15

COLLABORATIVE DEVELOPMENT OF HIGHER EDUCATION COURSES

The task group should collaborate with all relevant SSCs and other workforce development organisations in other sectors to establish a means of developing higher education syllabi that balance employer (vocational) and academic requirements.

Action: Nuclear Skills Task Group / SSCs / Workforce Development Organisations

4 AIM

NUCLEAR AND RADIOLOGICAL SKILLS STUDY

4.1 The aim of the Nuclear and Radiological Skills Study is to assess the state of the skill sector and produce recommendations for Government, industry, academia, professional institutions and the education sector on how to ensure sufficient numbers of appropriately skilled and educated people are available to satisfy UK employers' needs in the medium to long term future within:

- The health related professions using radiation technologies;
- The defence nuclear industry;
- The nuclear and radiological clean up industry, encompassing de-commissioning waste management and environmental remediation;
- The nuclear power generation sector, including operation of extant plant until planned closure and 'keeping the option open' for new build; and
- Other sectors and industries using radiation technologies in support of their operations.

4.2 The study must consider the factors that may influence the provision of skilled people over the next 15 years, in order to:

- Inform Government of potential skill shortages;
- Inform those involved in skills planning and the provision of education and training of potential needs to avert a shortage;
- Stimulate collaborative initiatives to encourage 'new blood' into the skill sector; and
- Stimulate collaborative initiatives to provide adequate career training thereafter.

5 TARGET AUDIENCE

BACKGROUND

5.1 The aim of this report is to establish where the nuclear and radiological skills sector is at risk from a potential skills shortage and to make recommendations on how to avert those potential shortages. The report is therefore targeted at:

- **Responsibility**: Those responsible for the safe delivery of UK's nuclear and radiological programmes.
- **Recruitment and Retention**: Those responsible for promotion of the skill sector in order to recruit people into the skill sector and retain those people.
- **Provision of Learning Pathways**: Those responsible for providing the learning pathways needed to cultivate the necessary skills.
- **Viability of Learning Facilities**: Those responsible for ensuring the viability of the education and training colleges, institutes and other facilities on those learning pathways.

5.2 The principal people and organisations within these four categories are:

RESPONSIBILITY

5.3 Those with responsibility for the provision of for the safe delivery of UK's nuclear and radiological programmes include:

- Department of Trade and Industry Ministers with responsibility for nuclear and radiological issues;
- Department of Health Ministers with responsibility for nuclear and radiological issues;
- Ministry of Defence Ministers with responsibility for nuclear and radiological issues;
- Health and Safety Commission, and especially the Nuclear Installations Inspectorate;
- Department for Environment, Food and Rural Affairs Ministers with responsibility for nuclear and radiological issues;
- Department for Education and Skills Ministers;
- The Scottish Executive;
- Bodies Corporate holding Site Licences under the Nuclear Installations Act; and
- Senior managers in Government and Industry with responsibility for provision of skilled people.

RECRUITMENT AND RETENTION

5.4 Those responsible for recruitment and retention include:

- Human resource directors and managers;
- Sector Skills Councils, or equivalent organisations;
- Engineering and Technology Board;
- Professional Institutions and Learned Societies; and
- Science Engineering Technology Mathematics Network (SETNET).

PROVISION OF LEARNING PATHWAYS

5.5 Those responsible for providing Learning Pathways include:

- Further Education Colleges;
- Higher Education Establishments;
- In-House Training Organisations; and
- Regional Development Agencies.

5.6 Those responsible for setting standards of education and training include:

- Professional Institutions (Annex M);
- Accreditation organisations; and
- National Occupational Standards Councils (Annex P).

VIABILITY OF LEARNING FACILITIES

5.7 Those responsible for ensuring the viability of Learning Pathways include:

- Higher Education Funding Councils;
- Research Councils;
- Learning and Skills Council;
- Regional Development Agencies; and
- Industry Sponsors of learning pathways.

OTHER STAKEHOLDERS

5.8 A number of international organisations have an interest in the development of skills in the nuclear and radiological sector and must be informed of the work of Nuclear Skills Study, including:

- The Nuclear Energy Agency of the Organisation for Economic Co-operation and Development; and
- The International Atomic Energy Agency of the United Nations.

5.9 Other important national institutions and organisations with whom the task group will need to establish close relations include:

- Trades Unions;
- Trade Associations;
- NTOs and SSCs, where they exist.

A list of such organisations is given at Annex M.

ISSUES

6

BACKGROUND

THE POTENTIAL SKILLS SHORTAGE

6.1 Many sectors are currently reporting a shortage of skilled people to satisfy demand, including the rail, oil and gas extraction, plumbing and power generation sectors. The common factor to these sectors is that they all employ people with science, engineering and/or mathematical skills; hence it is evident that the shortage lies in the broad engineering and physical science sector, not just the sub-sectors such as nuclear and radiological technology. This trend has been recognised in a recent report for the Treasury by Sir Gareth Roberts[10], who observed:

"The 'disconnect' between the strengthening demand for graduates (particularly in highly numerate subjects) on the one hand, and the declining numbers of mathematics, engineering and physical science graduates on the other, is starting to result in skills shortages."

6.2 The nuclear and radiological sectors also draw from the science, engineering and mathematical sector, and hence must be considered at risk. Nuclear and radiological skills are required nationally for a wide spectrum of activities. These include health, defence and the nuclear clean up arising from past activity, and also power generation, both using existing plant and 'keeping the option open' to construct and operate new plant. They also extend to a variety of other organisations dependent upon the technology in a secondary role to support their primary activity, eg non-destructive examination and the pharmaceutical industry. A skill shortage within this sector could severely hinder the ability of the user organisations to operate and, perhaps more importantly, hinder their ability to manage nuclear clean up[11].

6.3 This concern has been voiced both nationally and internationally. In 2000, the OECD published "Nuclear Education and Training: cause for concern?" [12] This report surveyed the provision of nuclear education (as opposed to the wider issue of the provision of the suitably educated and trained people) and highlighted that "the ability to educate was falling, perhaps to problematic levels." The OECD therefore recommended that Governments engage in strategic planning of education and manpower, integrated with human resource planning, to encourage young students into nuclear research and development.

6.4 HSE/NII followed up this report with "Education and Research in British Universities", again focusing on the provision of nuclear education, and identified a situation of ageing academics, ageing facilities and no undergraduate courses with significant nuclear content. The potential for a skill shortage therefore lies in many occupations and competencies, including practitioners, educators, trainers and regulators[13].

6.5 The Performance and Innovation Unit Energy Review[14], published in February 2002, also spoke of "good grounds for taking a positive stance to keeping the nuclear option open" and recognised that an adequate skills base was fundamental to that aim.

[10] SET for success: The supply of people with science, technology, engineering and mathematics skills. The report of Sir Gareth Roberts' Review. April 2002.

[11] Including decommissioning, environmental remediation and waste management.

[12] Organisation for Economic Co-operation and Development / Nuclear Energy Agency.

[13] Financial Times, 9 Oct 01, by Matthew Jones: "UK nuclear watchdog warns of missing teeth: Britain's nuclear regulator has warned that a shortage of safety inspectors could disrupt decommissioning programmes and prevent new nuclear power stations from being constructed."

[14] The Energy Review: Performance and Innovation Unit. February 2002. Para 7.75 & 7.76.

6.6 The 'Energy Review' states:

"Keeping the nuclear option open means maintaining an adequate skills base both for R&D and to ensure sufficient personnel to staff new nuclear stations… (and) that UK regulators are adequately staffed to assess any new investment proposals."

NUCLEAR SKILLS STUDY

6.7 In February 2001, a national forum was held to consider this issue, sponsored jointly by the NII and DTI. This confirmed the 'cause for concern' and highlighted three issues:

- the age profile of people currently in the industry;
- the difficulty attracting young people into the industry; and
- the fragility of the arrangements to educate people for the industry.

6.8 The forum resulted in formation of the Nuclear Skills Group, with the objective of conducting a study of the UK nuclear and radiological sector in order to produce recommendations on how to assure sufficient numbers of appropriately skilled and educated staff exist to satisfy the demands of UK employers. The sector comprises organisations that apply common technologies, and hence require people with common skill sets to function. Application of a particular technology may be all, a major part or a minor part of a given organisation's operation. The sector therefore bounds differing size elements of many organisations and is not coincident with a well-defined group of companies or organisations.

6.9 The OECD made the recommendation that education, manpower planning and human resource management should be integrated to address the provision of sufficient suitably educated and trained people to satisfy the nuclear industry's needs. The Nuclear Skills Group aimed to assess how this recommendation could be implemented. The Nuclear Skills Study has been sponsored by five Government Departments: the Department for Trade and Industry, the Nuclear Installations Inspectorate, the Ministry of Defence, the Department of Health, and the Department for Education and Skills. The study was conducted by the Nuclear Skills Group; chaired by John Chesshire, Honorary Professor, Science Policy Research Unit, Sussex University. The membership of the Nuclear Skills Group is at Annex Q.

6.10 The Nuclear Skills Group aimed to consider the factors that could influence the provision of skilled people over the next 15 years. To achieve this, the skills study was split into three phases:

Baseline: To establish a baseline of the industry's current needs and the available skilled population[15] to satisfy those needs, recognising the dynamic nature of the sector.

Foresight: To postulate the alternative scenarios that may occur and quantify their effect on the baseline.

Stimulation: To stimulate initiatives to prevent the potential skills shortages identified by the baseline and foresight exercises.

6.11 The study has considered all occupations (eg senior officials, professional staff, skilled trades and process plant operators) and all competencies (eg development, manufacture, maintenance, operation and regulation) in the sub sectors that comprise the sector (eg fuel cycle, power generation, defence, health, education and training). This report summarises the results of the first two phases (baseline and foresight) and makes a series of recommendations on how to take forward phase three (stimulation).

[15] HSE's Standard Site Licence Conditions refer to such personnel as SQEP – Suitably Qualified and Experienced Persons. In this study, SQEP means a person that is suitably qualified (educated and trained) and experienced to satisfy an industry need, rather than the narrower definition of being SQEP to perform a task affecting safety.

BASELINE

6.12 An audit of the nuclear and radiological sector was conducted to establish the profile of the national skilled population currently in that sector. The key features of that profile are that:

- It is a quantitative 'snapshot' of the current sector, considering both industry's needs and the availability of skilled people;
- Role profiles[16], rather than post profiles, have been considered to enable use of a 'common skill currency' across the industry;
- Differentiation has been made between education, training, experience and competency; and
- Differentiation has been made between generic skills, that any suitably skilled (non-nuclear) engineer or technician must possess, and unique skills that a suitably skilled person in the nuclear industry must additionally possess.

FORESIGHT

6.13 In conjunction with the skills audit, which is concerned with the 'here and now', a foresight exercise has been conducted to consider the future, which comprised:

- A literature survey, to review that work which had already been conducted and reported.
- A series of individual interviews with key people in the sector to capture their experience, views and opinions.
- A series of facilitated workshops to brainstorm and consolidate the experience, views and opinions of a wider cross section of the sector.

6.14 The main challenges highlighted by the foresight study are summarised in Table 6.1.

STIMULATION

6.15 The outputs from the skills audit and foresight exercises are summarised in the following sections. From these studies it is evident that the stimulation phase must concentrate on three issues: promotion of the sector; underpinning of learning pathways; and ensuring the viability of education and training establishments that support those learning pathways (Recommendation 1).

Recommendation 1

Recommendation 1

SKILLS DEVELOPMENT STRATEGY

The skills development strategy should focus on three principal issues:

- **Promotion of the Sector**: Collaborative promotion of engineering and physical science, to enlarge the pool of competent people who could potentially enter the sector, and promotion of the nuclear and radiological technology to encourage recruitment into that sub-sector.
- **Underpinning of Essential Learning Pathways**: Collaborative initiatives to ensure that the learning pathways needed to train and educate in the sector are available.
- **Underpinning of Education and Training Establishments**: Collaborative initiatives to ensure the viability of the further education colleges, higher education institutes and training establishments to enable those learning pathways to function.

[16] The concept of a Role Profile is that to function safely and effectively a company in the nuclear industry must have the ability to perform, or have access to, a number of vital roles. Individuals within a company may perform a variety of roles; hence each post profile within a company will be a composite of roles.

The Main Challenges

Table 6.1

SKILLS SUPPLY – THE MAIN CHALLENGES

Addressing the ‘root causes’ of failure to supply skilled people to the sector and developing the skills to those already in the sector creates a series of challenges for those responsible for the supply of skilled people. Those challenges are:

* Improving the understanding of the sector within the general public
* Improving the visibility of careers in the nuclear and radiological sector to overcome the public perception of this as a dirty and dangerous industry
* Ensuring secondary education explains properly and objectively the pros and cons of nuclear and radiological technology
* Making physical science and engineering attractive as undergraduate subjects
* Clearly stating and promoting Government policy on the use of nuclear and radiological technology
* Developing further the capability of secondary education to produce people with adequate skills in mathematics and science to firstly understand the nuclear and radiological debate and secondly join the sector
* Increasing the capacity of further and higher education to generate the volumes of scientists, engineers, technicians and capable operators to sustain the nuclear and radiological workforce
* Improving the training infrastructure that delivers continued professional development
* Creating a research community on nuclear and radiological science and technology

7 SECTOR CHARACTERISTICS

BACKGROUND

7.1 Many organisations in the United Kingdom apply nuclear and radiological technology as part of their operations, application of that technology being all, a major part or a minor part of a given organisation's activity. Those organisations are dependent, to a varying degree on, a common suite of skill sets and the sector that encompasses those skill sets bounds differing size elements of many organisations; the sector is therefore not coincident with a well-defined group of companies or organisations.

7.2 The sector encompasses organisations that apply nuclear and radiological technology as a primary purpose (power generation, health, defence, and nuclear clean up[17]) and also those that apply radiological technology as a secondary purpose (eg non-destructive examination, pharmaceuticals, veterinarians and dentists etc).

SECTOR POPULATION AND DISTRIBUTION

7.3 An audit of the sector has been conducted to establish its characteristics. The sector is approximately 135,000 strong, distributed as shown in Fig 7.1. One characteristic to note is the relative sizes of the 'primary' and 'secondary' user sub-sectors, around 64% being primary users and 36% secondary users.

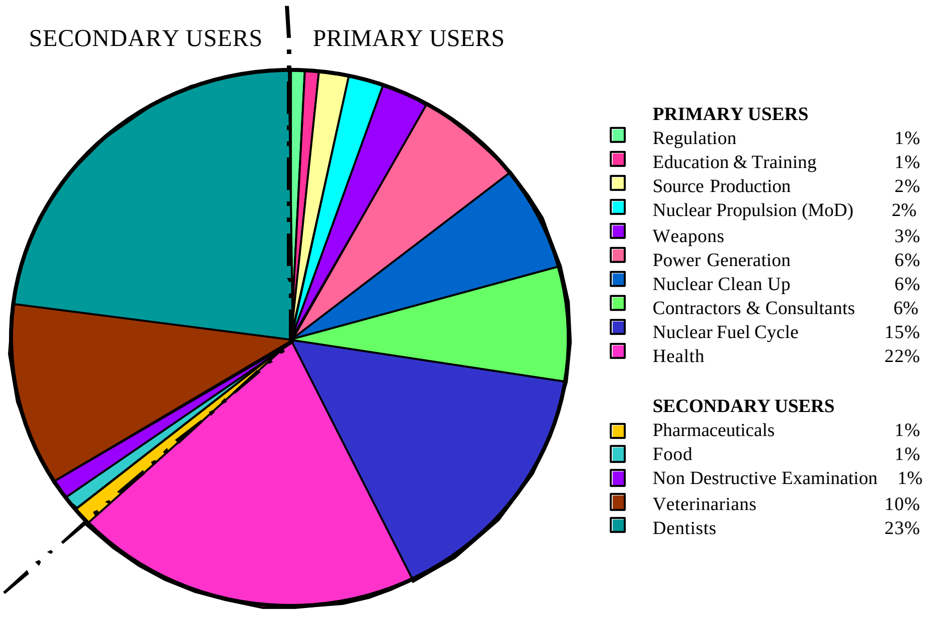

FIG 7.1 POPULATION DISTRIBUTION

SKILLED POPULATION	Population	%
TOTAL	135,000	
PRIMARY USERS	86,400	64%
SECONDARY USERS	48,600	36%

[17] Liabilities encompass the fields of decommissioning, waste management and environmental remediation.

7.4 Of the primary users, a distinction can be made between the health sub-sector, which comprises predominately medical diagnosticians and therapists supported by medical physicists and clinical scientists, and the power generation, defence and nuclear clean up sub-sector, which comprises engineers and physical scientists.

DISTRIBUTION OF OCCUPATIONS AND COMPETENCIES

OCCUPATIONS

7.5 The classification of occupations is based upon those used by the Office for National Statistics, those classifications, described in Annex A, comprise a range of generic occupations:

- Senior Officials;
- Professional Occupations;
- Associate Professional and Technologist;
- Administration & Secretariat;
- Skilled Trades;
- Process Plant & Machine Operators; and
- Elementary Occupations.

7.6 As the study is particularly concerned with technical skills, the four classifications of specific interest are: professional occupations; associate professional and technologist; skilled trades; and process plant & machine operators.

- **Professional Occupation** implies either a requirement to attain Chartered status from a Professional Institution or have equivalent qualifications and experience.
- **Associate Professional and Technologist** falls between Professional and Skilled Trades. Such persons may hold higher academic qualifications, for instance they may have a degree, but they do not have the qualifications and experience to be considered a Professional.
- **Skilled Trade** implies having a skill of hand developed in an apprenticeship, eg welding or turning, accompanied with an academic qualification such as a Higher National Certificate or Diploma, or NVQ Level 3. People who have attained an Advanced Modern Apprenticeship or equivalent typify this occupation.
- **Process Plant & Machine Operators** implies an occupation requiring a single skill and are typified by people who have attained a Foundation Modern Apprenticeship or equivalent.

7.7 The distinction between these occupations is not absolute and a significant overlap exists in terms of the employment of people in various categories. It is however useful to consider such broad classifications as they are indicative of the learning pathways that will need to be followed in order to pursue a given occupation.

7.8 The distribution of occupations is shown in Fig 7.2. The key features to note are:

- Secondary Users are classed as Skilled Trades. Many people in this sub-sector are professionals in their primary field, but in their application of radiological technology they are likely to be working at NVQ level 3 or below.
- In the medical sub-sector, clinical physicists, radiologists and nuclear oncologists are classed as professionals, whereas radiographers and medical physics technicians are classed as technologists. Many of the latter groups are degree qualified but their competence is vocational in nature, hence the classification.
- The proportionately large number of people with higher qualifications by comparison to other engineering based sectors. The ratio of Professionals/Associate Professionals to Skilled Trades in the nuclear power, defence and clean up sub-sector is 2:1, whereas by comparison the ratio in the electricity industry is almost the reverse at 1:1.6.

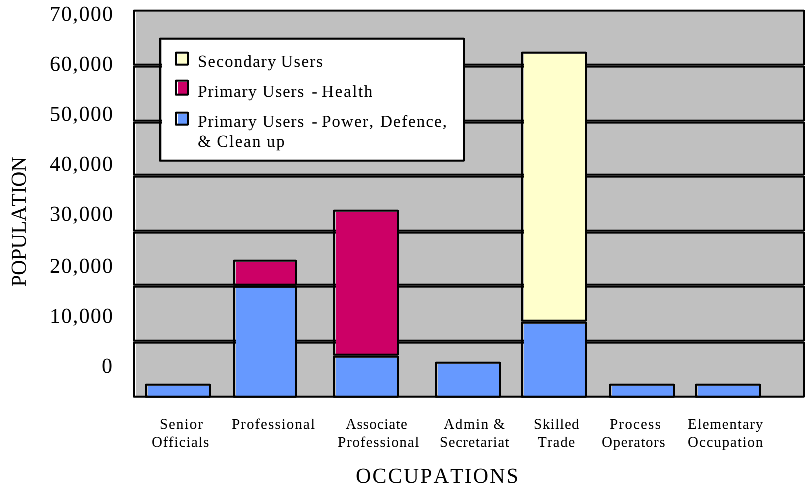

FIG 7.2 DISTRIBUTION OF OCCUPATIONS

COMPETENCIES

7.9 Competencies have been classified based upon those used by the Occupational Standards Council for Engineering (as defined in Annex A), which considers a range of competencies that reflect the life cycle of a project:

- Develop a product or process;
- Produce a product or process;
- Operate a product or process;
- Maintain a product or process;
- Improve a product or process (including QA and regulation);
- Plan, implement & manage a project; and
- Develop own competence (continuing professional development)

7.10 The distribution of competencies is shown in Fig 7.3.

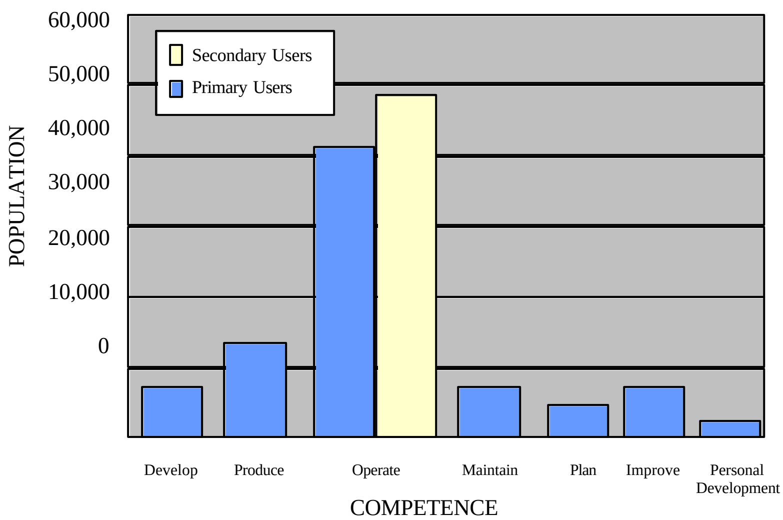

FIG 7.3 COMPETENCE DISTRIBUTION

SHORT-TERM DEMAND TRENDS

7.11 The Skills Audit questioned employers about anticipated changes in demand over the next two years. Employers reported the following likely changes:

OCCUPATION	EXPECTED CHANGE IN DEMAND IN NEXT 2 YEARS
Senior Officials	5% increase in population
Professionals	1% increase in population
Associate Professional	1% increase in population
Skilled Trades	5% decrease in population
Process Plant Operators	1% decrease in population

EDUCATION AND TRAINING LEAD TIMES

7.12 Table 7.1 summarises the education and training lead times estimated from the skills audit and the anticipated changes in population over the next 2 years.

TABLE 7.1

EDUCATION & TRAINING LEAD TIMES

SENIOR OFFICIALS

- Typically have a Bachelor/Doctor degree and more than 5 years in-house training and experience.

Combined Education and In-House Training

[10 Years plus]

PROFESSIONALS

- Typically have a Bachelor or Masters degree and half of them need up to five year's training and experience.

Combined Education and In-House Training

[Up to 10 Years]

ASSOCIATE PROFESSIONALS

- Typically have an HND or Bachelor's degree and at least one year's training and experience.

Combined Education and In-House Training

[Up to 5 Years]

PROCESS PLANT OPERATORS

- Typically have an ONC and require up to one year's training

[Up to 3 Years]

AGE PROFILE AND FUTURE RETIREMENTS

7.13 Evidence from other UK engineering and physical science based skill sectors, and from overseas nuclear sectors (principally the USA, Germany and Sweden), gave rise to an anticipation that the skill sector would exhibit a distinct age skew towards the older age groups. However, the skills audit has not confirmed this suspicion, the age profiles of the primary users and the power generation, defence and nuclear clean up sub-sector being shown at Figure 7.4. One reason for this is believed to be re-organisations and downsizing in recent years resulting in early retirements from the skill sector from the older age groups. On the evidence of the skills audit and foresight study, a major skill shortage does not exist today, but a number of 'hot spots' do exist and there are worrying trends for the future.

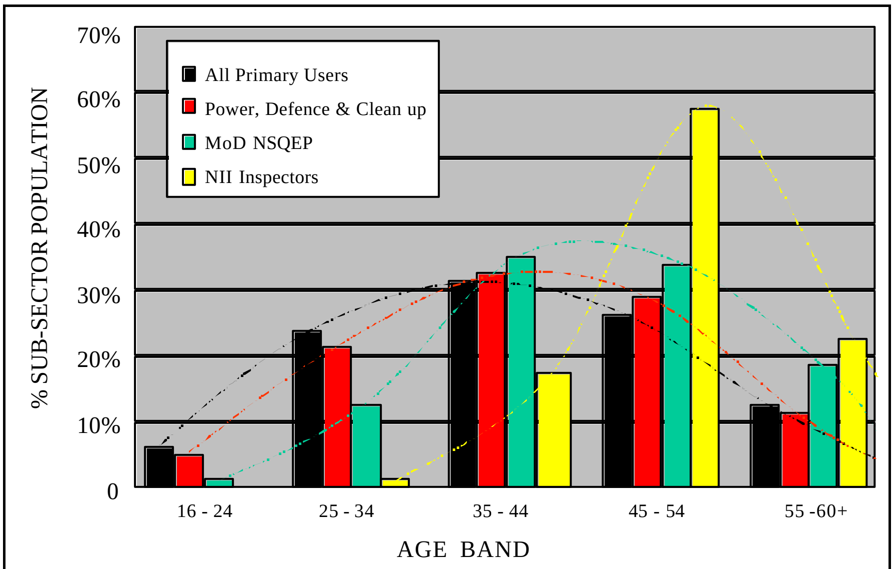

FIG 7.4 AGE PROFILE

Note: Age profiles are shown as percentages of the sub-sector population, ie:

- 'All Primary Users' Sub-sector population 86,400
- 'Power, Defence & Liabilities' Sub-sector population 56,400
- 'MoD' Sub-sector population 562
- 'NII Inspectors' Sub-sector population 168

7.14 Although the overall sector does not demonstrate a significant age skew, there are a number of 'hot spots', for example NII Site Inspectors, and to a lesser degree nuclear skilled people in the MoD. One reason for this is that, by necessity, an entry requirement for the NII is to have experience of working in the nuclear industry; hence new recruits are unlikely to be below the age of 30 to 35.

7.15 A significant number of retirements from the sector will occur over the next 15 years, the following projections of accumulated retirements having been calculated, assuming a retirement age of 60:

SECTOR RETIREMENTS	Over 5 years 2002 – 2007	Over 10 years 2002 – 2012	Over 15 years 2002 – 2017
Health	3,700	6,600	9,600
Defence, Power, Fuel & Clean Up[18]	6,400	14,500	22,600
Total Retirements	**10,100**	**21,100**	**32,200**

[18] Including both Clients and Suppliers.

7.16 Breaking these figures down further, the population of those that will retire contains the following numbers of professionals, and skilled trades.

SUB-SECTOR RETIREMENTS	Over 5 years 2002 – 2007	Over 10 years 2002 – 2012	Over 15 years 2002 – 2017
POWER, DEFENCE, FUEL & CLEAN UP			
Professional and Associate Professional [19]	3,500	8,000	12,400
Skilled Trade, Process Plant and Machine Operator[20]	1,800	4,000	6,300
Others	1,100	2,500	3,900
HEALTH			
Professional and Associate Professional	3,700	6,600	9,600
TOTAL RETIREMENTS	**10,100**	**21,100**	**32,200**

MANAGEMENT AND TECHNICAL SKILLS

7.17 The Foresight Study identified the following skills as being required in the sector.

MANAGEMENT SKILLS

MANAGEMENT SKILLS	
General area	**Specific skills**
Strategic planning	Creating joined up government and common agendas Developing and delivering capital programmes Leadership skills Strategic planning Working with EC funders and policymakers
Communication	Advocacy Influencing / Lobbying Media management Political understanding Public relations, Understanding public opinion
Commercial management	Allocation of risk and liabilities Contracting skills Cost estimation Maintaining intelligent customer status Making a winning bid and writing business case Marketing Procurement Supply chain management
Human Resources	Incentive and rewards management Linking with university and schools Managing international workforces Recruitment, Training and workforce development

7.18 Such generic management skills are included in a variety of MBA degrees and are possessed by many managers within the manufacturing, engineering and construction sectors. But the

[19] 'Professional and Associate Professional' refers to a person qualified to Level 4 and 5 in the National Qualifications Framework, typically having a minimum qualification of a Bachelors degree.

[20] 'Skilled Trade, Process Plant or Machine Operator' refers to a person with a vocational or occupational qualification at Level 3 or below in the National Qualifications Framework.

nature of nuclear and radiological technology is such that it cannot be safely managed without an appreciation of the particular risks and hazards associated with it. Two options exist to develop people with both the required management skills and commensurate nuclear skills. Attract managers from other industries and provide appropriate nuclear training to enable them to operate safely in the nuclear environment, or establish management-training programmes to develop managers from nuclear skilled people within the industry.

TECHNICAL SKILLS

7.19 The nuclear and radiological sector requires a range of science and engineering skills at postgraduate, Degree and HND/C levels. The engineer of the future is likely to be a skilled generalist who, to apply his or her skills within the nuclear sector, will have had appropriate application training. The typical technical skills required by the sector are:

TECHNICAL SKILLS	
General area	**Specific skills**
Nuclear science	Assay Characterisation of sources Health physics Radio analysts Radio chemists
Engineering	Data and knowledge capture Electrical Engineering Electronics, Control and Instrumentation High energy systems engineering High speed computing Information management Logistics and manufacturing Mechanical Engineering Modelling Non destructive examination Quantity surveying Structural engineering Technical archaeology Technology transfer
Environmental Engineering	Environmental impact assessment Geophysics Land remediation Measurement Retrievability Site evaluation and determining base levels Storage Waste management
Design	Design for decommissioning Design of nuclear facilities
Operations	Capability and resource planning Decontamination of equipment Plant operation and maintenance Project management Refurbishment Remote handling Resource management

8 PRESSURES ON THE SECTOR

NOW, IN 5 YEARS, 10 YEARS AND 15 YEARS TIME

BACKGROUND

8.1 To assess the pressures that may befall the sector, a simplified model of the sector should be visualised as a client / supplier matrix (Fig 8.1). Six generic 'clients' exist: health, defence, power generation, fuel cycle, nuclear clean up and secondary users, underpinned by four support or 'supplier' sectors: contractors and consultants; trainers and educators; researchers; and regulators.

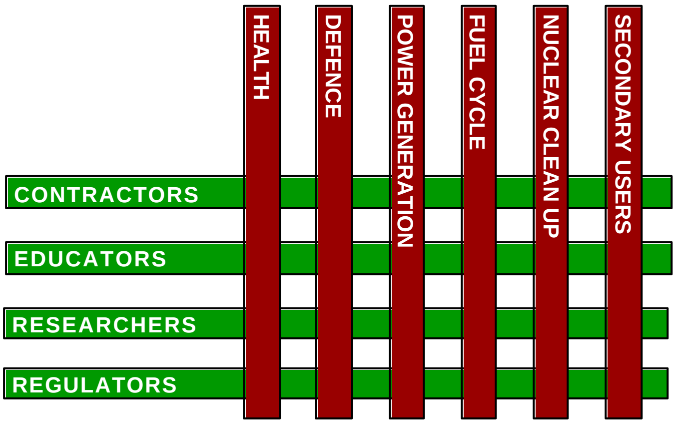

FIG 8.1 SKILL SECTOR MATRIX

8.2 The significance of this matrix is that the futures that befall the six 'clients' will largely dictate the futures of the 'supplier' sectors.

RESPONSIBILITY

8.3 The skills study has sought to establish the health of the nuclear and radiological sector, now and over the next 15 years. But, in isolation, the analysis reflects only a tactical picture of the situation, highlighting local problems and postulating reasons for those problems. In conducting the research for the report, a more worrying strategic shortfall has been encountered: namely an absence of overall responsibility. The absence of responsibility is the root cause of many of the local problems and also the cause of a deeper underlying trend, not only in the nuclear and radiological sector, but in the wider engineering and physical science sector.

ATTRACTION OF THE SECTOR

8.4 The brief for the foresight exercise required the workshop facilitator to consider a range of plausible scenarios, the following 'seasons' being postulated:

- **Autumn**: Operation of extant equipment to the end of design life, but not replaced, followed by nuclear up.
- **Winter**: Abandonment of nuclear or radiological technology, leaving nuclear clean up as the core of the industry, and skilled persons attracted out of the industry to other UK and international sectors.
- **Spring**: The 'autumn' scenario, but with equipment replacement.
- **Summer**: Significant expansion of nuclear or radiological technology.

8.5 It became evident in the workshops, however, that while these scenarios were of significance for the economic strength of the sector, they were not the drivers for skill development. When considering the ability of the sector to recruit, train and retain staff, the 'barometer' by which the strength of the sector, or of individual sub-sectors, should be measured embraces:

- **Expansive**: Perception that the sector will provide a stimulating career with potential for career development, eg by research, new design and build leading to growth in the sector.
- **Stable**: Perception that the sector will stabilise at its current size, hence offering a stable, if less stimulating career.
- **Contractile**: Perception that a controlled reduction in the size of the sector will occur, resulting in limited potential for career development.
- **Uncertain**: Uncertainty and indecision about the future leading to disillusion with the sector as a career choice.

8.6 The attraction of the sector is not a simple linear relationship as suggested by the barometer, factors such as remuneration, stimulation, status and mission having a significant effect. As a consequence, the attractiveness of the sector can be considered in terms of 'traffic lights' dictated by the matrix at Fig 8.2:

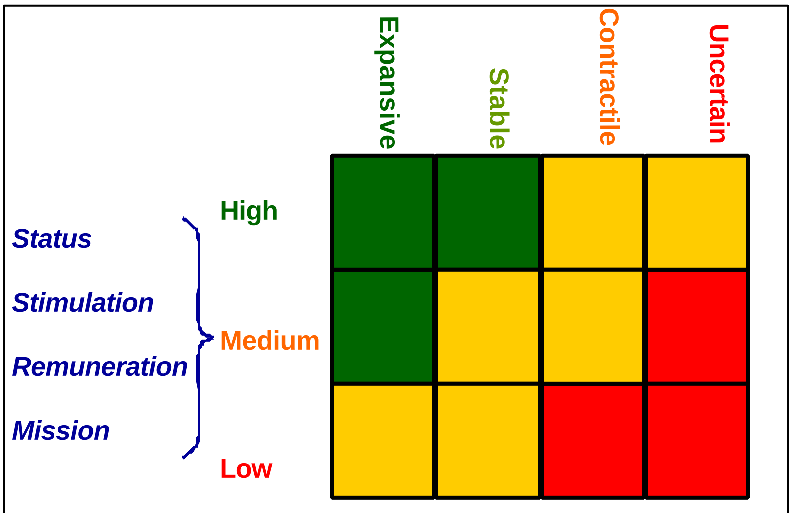

FIG 8.2: ATTRACTION OF A SKILL SECTOR

8.7 The relationship between pay and other factors is also complex, the plot at Fig 8.3 illustrating this effect. The lower part of the curve reflects a low paid occupation with minimal stimulation and career development prospects. A pay threshold exists below which people are unlikely to consider joining such a sector. Above this threshold two influences occur: pay competes with stimulation, the potential for career development and status; hence people may join the sector without expectation of excessive salaries. At higher salaries a plateau exits at which people will undertake less stimulating tasks with the principal driver being financial remuneration, this upper plateau being typified by employment in parts of the financial sector. The nuclear and radiological sector lies in the mid-zone, evidenced by the response of people in the foresight workshops, indicating that those in the sector find the work very stimulating.

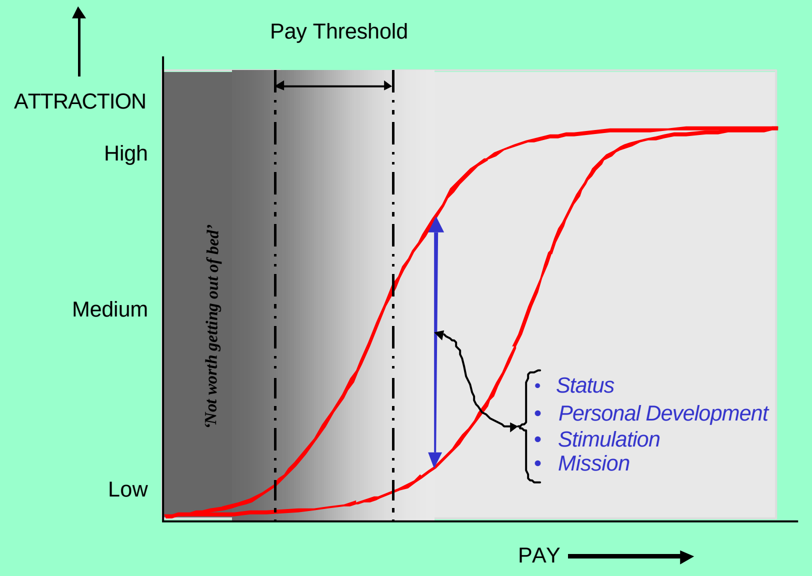

FIG 8.3: SKILL SECTOR ATTRACTION AND PAY

8.8 Interestingly, the ethics of applying nuclear and radiological technology has not been highlighted as a reason for dissuasion from joining the sector. Peer review plays an important role in the nuclear and radiological sector: a key principle in safety management being independent peer review and constructive critique being stimulation for academic development. Those that form the pressure groups that oppose nuclear and radiological technology must also be considered part of the sector, their questioning being one of the factors that ensures the industry functions with high regard for safety.

8.9 Considering the four time frames: now, 5 years time, 10 years time and 15 years time, the following table summarises the potential states of the sector in those periods. Projections to 2007 are based upon extrapolations of the situation today, but beyond that date the foresight approach considers what may happen, and does not predict what will happen.

	Now	2007	2012	2017
Health	Stable / Expansive	Stable / Expansive	Stable / Expansive	Stable / Expansive
Defence	Stable / Contractile	Stable / Contractile	Stable / Contractile	Stable / Contractile
Power Generation	Contractile / Uncertain	Contractile / Uncertain	Contractile / Uncertain	Contractile / Uncertain
Fuel Cycle	Stable / Contractile	Stable / Contractile	Stable / Contractile	Stable / Contractile
Nuclear Clean Up	Expansive / Uncertain	Expansive / Uncertain	Expansive / Uncertain	Expansive / Uncertain
Secondary Users	Stable / Expansive	Stable / Expansive	Stable / Expansive	Stable / Expansive

PRESSURES ON THE SECTOR – NOW: 2002

FACTORS

8.10 As a general appreciation of the current situation, four key messages have been reiterated in foresight workshops as factors that hinder recruitment to the sector:

- **Short-termism**: Industrial leaders plan at best between 3 and 5 years ahead, and more often only 1 to 3 years ahead, whereas the lead time for developing specialist skills is often between 5 and 10 years, or more.
- **Fragmentation**: Liberalisation of markets in all sectors has resulted in fragmentation of industries, and greater use of contractors, hindering strategic planning of workforce development.
- **Indecision**: Potential recruits to the sector perceive an industry fraught with indecision, eg: 'no new build but keep the option open', 'consider safe-store and defer decommissioning', 'long consultation periods are necessary before commencing decommissioning'. Such environments are not attractive to recruitment.
- **Communication**: The sector has a difficult communication challenge, inherent with the language used in the sector, emotional fears of the effects of the technology and a defensive stance brought about by a hostile media.

FRAGMENTATION

8.11 The employment of suitably skilled people in the application of nuclear and radiological technology is of more significance than in any other sector, the potential to cause harm being ever present. The International Convention on Nuclear Safety therefore requires contracting parties (Governments)[21] to ensure that only adequately skilled people are employed in the application of nuclear technology and the health industry demands exacting qualifications before people are allowed to practise in disciplines using radiological technology. One of the basic principles upon which the Nuclear Installations Act is based is that of 'no fault liability'. This provision means that a nuclear licensee is automatically liable for any dangerous occurrence on a licensed site, whether the licensee was at fault or not. This condition encourages the licensee to be either directly responsible for, or be an intelligent customer of, all activities on the site; this includes the qualification and experience of people employed there. Admiral Rickover, founder of the US Naval Nuclear Propulsion Programme, observed, "compartmentalisation is typical of Government work, but the problem of shared responsibility means that nobody is responsible".

8.12 And yet despite such recognition of the uniqueness of nuclear and radiological technology, and the need for only suitably skilled people to be employed in application of the technology and the dangers of loss of responsibility, evidence of this strategic failure has been encountered in all areas of the sector:

- Six Government departments have part responsibility for the sector (DTI, MoD, DH, HSE and DfES [co-sponsors of the skills study] and DEFRA).
- The sector is dependent upon multiple Government sponsored organisations for administration of skill development, including:
    - Qualifications and curriculum authorities;
    - Learning and Skills Council;
    - Higher Education Funding Councils;
    - Regional Development Agencies;
    - Research Councils; and the
    - Sector Skills Development Agency.

[21] Convention on Nuclear Safety. IAEA 1994. Legal Series No 16. Article 11. Financial and human resources. 2. Each Contracting Party shall take the appropriate steps to ensure that sufficient numbers of qualified staff with appropriate education, training and retraining are available for all safety-related activities in or for each nuclear installation, throughout its life.

- The sector is also dependent upon multiple non-Government organisations for the accreditation of skill development, including:
    - Engineering and Technology Board;
    - Professional Institutions (9 major institutions);
    - Learned Societies;
    - Trade Associations;
    - Apprenticeship accreditation organisations; and
    - Occupational Standards Council for Engineering.
- In an increasingly liberalised market, it is often unclear who is responsible for provision of skilled people: Government or industry?
- Within industry, a high degree of out-sourcing of specialist skills occurs. Each company looks to its internal and short to medium term needs, but no vehicle exists to manage the macro and long term needs of the sector.
- Within companies, poor communication has been often encountered between the human resource departments, training departments and research departments.
- Skills issues tend to be low in the order of priority in any agenda.

8.13 If the availability of skilled personnel is to be improved, a cross-sector organisation must be established and empowered with the authority to co-ordinate and, in certain cases direct, skills development.

CLIENT SUB-SECTORS

8.14 Considering the 'client' sub-sectors:

HEALTH

8.15 The health sub-sector comprises people with a range of occupations and competencies. Two distinct groups of people constitute the sub-sector: those directly involved with diagnosis and treatment, typified by diagnostic and therapeutic radiologists and radiographers; and clinical scientists, specialists in a particular area of science or engineering, typified by medical physicists and clinical engineers. The former group are by far the larger, the NHS Cancer Plan identifying over 9,800 therapeutic and diagnostic radiographers, but only 800 medical physicists, engaged in the treatment of cancer in 1999. Over the whole sub-sector this ratio is of the order 25,000:5,000.

8.16 Considering the sector model described at Annex A, the sub-sector has a range of professionals and associate professionals engaged in the installation, operation, and maintenance of equipment, and the project management and quality assurance activities needed to support those activities. In addition to a large number of radiographers and radiologists, a range of healthcare engineering and physical science professions (clinical scientists) exist[22] that need radiological skills, including:

- Clinical Engineers, responsible for the design, development and use of new instrumentation for patient monitoring, diagnosis or research;
- Medical Physicists, responsible for the safe and appropriate clinical application of medical radiation;
- Medical Physics Technologists, to assist clinical and scientific staff in the construction of medical devices;
- Nuclear Medicine Technologists, responsible for the use of radioactive pharmaceuticals in diagnosis and therapy; and
- Radiotherapy Technologists, responsible for maintenance and quality control on radiotherapy dosimetry equipment and treatment units, such as linear accelerators and brachytherapy equipment.

[22] Making the Change: A Strategy for the Professions in Healthcare Science. National Health Service. Feb 2001.

Human Resources in the NHS Plan

TABLE 8.1

HUMAN RESOURCES IN THE NATIONAL HEALTH SERVICE PLAN

HR in the NHS Plan

- The plan works to a realistic time frame of ten years and considers the full NHS workforce of approximately 1,000,000, representing 1 in 20 of the UK national workforce.
- With a 25 year low in employment, and other organisations expanding their workforces, the NHS must persuade huge numbers of school and college leavers that the NHS is an attractive place to work, against the backdrop of a negative media spotlight.
- HR in the NHS Plan is built on four pillars:
  - Making the NHS a model '3 star' employer;
  - Ensuring the NHS provides a model career – the Skills Escalator;
  - Improving staff morale; and
  - Building people's management skills.
- The **model '3 star' employer** embraces a composite of best policies, practices and facilities.
- The **'Skills Escalator'** considers a career as a succession of stages with its own learning requirements. Staff are encouraged to constantly extend their skills and knowledge, enabling them to move up the escalator, while roles and workload are delegated down the escalator, generating skill mix benefits. A greater variety of step-on and step-off points are created, complementing traditional entry points, such as registered professional staff, with other entry routes, such as cadet schemes and role conversion, to attract people in other careers who are seeking new challenges.
- A programme of **Modernising Learning and Personal Development** is proposed, including:
  - Re-designing education, training and support to create more flexible and accessible learning, and ensure transferable skills and career pathways;
  - Investing learning resources effectively;
  - Ensuring that learning opportunities are adaptable and reflect new role developments;
  - Offered high quality career counselling from skilled facilitators with strong links to local schools, NHS Careers, Further Education colleges and Universities, and opportunities for 'taster' experiences to help those unsure of their career options;
  - Use of credits and transferable skills with diverse access and entry routes;
  - Use of vocational qualifications and training, including NVQ; and
  - Use of National Occupational Standards.
- A programme of **Modernising Workforce Planning** is proposed, including:
  - Bottom-up planning from stakeholders represented in **Workforce Development Confederations**.
  - Top-down planning from the **National Workforce Development Board**.

8.17 The health sector has the most immediate problem, skill shortages being reported in sectors applying radiological technology brought about by:

- Increased demand for skilled people following investment in new technology and equipment to improve medical services.
- High competence standards demanded by legislation, resulting in long training programmes.
- Poaching of skilled people capable of advanced mathematical modelling by the financial and insurance sectors, using high financial remuneration as bait.
- Low relative status of scientifically skilled people in relation to medical and clinical health care professionals, resulting in low morale.

8.18 This situation is highlighted in the NHS Report, The NHS Cancer Plan[23], which states:

"Too many therapy radiography students fail to complete their training. In some places up to 30% of students drop out of their courses. This is a waste of money and of time and potential."

8.19 NHS plans have recognised that a shortage of skilled people exists and the NHS, working with training providers and the College of Radiographers, is taking action to address shortages. However, these measures are targeted predominately at the diagnosis and therapeutic skills. Clinical scientists constitute the group with skill sets most in common with the nuclear clean up, defence and power generation sub-sectors and, in recognition of other NHS initiatives, it is at these groups that the recommendations in this report should be targeted.

8.20 Considering the wider NHS, the NHS Plan, published in July 2000, sets out a strategy for reform of the NHS, a key part of which is management of Human Resources. A consultative document, 'Human Resources in the NHS Plan', was published in April 2002, which set out the proposed concepts to address HR Planning. Many of the concepts and issues are similar to those facing the nuclear and radiological sector and Table 8.1 contains extracts from that report. These are included: firstly as a benchmark against another sector facing a similar challenge, but also because groups such as clinical scientists, radiologists and radiographers feature in both sectors; hence it is important that synergy is achieved between the two skills strategies.

8.21 An example of progress made in the health sector pertinent to the nuclear and radiological sector is the piloting of a scheme to introduce a new grade of Assistant Practitioner in Radiography, trained to undertake some tasks carried out by radiographers within the National Breast Screen Service.

STATE

8.22 The health sub-sector is in expansive mode, but suffers from poor esteem and poor relative (to other health care professionals) pay; hence in terms of the 'traffic lights' the sector is **amber** to **red**.

Recommendation 5

RAISE THE PROFILE OF RADIOLOGICAL SKILLS WITHIN THE HEALTH SECTOR

The profile of radiological skills within the health sector must be raised, not only of the diagnosticians and therapists, but also the medical physicists and clinical scientists, engineers and technicians that support them. The nuclear skills task group and emerging Sector Skills Councils must work closely with the health sector skills development organisations to ensure synergy in their actions. This must:

- Take into account the radiological sub-groups within the health sector;
- Encourage action to be taken by those best placed to do so; and
- Ensure that all elements of the sector are adequately represented.

Action: Nuclear Skills Task Group / NHS National Workforce Development Board and Confederations

[23] The NHS Cancer Plan: A plan for investment; A plan for reform. Sept 2000. Section 8 – Investment in Staff.

DEFENCE

8.23 The defence sector has two principal uses of nuclear technology: the Naval Nuclear Propulsion Programme and the Nuclear Weapon Programme. Nuclear submarines continue to be operated by uniformed personnel, but the defence sector has undergone major change over the past two decades in relation to procurement and logistics support. Whereas the MoD formerly conducted design of equipment and operated establishments such as the Royal Dockyards and the Atomic Weapons Establishment, the Royal Dockyards have been privatised and the Atomic Weapons Establishment is run under Government Owned Contractor Operated arrangements. Throughout defence procurement and logistic support there is increased dependency upon contractors.

8.24 The Government has committed to maintain nuclear submarines and the UK's independent nuclear deterrent as part of the UK's defence capability for the foreseeable future. A new build programme is in hand (the Astute Class) which is anticipated to continue for the next 5 to 10 years and beyond. An indicative programme is shown at Fig 8.4[24].

8.25 However no wholesale new design reactor plant is currently planned; hence the sector is changing its focus from development and new design to consolidation, in service support and repeat build of proven designs. Similarly the weapon programme is engaged in a continued programme of in-service support. Active work to replace the deterrent is not being undertaken but a policy of 'keeping the option open' is in place.

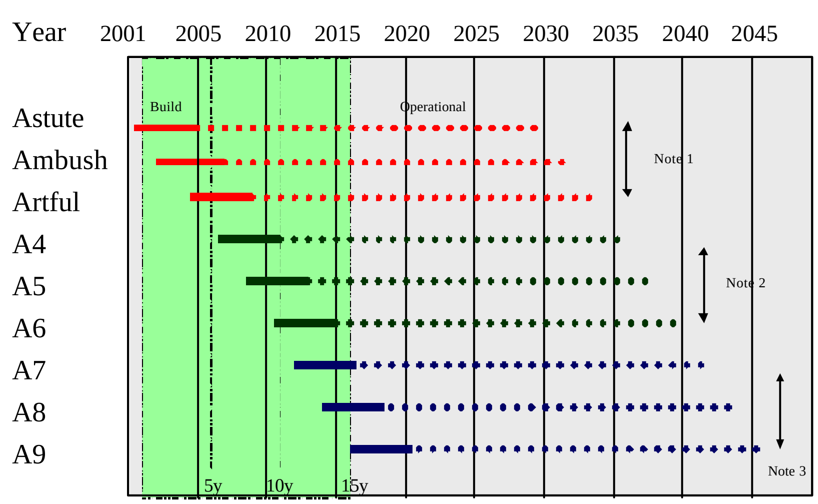

FIG 8.4 INDICATIVE SUBMARINE PROGRAMME

Basis: 1998 Strategic Defence Review

Note 1: Batch 1 Astute. Ordered 1997.	Source (Non MoD): naval-technology.com, Website for Defence Industries
Note 2: Batch 2 Astute. Anticipated order 2002.	Source (Non MoD) : geocities.com
Note 3: Batch 3 Astute. Projected order 2007.	Source (Non MoD) : geocities.com

8.26 When nuclear powered submarines leave operational service, the policy to-date has been to de-fuel, de-equip and lay-up afloat, ie safe-store afloat. A change in policy is now being pursued which would see the nuclear components stored on land allowing for disposal of the rest of the submarine. The defence sub-sector is also engaged in an environmental remediation programme to restore its various nuclear sites for other uses. A process of public consultation and discussion with potential contractors is being undertaken, but no contracts have yet been let to conduct work; hence the situation may be perceived as one of indecision.

[24] This data has been taken from open sources and is an indication of civil perception of the naval programme. It is not a statement of MoD policy.

8.27 The overall size of the defence sub-sector is in decline and the loss of experience is a concern. Additionally, one consequence of taking activities out of Crown control is to increase the load on national regulators (NII, EA and SEPA).

STATE

8.28 The operational aspects of defence applications of nuclear and radiological technology are in a stable state, but the skilled population is contracting. Relative pay and status is also medium, hence in terms of the 'traffic lights' the sector is overall **amber**. But in those areas where indecision is perceived, the state may tend to **red**. Such areas include weapons development and decommissioning.

POWER GENERATION

8.29 In 2001, nuclear power accounted for approximately 23% of the UK's generating capacity, that capacity comprising:

- 7 Magnox stations operated by BNFL Magnox, due to close by 2010
- 7 AGRS operated by British Energy, due to close by 2023
- 1 PWR operated by British Energy, due to close by 2035

The variation of nuclear power generation capacity with time is shown in the Figure 8.5.

8.30 There are currently no plans to replace these power stations, the policy proposal outlined in the recent PIU Energy Review being to 'keep the nuclear option open'. Although outside the scope of this report, indicative numbers of the people required to engage in a new build programme in the UK are given in Table 8.1.

8.31 Mention must also be made of the relationship between power generation and the fuel cycle, BNFL also operating the UK's nuclear fuel reprocessing facility at Sellafield, reprocessing fuel for Magnox, British Energy and overseas customers.

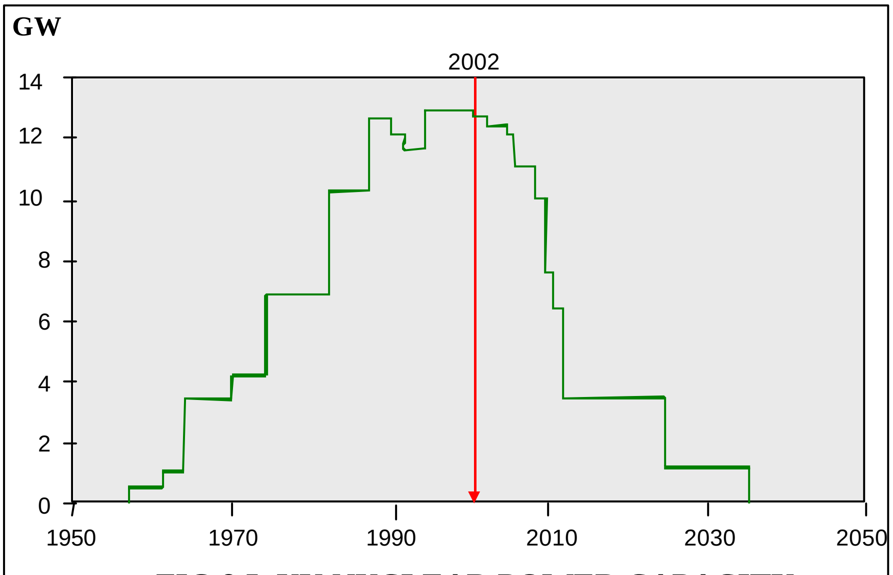

FIG 8.5 UK NUCLEAR POWER CAPACITY

STATE

8.32 The closure programme for the Magnox stations has recently been revised bringing their closure dates forward. The sector is about to move into a 'Contracting' state with an uncertain future based upon a policy of 'keeping the nuclear option open', which will be interpreted as indecision by potential recruits. The international dimension of the sector helps boosts its attractiveness to some extent; but the overall status is considered **red**.

TABLE 8.1

INDICATIVE NUMBERS OF PEOPLE REQUIRED TO ENGAGE IN NEW BUILD

Based upon past national and international experience of nuclear build, it is estimated that the following numbers of people would be required to engage upon new build of nuclear power stations in the UK.

- 1000 people to form the core Operating Organisation throughout the plant life cycle.
- An additional 500 operating staff per station during the operating phase of the life cycle.
- 3000 contractors, consultants and suppliers to construct a station. Many of these people would require generic civil, electrical and mechanical engineering skills only, not necessarily specialist nuclear skills.
- A regulatory organisation of approximately 25 inspectors and assessors, including the Nuclear Installations Inspectorate and environment agencies.

NUCLEAR CLEAN UP

8.33 Nuclear clean up is currently in a period of major change and new arrangements are being proposed to deal with the nuclear legacy represented by:

- those nuclear sites and facilities now operated by the United Kingdom Atomic Energy Authority (UKAEA) and British Nuclear Fuels plc (BNFL), which were developed in the 1940s, 50s and 60s to support the Government's research programmes, and the wastes, materials and spent fuel produced by those programmes; and
- the Magnox fleet of nuclear power stations designed and built in the 1960s and 70s and now operated on the Government's behalf by BNFL, plant and facilities at Sellafield used for the reprocessing of Magnox fuel and all associated wastes and materials.

8.34 This legacy represents about 85% of total UK nuclear liabilities and is wholly the responsibility of Government. The new arrangements are outlined in the recent White Paper "Managing the Nuclear Legacy, a strategy for action"[25], which proposes to set up a new Liabilities Management Authority (LMA) responsible to Government with a specific remit to ensure that the nuclear legacy is cleaned up safely, securely, cost effectively and in ways which protect the environment for the benefit of current and future generations.

8.35 The amount of work outstanding is considerable (estimated at some £47.9b); hence this sector should be in expansive mode. However, no contracts have yet been offered to industry and the debate continues about whether to decommission early or to safe-store and decommission in the future. Questions also exist in relation to the length of the consultation process that should be undertaken before committing to action.

8.36 As an example, Fig 8.6 illustrates the April 2000 Corporate Plan[26] for decommissioning UKAEA sites, highlighting the timescales for decommissioning against the planning times discussed in this report.

8.37 Although they share the same generic skills, a different range and scale of unique skills are needed for liability management, compared with the design, construction, operation and maintenance of the equipment that gave rise to those liabilities. The basic principles are relatively simple, summarised as 'immobilise and store'. Bulk material is assayed to assess that fraction of its content that is hazardous. The hazardous material is segregated from the non-hazardous, which can be recycled; and the hazardous material is immobilised and stored until it decays into non-hazardous material or is subject to further processing. A balance must be struck between what processing should be conducted now, to segregate material, and what should be deferred. Storing material in its operational environment for a period allows advantage to be taken of natural radioactive decay to reduce the hazard to operators and cost

[25] Managing the Nuclear Legacy – a strategy for action. July 2002.

[26] UKAEA Today – Corporate Plan – Site Strategies. April 2000.

of operation when processing is eventually carried out. Underpinning this simple assessment lie a number of significant scientific and technical challenges, the response to which is dependent upon skilled engineers and scientists. Research is also required into technologies such as transmutation, to explore alternatives to immobilise and store, eg by changing hazardous material into a more stable material. The ranges of skills to conduct these activities were considered in a recent EPSRC workshop, the output of which is summarised at Annex I[27].

STATE

8.38 In terms of the 'traffic light' indictor, the sector has the potential to be **green**, but tends towards **red** due to the uncertainty in the programme, interpreted by observers of the sector as indecision.

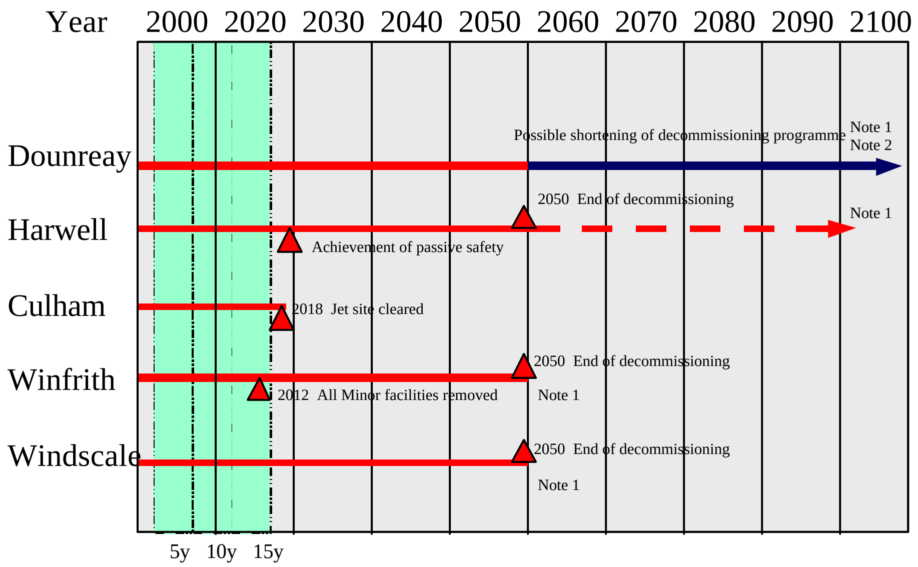

FIG 8.6 DECOMMISSIONING TIME SCALES - UKAEA

Note 1: Until bulk wastes can be sent for disposal these will need to be stored on the site
Note 2: Because of the LLW facilities at Dounreay, extended surveillance will be required beyond this period

SECONDARY USERS

8.39 A large array of secondary users exists, evidenced by the large numbers of vets, dentists and other users of radiological technology. These groups apply radiological technology, but it is not their principal discipline, ie a dentist is a professional person in terms of dentistry, but is a process operator in terms of radiological technology. The secondary user sector is very diverse, and the key issue is raising the level of awareness of the hazards associated with radiological technology to an adequate level. This awareness must include the principles that must be applied when working with radioactive material, in particular the handling and disposal of sources, many of which are high activity. The highest specialist skill set in the sector is that associated with source manufacture and regulation. Achievement of safety is heavily dependent upon regulation. The implications for the sector are therefore to provide an adequate number of suitably skilled regulators, with a broad training programme for all users in the basic principles of working with radioactive materials. The highest skill levels will therefore be needed in the NRPB, the EA and SEPA.

8.40 The environment agencies must consider a wide range of mechanisms that may affect the environment, radiological factors being only one. A particular challenge for the environment agencies is the need to achieve a balanced workforce that has the range of generalist environment skills and also the specialist radiological skills.

[27] New Applications of Nuclear Physics: Opportunities in biology, medicine, environmental and analytical sciences, materials, power and energy technology, process engineering and other areas. 13 / 14 May 2002.

STATE

8.41 In terms of the 'traffic light' indictor, the sector is **amber.**

SUPPLIER SECTORS

8.42 The relationship between the client and supplier sectors has many analogies with the project/production relationship that exists in the matrix management applied across industry. The British Standard on Matrix Management identifies a project/production relationship described at Figure 8.7, in which a range of relationships may exist, extending from a project led organisation at the extreme left to a production led organisation at the extreme right. The matrix organisation lies in the centre of the diagram.

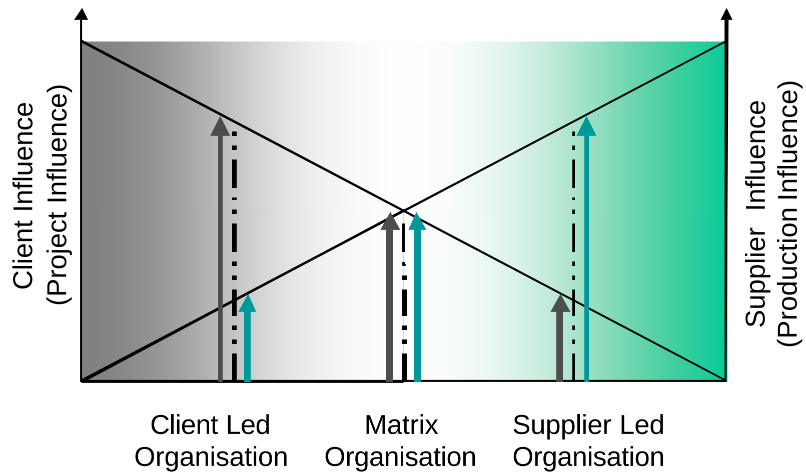

FIG 8.7 MATRIX MANAGEMENT

8.43 Over the past two decades, the organisation within the nuclear and radiological sector has migrated, under the influences of privatisation and reduction of operating costs by increased contractorisation, from a 'client' led organisation to a 'matrix' organisation. In the past, large organisations in the sector conducted the majority of required functions in-house, eg the Atomic Energy Authority conducted the technology development, training, education and research it needed to satisfy its own needs. But today increasing use is made of 'bought out' services, the driver being to procure specialist skills for particular applications when needed rather than maintain an in-house capability that may only be partly utilised, and the cost that this incurs. The sector therefore functions as a matrix of client and supplier organisations. There are limitations to the potential of outsourcing for both commercial and regulatory reasons. Companies must retain sufficient expertise to act as 'intelligent customer' and operators must have security of supply. Investment by the supply chain in this expertise requires confidence in the future of the industry.

8.44 It should be noted that the majority of the 'client' organisations in the nuclear and radiological sector are Government led (health, defence, nuclear clean up), whereas the supplier organisations are increasingly 'liberalised'. The question arises; who is responsible for ensuring the viability of support organisations? Should it be:

- 'Client' led, implying Government takes the lead;
- 'Supplier' led, implying industry led solutions; or
- A matrix relationship?

8.45 Whichever model is applied, the range of support skills available will be dependent upon the demands made by the 'client' organisations; the state of the support sector being dependent upon the range and scale of contracts tendered or support demanded (education and regulation included). A key factor in this balance is that not only individuals with defined skill sets are needed, but corporate capabilities are also required, to marshal individuals to meet the sectors' requirements on demand.

CONTRACTORS

8.46 The state of contracting and consultant organisations today reflects this model:

- In the past, companies such as NNC designed nuclear power stations for the then 'client', the CEGB or SSEB. The last indigenous design and build was Torness, completed in 1989. The indigenous ability to conduct such a complete design of a nuclear power station not been used since; hence that capability no longer exists as a corporate capability. Individuals that formerly composed those design teams may still be in the employed sector, but not marshalled as a power station design team. It should also be noted that when Torness power station was built, a shortage of skilled trades existed in the region and a requirement of the construction contract was to set up an apprenticeship-training programme; an example of 'client' led skills development.
- The last nuclear power station built in the United Kingdom, Sizewell B, was commissioned in 1995. A proven US plant[28] was used as a reference design for the plant and modified to meet British safety standards. This included additional containment, back-up safety systems and safety instrumentation. The operating organisation was Nuclear Electric and its PWR Project Group (PPG) carried out the necessary design modifications and also managed construction of the station. The corporate capability to repeat that operation does not exist in the UK today. If a decision were made to construct a nuclear power station in the near future, the project management and production teams would have to be assembled from skilled personnel elsewhere in the national, or international, sector.
- Few major contracts are currently being let within the nuclear industry, hence contractors may question the viability of retaining a corporate nuclear capability: AEA(T) has already made the decision to withdraw from the nuclear market. Organisational change in companies such as Rolls Royce should also be monitored: Rolls Royce and Associates was formerly dedicated to the design, build and manufacture of reactors for the Royal Navy's nuclear propulsion programme. But re-organisations have focused Rolls Royce's commercial interests on gas turbine manufacture: what drivers encourage the company to maintain its nuclear capability?

STATE

8.47 Where contracts are being let, or where a reasonable prospect of contracts exists in companies' planning horizons, the state of contractors' and consultants' skills is **green**, but where the prospect of contracts is perceived as indecision, the state of skills is **red**.

EDUCATORS

8.48 The national training and education sector has become increasingly market driven; hence training and education establishments deliver that education which is economically viable, not that education that may be considered to be in the national interest. A complex supply situation exists in which:

- Educators supply those courses that are demanded by students and hence which are financially viable.
- Students are attracted to subjects that stimulate them and/or in which they expect to gain a valued qualification that will enable them to pursue a successful career.

8.49 Engineering and Physical Sciences are currently unpopular subjects because of the difficulty of the subjects and the poor perceived rewards if successful; hence colleges and institutes that deliver such education and training are under increasing commercial pressure. Higher education institutes also have to compete with in-house training.

[28] The design of Sizewell B is based on the Bechtel Standardised Nuclear Unit Power Plant System (SNUPPS) and incorporates the Westinghouse PWR. This design is also embodied in the US installations at Callaway and Wolf Creek.

STATE

8.50 The state of public education and training of generic skills needed by the nuclear and radiological sector is **amber** but, as highlighted by the NII report on Nuclear Higher Education in British Universities[29], the state of education and training of unique skills is **red**.

RESEARCH

8.51 The state of research is dependent upon a number of factors, including:

- The quality and quantity of proposed research.
- The popularity of research topics.
- The demand from industry for research.

8.52 The sponsorship of research into nuclear issues has undergone change in recent years. The Atomic Energy Authority sponsored original nuclear research in the United Kingdom; hence nuclear research has not traditionally been the responsibility of the research councils. A recent change highlighting this distinction is research into nuclear fission, sponsorship of the UK contribution having recently been transferred from the Nuclear Industries Directorate of DTI to the Office of Science and Technology.

8.53 Analysis of Research Council funding demonstrates that, while a significant amount of research is sponsored into particle physics, only minimal research into applied nuclear physics is sponsored. Some industry-sponsored research is being conducted, eg radiochemistry research at Manchester University, sponsored by BNFL. A key factor in the state of research also includes the quality of facilities and laboratories, the availability and quality of staff and the perceived vibrancy of the research area.

STATE

8.54 With the exception of research into fusion, the state of research into applied nuclear technology outside of industry is weak and currently assessed as **red**.

REGULATORS

8.55 The size of required regulatory organisations is dependent upon the scale of work undertaken by the skills sector. The key issues are:

- Regulatory organisations must recruit from the pool of experienced people in the sector; hence the sector must produce a small surplus of skilled people that can be employed as regulators.
- The NII are currently recruiting, but have not achieved their full recruitment targets. Although progress is being made in this area and they are able to current commitments, their capacity to assess new projects is limited.
- With regard to the environment agencies, achieving a balanced skill base of people with both generalist environment skills and specialist radiological skills can pose a problem.
- Remuneration is not particularly attractive, however skilled people are attracted to the sub-sector to gain experience. Having been a regulator is a valuable entry on a CV, hence regulation has a role in the career development plans of individuals.

STATE

8.56 The state of the regulatory sector is currently assessed as **amber** to **red**.

[29] Nuclear Education in British Universities. NII. April 2002.

HOT SPOTS

8.57 The sector is currently experiencing the following ‘hot spots’:

HEALTH

8.58 Shortages currently exist in all health sub-sector occupations, with shortages as high as 30% being reported by foresight delegates in some areas. The shortages are in all disciplines, including diagnosis and therapy (radiology and radiography) and within the clinical sciences; hence there is an immediate need to attract, train and retain more staff. The consequences of these shortages are that the full benefits of nuclear medicine are being withheld, waiting times are being extended and the service available from radiology departments is being degraded. The causes of these shortages include:

- Remuneration: pay being significantly below what industry would pay people with similar qualifications and experience.
- The qualifications structure: qualifications being stipulated by professional institutions that are in excess of user needs[30].
- Shortage of training places: training posts having been deleted to meet short-term budget targets, training having no immediate impact on operational capability.
- Loss of strategic focus: responsibility for training has, in recent times, been considered a tactical issue and delegated to NHS Trusts. But addressing training purely as a tactical issue means that no one is charged with addressing the strategic issues; hence national problems can develop unchecked.
- Status of Scientists and Engineers: Medical professions are considered superior to engineers and scientists. Career prospects for engineers and scientists are limited by comparison to medical practitioners, which acts to de-motivate engineers and scientists.

8.59 Pay and remuneration appear to be the only means of addressing short-term retention. In the longer term, the health sub-sector must make a strategic response to recruitment and retention.

POSTGRADUATE EDUCATION

8.60 A dichotomy exists in relation to postgraduate education. In the formative years of the nuclear programme there was enthusiasm for the new technology and a drive for education excellence; hence appropriate courses were established. However, the technology has now matured and the industry operates in a more liberalised regime, resulting in questioning of whether postgraduate education is an essential requirement or an unnecessary overhead. In the health sector, a Masters qualification is the required competence level in order to practice; hence the requirement for postgraduate education is enforced by regulation, but such a requirement does not exist in the power and decommissioning sectors. Postgraduate education is not valued to the same degree as in former times and often competes with in-house training; hence, as identified by the NII survey of nuclear education in the United Kingdom[31], the viability of postgraduate education is under threat.

8.61 DTI/OST fund MScs through the research councils, but current policy is to fund course start up costs only, requiring courses to be self-sustaining after 5 years. Thereafter, reliance is placed on market forces to underpin postgraduate education. There is a common view in industry that it needs generalist engineers who can be given specialist in-house training. As a consequence students do not seek postgraduate nuclear education; hence postgraduate education is in a fragile state. If unchecked, this capability may disappear and, as no specialist undergraduate courses exist, the sector would be reliant upon engineers with no academic education in nuclear technology.

[30] This situation has been recognised and will be in part addressed by the ‘skills escalator’ initiative and an example of corrective action is the introduction of the grade of Assistant Practitioner in Radiography to undertake some tasks within the National Breast Screen Service.

[31] Nuclear Education and Research In British Universities. NII. April 2002.

REGULATORS

8.62 The age profile of NII inspectors exhibits a definite age skew, as shown in Fig 7.4. One reason for this is that, by necessity, an entry requirement for the NII is to have experience of working in the nuclear industry; hence new recruits are unlikely to be below the age of 30 to 35.

8.63 Experience is an essential element of regulation and cannot be compromised; however the potential exists for NII to lose a significant amount of experience over a short period due to retirement. Full support must be given to NII in their recruitment initiative to ensure that their succession planning targets are met and that suitably experienced and qualified personnel are employed.

CONTROL AND INSTRUMENTATION ENGINEERS AND TECHNICIANS

8.64 Control and Instrumentation is key to all process-engineering technologies; hence there is a high national, and international, demand for C&I engineers and technicians. The nuclear sector must therefore compete for such skilled people, resulting in pressures on satisfying demand. Given the national and international demand for these skills, it is hard to compete without being able to provide a vision of an attractive career in a viable and sustainable industry.

HEALTH PHYSICISTS

8.65 A shortage of health physicists has been reported by the industry since its inception, for which a number of reasons exist. Two reasons highlighted by the study relate to the promotion of career opportunities and career development plans. Promotion of career opportunities in health physics remains poor, with few people outside of the sector being aware of the profession. Despite the shortage of people, evidence was also received of the difficulties encountered by young people endeavouring to enter the sector of finding out about opportunities. Evidence also suggests that an adequate number of skilled people may exist in the sector but many have progressed from practitioner to manager in order to develop their career. The root cause of this issue applies to many science and engineering disciplines within which, in order to provide an attractive career development plan, people have to leave the specialisation for which they were educated and trained.

SAFETY CASE WRITERS

8.66 Safety cases are fundamental to any safety campaign in the nuclear sector. Such documents were traditionally unique to the nuclear industry but, as a result of a number of high profile accidents, the adoption of written safety cases is now much more widespread throughout industry in general. The nuclear sector therefore finds itself in competition for such skills. Good safety case writers should also have adequate experience of their topic; hence the sub-sector suffers similar pressures to regulators.

CRITICALITY ASSESSORS

8.67 Criticality assessment is one of the truly unique skills to the nuclear sector, and is a skill that demands a good theoretical knowledge of nuclear physics accompanied with mathematical modelling skills. With the decline of nuclear research facilities and specialist nuclear faculties in the United Kingdom, the ability to train and educate such people is diminishing and, with the decline in the industry, there is less incentive for individuals to pursue a learning pathway to develop such skills.

RADIOCHEMISTS

8.68 Until recently, only a few people recognised the demand for radiochemists and as a result skilled people were not emerging as a matter of course from either chemistry or physics faculties. BNFL, and their support for the Manchester radiochemistry department, has corrected this in part, but the question remains about what is required: a focal point upon which radiochemistry research is concentrated or a centre of excellence supporting satellite departments that achieves diversity across the research sector?

Graduates in Numerate Subjects

8.69 People with high quality mathematical modelling skills are in great demand by this and other sectors, eg the finance and insurance sectors. The financial and insurance sectors have the ability to pay high salaries for those skills; hence there is a migration of skilled people from engineering and physical sciences into higher paying sectors.

Project Managers

8.70 A decreasing number of people have both the skills to project manage a major development and an appropriate appreciation of nuclear issues.

Corporate Capabilities

8.71 A number of corporate capabilities exist in only limited numbers, nationally and internationally, eg the design and manufacture of nucleonic detectors and the manufacture of large pressure vessels.

PRESSURES ON THE SECTOR – 5 YEARS TIME: 2007

FACTORS

8.72 It is presumed that trends extant in the industry today will continue and hence the state of sector in 5 years time will broadly be an extrapolation of the state today.

8.73 The skills demand in each of the sub-sectors will depend upon the point in the life cycle in which that sub-sector is engaged. The life cycle is reflected in the competencies used in the sector structure model (Annex A) and the life cycle stages identified in NII's Licence Conditions[32], namely:

- Design and Develop
- Produce
- Install
- Operate
- Maintain
- Decommission

HEALTH

8.74 The health sector will continue to be involved in all phases of the life cycle, but with NHS skills focused on 'install', 'operate' and 'maintain'. The demand for improved health care is likely to continue which, in conjunction with an ageing national population, means that the demands on this sector are likely to increase.

DEFENCE

8.75 The MoD will focus on 'Operation' and contract out 'Production', 'Installation', 'Maintenance' and 'Decommissioning' to contractors.

8.76 The programme of new submarine construction to replace older vessels will continue in order to maintain forces at about their current levels. This will be set against a background of measures seeking to reduce the cost of nuclear ownership. MoD will continue to contract industry for submarine construction and to deliver logistics support to enable the operation of submarines and deployment of weapons by the Royal Navy.

8.77 Defence contractors traditionally involved with design will experience a change as contracts focus primarily on repeat build and support. Industry may question whether adequate profit exists in maintaining corporate capability and problems may be encountered with specialist skill sets. An example of a skill set where only a small number of capable contractors, or even a single capable contractor, exists is the design and manufacture of nucleonic detectors.

POWER GENERATION

8.78 A number of power stations will close, and hence migrate into the decommissioning phase, while Government pursues a policy to keep open the option to develop, produce, install and operate new installations. The PIU Energy Review identified the need to keep the nuclear option open, recognising that:

"Keeping the nuclear option open means maintaining an adequate skills base both for R&D and to ensure sufficient personnel to staff new nuclear stations… (and) that UK regulators are adequately staffed to assess any new investment proposals."

8.79 By 2007, current plans indicate that five Magnox reactors will have closed: Bradwell (2002), Calder Hall (2003), Chapelcross (2005) Dungeness A (2006) and Sizewell A (2006). These sites will therefore have transferred to the nuclear clean up programme.

[32] Licence Condition 14: the licensee shall make and implement adequate arrangements for the production and assessment of safety cases consisting of documentation to justify safety during the design, construction, manufacture, commissioning, operation and decommissioning phases of the installation.

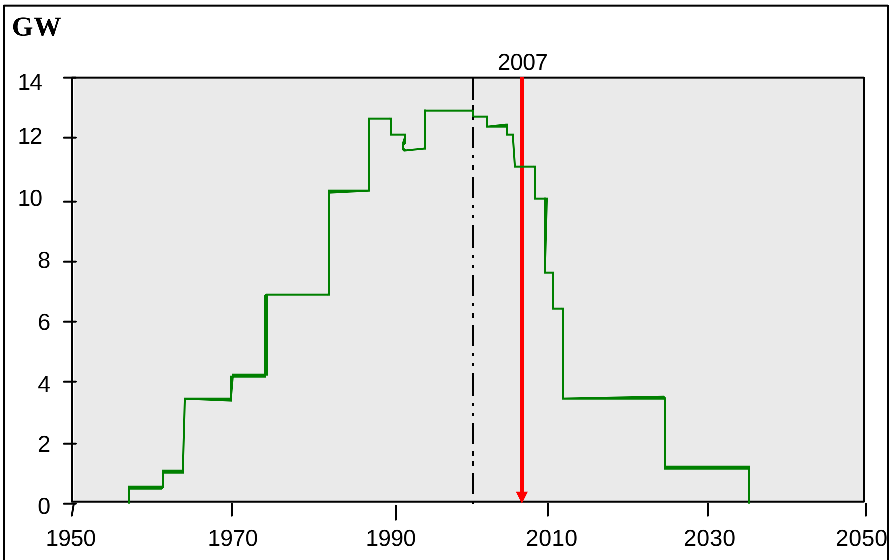

FIG 8.8 UK NUCLEAR POWER CAPACITY

8.80 Unless a planned new build is announced, the Magnox closures and pursuing a policy of 'keeping the nuclear option open' will perpetuate a perception of indecision, which is likely to have a negative impact on image and hence recruitment. Collectively, the five stations account for only 1.5 GW capacity, or approximately 3% of UK electricity capacity in 2000, a loss of capacity that is unlikely to have a significant impact on the argument for or against new generation capacity. Magnox technology would not be used for any potential future generation programme; hence the loss of skills uniquely related to that technology will not affect the ability to 'keep the nuclear option open', but the pool of people with generic nuclear skills, eg in safety or maintenance, would be reduced, which may have an impact. The perception created of closure without replacement is one of an industry in decline, putting the skill-state at **red**.

8.81 If new build were to be announced, nuclear power stations incur very long planning and construction time-scales; the planning application and construction process for Sizewell B took over 15 years. Estimates for the Westinghouse AP600[33] plant, one option if new design were to be pursued, suggest construction time could be reduced to 3 years, but the planning lead time, particularly for the first plant, would add considerably to this. The skills audit highlights that the lead-time for training operators is less than 5 years, operator training would therefore need to be carried out in parallel with planning and construction. This approach has been successfully applied to many nuclear facilities.

8.82 Sizewell B was commissioned in 1995, on completion of which the design, construction and commissioning teams were disbanded. An indigenous build capability for civil nuclear plant does not exist in the UK and, if required, a skilled team would have to be generated from what exists nationally, supplemented by importing skills where deficiencies exist. A wide range of skills is needed, including project management, pressure vessel construction, design and manufacture of nucleonic detectors, welding techniques for stainless steel and other materials, and control and instrumentation skills. A potential operating organisation for a new plant must either acquire these skills, or at least attain the ability to be the 'intelligent customer' of these skills. If the option is to remain open, a means of maintaining contact with the technology is needed: a 'yeast' from which the capacity can be regenerated. Such a skill base must include experience, and not just theoretical knowledge.

8.83 Two potential options to maintain that link with the technology are:

- Construction skills are being employed in the build of the Royal Navy's Astute class submarines and full advantage must be taken of the opportunities that project offers to maintain a kernel of skills that could be employed in design and construction of a civil nuclear plant.

[33] AP600 – a safe, simplified, economic plant. H J Bruschi. Nuclear Energy. June 2000.

- In the absence of a UK programme, involvement in international projects where new construction is still being pursued should be encouraged.

8.84 In summary, the power generation sub-sector faces two challenges:

- To maintain confidence in a declining industry to enable operation of remaining plant until end of life, without which safe operation cannot be ensured which would most probably result in early closure of the plant due to regulatory action.
- To retain sufficient capability to regenerate a nuclear capability, in order to implement Government policy and 'keep the nuclear option open'.

NUCLEAR CLEAN UP

8.85 Nuclear clean up is focussed on the decommissioning phase. Within the next five years it is planned that the Liabilities Management Authority (LMA) will be formed and its influence should be taking effect. Two principal effects are anticipated:

- If a positive programme of waste management is commissioned, the current perception of indecision could be reversed and confidence raised that the sector offers a worthwhile and stimulating career; hence the potential exists for the state of the sector to move to **green**. However, if the sector is perceived as procrastinating, either because of regulatory influence or excessive assessment of options, it will be perceived that the sector suffers from indecision leaving the state of the sector at **Red**.
- The largest single organisation in the sector is BNFL, and their size has enabled them to pursue a commendable programme of skills development targeted at all levels: apprenticeship training, graduate development and postgraduate research. One aim of the LMA will be to seek competition to achieve the best value for money. In seeking to reduce costs, efficiency measures will be sought and other industries in this situation have responded by reductions in size and contraction in skill development and research. Such action would be perceived as contraction and indecision, which would drive the state of the sector towards **Red**.

8.86 The impact on clean up skills of the Magnox closures will depend on the post closure programme. Immediate progression to dismantling post de-fuel will create the perception of an expansionist programme, which may assist recruitment. If, post de-fuel, safe-store and deferral of dismantling is pursued, this will create a perception of decline or uncertainty, which will have a negative impact across the nuclear clean up sector. There are strong arguments for safe-store, principally that deferral of dismantling allows natural radioactive decay to occur, so reducing the dose uptake from eventual dismantling and reducing the cost of that activity. A different skill set is needed for safe store and deferral, however, namely that of knowledge management to capture data pertinent to the plant that may be needed when it is eventually dismantled in what may be several decades time. The policy applied at Berkeley and Trawsfynydd, two Magnox stations that have already closed, was to commence dismantling soon after closure to take advantage of the skills and knowledge available within the operating organisation.

SECONDARY USERS

8.87 The secondary user sector is not subject to political, environmental and image factors to the same degree as the remainder of the sector. The public is generally comfortable with dental x-rays, animal x-ray by veterinarians or the use of x-ray techniques for non-destructive examination, although suspicion of the radiation of foods does exist. The ethical limitations to growth in this sector are not as strong as other applications, hence it can be anticipated that the sector will grow. Growth in this sector poses a number of problems as the radiological skills and knowledge is additional to the primary skills of people in the sector. Growth in the sector will therefore increase the demand for:

- Education and training on basic radiological protection principles.
- Regulators to ensure that those principles are applied.
- Waste management facilities for active materials.

PRESSURES ON THE SECTOR – 5 YEARS TIME: 2012

FACTORS

8.88 Prediction of the factors that will effect skill demand in 10 years time cannot be made with any accuracy. The following summarises a combination of extrapolation of the impact of policies in place today coupled with views expressed in the foresight workshops.

HEALTH

8.89 The health sector will continue to be involved in all phases of the life cycle, but with NHS skills focused on 'install', 'operate' and 'maintain'. The demand for improved health care is likely to continue which, in conjunction with an ageing national population, means that the demands on this sector are likely to increase.

DEFENCE

8.90 The structure of the UK's armed forces in the post Cold War era was addressed in the Strategic Defence Review. That review confirmed the need for the UK to maintain its minimum nuclear deterrent based upon the Trident submarines for up to 30 years and to maintain a slightly smaller nuclear powered attack submarine force with the new Astute class submarines. The main skill drivers are expected to be further improved safety and reduced cost of ownership. An impact on skills will be whether a steady state situation will have been reached of repeat build of a proven design or whether a new generation of power plant and/or weapons is required.

8.91 One improvement being pursued today that will impact in a decade's time is development of a core designed for the life of a submarine. The aim of this development is to remove the need for mid-life refuelling, which will correspondingly reduce the demand on that corporate capability and individual skills.

POWER GENERATION

8.92 By 2012, current plans indicate that the Magnox reactors at Oldbury-on-Severn and Wylfa will have closed (by 2010). In addition five AGR reactors will have closed: Dungeness B (2008), Hartlepool (2009), Heysham 1 (2009), Hinkley Point B (2011) and Hunterston B (2011). Management of these sites will have moved into the nuclear clean up sector.

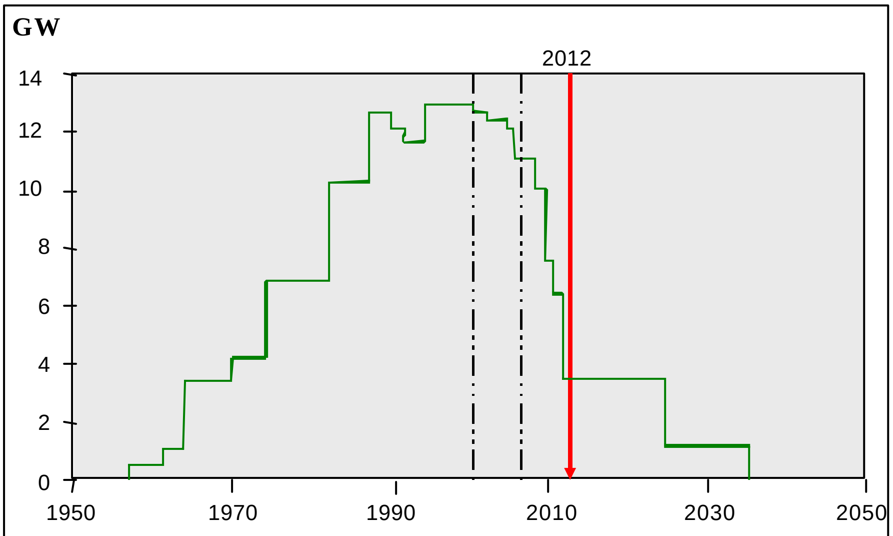

FIG 8.9 UK NUCLEAR POWER CAPACITY

8.93 These stations collectively supply 7.4 GW, or 13.5% of the UK's capacity in 2000. The collective loss (including the Magnox closures prior to 2007) of 8.9 GW may influence energy policy, particularly if renewable energy has not delivered against anticipated targets and/or concerns exist about the security of supply of gas. There could be a number of effects on skills demand in the power generation sub-sector:

- If the loss in capacity does not stimulate new construction, this part of the the industry must be considered in permanent decline.
- If the loss in capacity stimulates new build, it will be necessary to regenerate the skills needed to construct, commission and operate plant. If this policy were pursued, it is probable that the project will be an international collaboration. Sufficient indigenous skills will be required to satisfy national regulatory requirements that the UK licensee is the intelligent customer (client) of any services contracted out. As already stated, the lead-time for a new nuclear power station is in the order of 15 years. A decision to embark on new build in 2012 would mean that the station would be unlikely to be on-line until 2027. This would result in a marked 'trough' in both power generation capacity and the demand for skilled people.

8.94 International factors on energy production may also affect the state of the sector. A new construction programme in the USA, for instance, would be likely to attract skilled people from the UK to compensate for skill shortages overseas. This would have a number of effects. The demand would draw people out of the UK sector, so placing further pressures on the national pool of skilled people. But overseas demand would stimulate the sector, it being perceived as an expanding sector, with opportunities for career development and work overseas. A US led recovery may place increased demand on UK skills, but it may also stimulate people to study nuclear related technology in UK education establishments.

NUCLEAR CLEAN UP

8.95 The scale of the liability task will inevitably increase, with the addition of a further Magnox station to the extant national liability. Five AGRs will also have closed, these stations being the responsibility of British Energy rather than the LMA. The market for liability management will become more complex with the involvement of two 'client' organisations. The impact on the sector will depend on the post closure programme. Immediate progression to dismantling will create the perception of an expansionist programme, which may assist recruitment. If safe-store and deferral of dismantling is pursued, this will create a perception of decline or uncertainty, which may have a negative impact across the nuclear clean up sector. British Energy have considered plans for safe-store for a possible period of 50 years which, if implemented, would have a significant impact on the skills requirement.

SECONDARY USERS

8.96 Development of the secondary users' sector is anticipated to continue to grow. Hence the demand for education and training of basic radiological protection principles, regulators to ensure that those principles are applied and waste management facilities for active materials is also anticipated to grow.

PRESSURES ON THE SECTOR – 5 YEARS TIME: 2017

FACTORS

8.97 Accurate prediction of the state of the sector in 15 years time cannot be achieved, however foresight can be applied to consideration of the factors that may influence the sector in that time-scale.

HEALTH

8.98 The health sector will continue to be involved in all phases of the life cycle, but with NHS skills focused on 'install', 'operate' and 'maintain'. The demand for improved health care is likely to continue which, in conjunction with an ageing national population, means that the demands on this sector are likely to increase.

DEFENCE

8.99 Major events are possible that could change defence policy, but the equipment procurement policy in place today will still be influencing the state of the defence sector in 15 years time. It is expected that there will still be a rolling programme of submarine construction and contractor provision of logistic support for military operation. The most significant impact on skills demand would be a decision for new design, which would necessitate the formation of design teams almost from first principles, the continuity of that corporate capability having been diluted with the focus on support rather than new design.

POWER GENERATION

8.100 By 2017, current plans indicate that only Heysham 2, Torness and Sizewell B will be operational, the total reduction in capacity being 8.9 GW, or 16% of the UK's capacity in 2000.

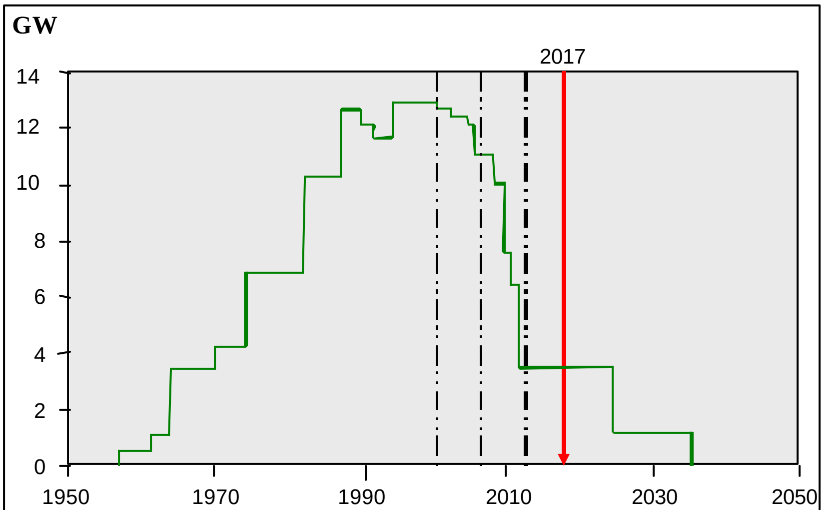

FIG 8.10 UK NUCLEAR POWER CAPACITY

NUCLEAR CLEAN UP

8.101 The scale of the liability task will continue to increase, with the addition of 2 further Magnox stations to the extant national liability. The impact on the sector will again depend on the post closure programme: immediate progression to dismantling or safe-store and deferral of dismantling.

SECONDARY USERS

8.102 Development of the secondary users' sector is anticipated to continue to grow, hence the demand for education and training of basic radiological protection principles, regulators to ensure that those principles are applied and waste management facilities for active materials is also anticipated to grow.

PRESSURES ON THE SECTOR – RECRUITMENT DEMAND

FACTORS

8.103 Although the sector age profile does not demonstrate a significant age skew, human resource departments are reporting an increasing difficulty in recruitment. That recruitment is from the wider engineering and physical science sector, which is known to be in decline (see Annex B), therefore measures are needed to address the strength of the sector over the period under review. Engineering and physical sciences are unpopular fields of study, both academic and vocational, and it is from this pool of students that the nuclear sector must recruit. Unless this trend is reversed, the nuclear sector will face the challenge of recruiting from a diminishing pool of potential recruits.

8.104 As highlighted in Section 9, the general unpopularity of engineering and physical science has been recognised in the recent review conducted for the Treasury by Sir Gareth Roberts[34]. The IAEA have also recognised this issue, as identified at a recent IAEA conference on managing nuclear knowledge[35]:

"There is a general difficulty in attracting young people into the field of nuclear engineering and physical sciences: the courses seem too difficult; upon graduation the jobs are uninteresting and the pay is too low, and there is a view that only the 'least attractive' people go into these fields. It was also pointed out that "before we can educate new people in this field, we must first attract them to the field; and engineers themselves are lousy marketers!"

8.105 The sector recruitment demand is assessed as follows:

- A baseline is taken of the current sector population.
- An assessment is made of the recruitment demand to maintain the baseline status quo over the next 15 years. The assumption has been made that the principal driver will be recruitment to replace retirements from the sector, a retirement age of 60 being applied. Other wastage will occur but it should be noted that what may appear to be wastage to an individual employer may actually be movement within the sector as engineers and scientists make career moves between employers, not necessarily between sectors.
- An assessment is made of the effects of volumetric changes to the population brought about by changes in sector demand. These are presented as variations to the status quo assessment of demand.

[34] SET for success: The supply of people with science, technology, engineering and mathematics skills. The report of Sir Gareth Roberts' Review. April 2002.

[35] Meeting of Senior Officials on Managing Nuclear Knowledge. 17-19 June 2002. International Atomic Energy Agency, Vienna International Centre, Austria.

BASELINE

8.106 The baseline population in 2002 is:

SUB-SECTOR	BASELINE POPULATION	
HEALTH	30,000	
Radiologists and Radiographers		25,000
Clinical Scientists		5,000
POWER, DEFENCE, FUEL & NUCLEAR CLEAN UP [36]	46,000	
Defence		7,000
Power Generation		8,000
Fuel Cycle		20,000
Source Manufacture		3,000
Nuclear Clean Up		8,000
SECTOR SUPPLIERS	10,000	
Contractors		8,000
Education & Research		1,000
Regulators		1,000
SECONDARY USERS	49,000	49,000
TOTAL	**135,000**	**135,000**

STATUS QUO

8.107 The projected accumulative retirements of primary users is indicative of recruitment demands over the next 15 years to maintain the status quo, those projections being:

SECTOR RETIREMENTS	Over 5 years 2002 – 2007	Over 10 years 2002 – 2012	Over 15 years 2002 – 2017
Health	3,700	6,600	9,600
Power, Defence, Fuel & Nuclear Clean Up [37]	6,400	14,500	22,700
TOTAL	**10,100**	**21,100**	**32,300**

8.108 The relative numbers of professionals and skilled trades within these figures are:

SUB-SECTOR RETIREMENTS	Over 5 years 2002 – 2007	Over 10 years 2002 – 2012	Over 15 years 2002 – 2017
Health			
Professional & Associate Professional	3,700	6,600	9,600
Power, Defence, Fuel & Nuclear Clean Up			
Professional & Associate Professional [38]	3,500	8,000	12,400
Skilled Trade, Process Plant & Machine Operator [39]	1,800	4,000	6,300
Others [40]	1,100	2,500	3,900
TOTAL	**10,100**	**21,100**	**32,300**

8.109 The above figures are a guide to what may be required, not projections of what will be required, the actual requirement being dependent on many other factors including growth or decline in the sector or external demands which may attract people out of the sector. The

[36] Including both 'Clients' and 'Suppliers'.

[37] Including both 'Clients' and 'Suppliers'.

[38] 'Professional and Associate Professional' refers to a person qualified to Level 4 and 5 in the National Qualifications Framework, typically having a minimum qualification of a Bachelors degree.

[39] 'Skilled Trade, Process Plant or Machine Operator' refers to a person with a vocational or occupational qualification at Level 3 or below in the National Qualifications Framework.

[40] 'Others' includes the remainder of the population, principally Administration and Secretariat.

significant factor is the order of magnitude of skilled people needed over the next 15 years, and the recruitment environment that exists from which to draw those people.

VOLUMETRIC POPULATION CHANGES

FORESIGHT

8.110 A range of plausible scenarios for each sub-sector were considered in the foresight exercise, the following 'seasons' being postulated:

- **Autumn**: Operation of extant equipment to the end of design life, but not replaced, followed by management of the nuclear clean up.
- **Winter**: Abandonment of nuclear or radiological technology, leaving management of liabilities as the core of the industry, and skilled persons attracted out of the industry to other UK and international sectors.
- **Spring**: The 'autumn' scenario, but with equipment replacement.
- **Summer**: Significant expansion of nuclear or radiological technology.

8.111 The nature of the nuclear sector, with its residual clean up, is such that the rate at which any of these scenarios can be pursued will be limited by the availability of skills. The nature of the problem in each scenario is the same: to attract recruits from the wider national (and international) pool of engineers and physical scientists. But since engineering and physical sciences are increasingly unpopular fields of study and career choices, the sector inevitably faces the challenge of recruiting from a potentially diminishing pool of suitable recruits. The basic recommendations are therefore the same for each scenario, to work with other sectors to enlarge the pool and recruit the sector's needs from that pool.

INDICATIVE SCENARIO

8.112 Indicative numbers of the accumulated total of skilled people likely to be demanded by the sector over the next 5, 10 and 15 years are given by consideration of one illustrative scenario in which:

- Health has a current 10% shortfall and grows by 10% every 5 years (summer);
- Work on nuclear clean up doubles over the 15-year period, in addition to taking on station closures (summer);
- The current power station closure programme is implemented, but new build is not pursued (autumn); and
- Defence and the Fuel Cycle remain status quo (spring).

HEALTH

8.113 A report published by the Audit Commission in 2002[41] indicated that the overall national mean vacancy rate for radiographers and radiologists in 2000/01 was 10%. This was confirmed by the foresight study, which highlighted that local shortages as high as 30% were currently been experienced. The foresight study also indicated that this sub-sector was likely to grow in the future. Assuming an average shortages of 10% across the sub-sector today and a growth of 10% every 5 years over the next 15 years, the consequent population change would be:

HEALTH	Now	Over 5 years 2002 – 2007	Over 10 years 2002 – 2012	Over 15 years 2002 – 2017
Shortages	3,000	3,000	3,000	3,000
Retirements		3,700	6,600	9,600
Growth		3,000	6,000	9,000
TOTAL	**3,000**	**9,700**	**15,600**	**21,600**

[41] Radiology: Review of national findings – acute hospital portfolio. Audit Commission. July 2002.

NUCLEAR CLEAN UP

8.114 The foresight study indicated that this sub-sector was likely to grow in the future, both to address extant liabilities and to take on the liabilities arising from the planned closure of power stations.

8.115 The closure of Trawsfynydd power station resulted in the number of people employed on site being reduced from 480 to 270, ie 480 people left the power generation sub-sector, but 270 entered the nuclear clean up sub-sector. Assuming such reductions to be typical of future programmes, and assuming that addressing extant liabilities may cause the sub-sector to double in size over the 15-year period, the consequent population change is:

NUCLEAR CLEAN UP	Now	Over 5 years 2002 – 2007	Over 10 years 2002 – 2012	Over 15 years 2002 – 2017
Retirements		1,130	2,540	3,950
Growth due to Station Closures		1,350	3,300	3,300
Overall Growth		2,700	5,300	8,000
TOTAL		5,180	11,140	15,250

POWER GENERATION

8.116 Operation of a fleet of power stations involves two types of organisation: power station operators and a central design and support organisation. Closure of individual stations will result in a reduction in the number of operators but the size of the support organisation will be little changed for operation of 1 or 7 power stations; hence its size will be relatively constant until the final station is closed. The planned closure programme will result in a contraction of the sub-sector, which may counter the recruitment needs to replace retirements to some extent. The overall effect on the sub-sector is estimated to be:

POWER GENERATION	Now	Over 5 years 2002 – 2007	Over 10 years 2002 – 2012	Over 15 years 2002 – 2017
Retirements		1,130	2,540	3,950
Station Closures		-2,000	-5,800	-5,800
TOTAL		-870	-3,260	-1850

OVERALL DEMAND

8.117 Assumed that the remaining sub-sectors continue in steady state, the overall recruitment requirements could be as high as:

PRIMARY USER DEMAND	Now	Over 5 years 2002 – 2007	Over 10 years 2002 – 2012	Over 15 years 2002 – 2017
RETIREMENTS		10,100	21,100	32,200
SHORTAGE	3,000	3,000	3,000	3,000
GROWTH		4,900	8,900	14,800
TOTAL DEMAND	**3,000**	**18,000**	**33,000**	**50,000**

8.118 The composition of the above demand is:

SUB-SECTOR DEMAND	Over 5 years 2002 – 2007	Over 10 years 2002 – 2012	Over 15 years 2002 – 2017
HEALTH			
Radiologists and Radiographers	8,000	13,000	18,000
Clinical Scientists	1,600	2,600	3,600
DEFENCE, POWER, FUEL, & CLEAN UP			
Professional and Associate Professional[42]	4,450	10,000	15,500
Skilled Trade, Process Plant and Machine Operator[43]	2,250	4,900	7,850
Others [44]	1,700	2,500	5,050
TOTAL DEMANDS	**18,000**	**33,000**	**50,000**

8.119 15,500 graduates required by the power, fuel, defence and clean up sub-sector over the next 15 years equates to approximately 1,000 graduates per year. Of these, 700 are replacements for retirements and 300 are a response to growth of nuclear clean up.

IMPACT - SUPPLY VERSUS DEMAND

8.120 The power, fuel, defence and clean up sub-sector demand is for engineers and physical scientists, and the sub-sector's recruitment target in 2002 was approximately 560 graduates. UCAS statistics indicate that in 1994 and 2001, the numbers of students accepted for engineering and physical science courses were:

DISCIPLINE // YEAR	1994	2001	% Fall
MECHANICAL ENGINEERING	3,631	2,985	-18%
CIVIL ENGINEERING	2,752	1,625	-41%
ELECTRICAL & ELECTRONIC ENGINEERING	3,721	2,670	-28%
CHEMICAL ENGINEERING	1,048	660	-37%
PHYSICS	3,989	2,887	-28%
CHEMISTRY	2,780	2,433	-12%
TOTAL	**17,921**	**13,260**	**-26%**

8.121 The above table records those students that were accepted to study the identified engineering or physical science courses, which has demonstrated a steady decline over the past 8 years. The population of graduates will be somewhat less than this, the population being depleted by those that fail to graduate and those that choose a career outside of the engineering or physical sciences discipline.

8.122 If these trends continue, in 10 years time, the sector may be seeking to recruit the equivalent of 10% of the UK's engineering and physical science graduates. And this at a time when there will be increasing demand from other sectors such as rail, renewable energy, the chemical industry or oil and gas extraction, and in particular education at all levels.

[42] 'Professional and Associate Professional' refers to a person qualified to Level 4 and 5 in the National Qualifications Framework, typically having a minimum qualification of a Bachelors degree.

[43] 'Skilled Trade, Process Plant or Machine Operator' refers to a person with a vocational or occupational qualification at Level 3 or below in the National Qualifications Framework.

[44] Others includes the remainder of the population, principally Administration and Secretariat.

PROPOSALS

9 PROMOTION OF THE SECTOR TO ENCOURAGE RECRUITMENT

BACKGROUND

9.1 A PIU report on workforce development[45], published in Dec 01, proposed a strategy for a demand-led system for workforce development, shifting the emphasis of policy making from increasing supply, to stimulating demand from employers. The following discussion is predicated on the assumption that this concept is pursued.

9.2 The nuclear and radiological sector faces the challenge of recruitment of scientists, engineers and technicians at a time when science and engineering is unpopular and, for a number of reasons, the nuclear and radiological sector is considered the unpopular end of an unpopular occupation.

9.3 The unpopularity of science and engineering to potential graduates is demonstrated by analysis of the University and Colleges Acceptance Service data for the years 1994 to 2000, summarised at Annex B. During this period the number of acceptances of UK students for mechanical, civil & electrical engineering, physics & chemistry courses fell by 25%, from approximately 18,000 to 13,500. This reduction is more concerning considering that the total number of acceptances rose over the same period rose by 23%, from 228,000 to 282,000 (Fig 9.1). Engineering & physical sciences' market share therefore fell from 8% to 5%. It should also be noted that computer science acceptances rose from 8,500 to over 14,000 in the same period.

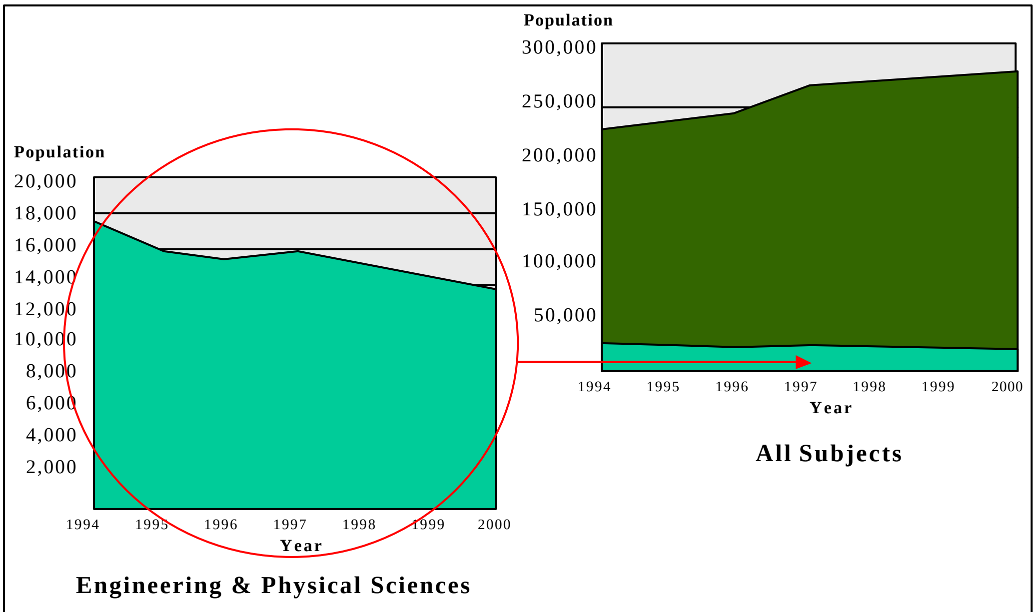

Fig 9.1 UCAS ACCEPTANCES

9.4 The training of skilled trades people is in an even more fragile state. Traditional apprenticeships have been in decline for a number of years, particularly following privatisation of the nationalised industries, which were strong sponsors of such schemes. The DTI and DfES are promoting Modern Apprenticeships in an attempt to restore the needed vocational training, but such training remains unpopular and undervalued.

9.5 Promotion of the sector in this environment requires careful consideration of who to target, where and when. Also how, and perhaps more importantly, how not to promote the sector. In addressing these questions it must be remembered that the nuclear and radiological sector is

[45] In Demand: Adult skills in the 21st century. Part 1 November 2001.

a sub-sector of the wider science and engineering sector. Sir Gareth Roberts has reviewed the national shortage of scientists and engineers and published his findings in his recent report[46]. The aim of this, nuclear and radiological sector, report is to build upon Roberts' observations and recommendations, to consider what action can be taken to contribute to the wider issue, whilst addressing the unique needs of the nuclear and radiological sector. Before embarking upon a consideration of particular initiatives to promote the sector, it is important to note a number of general points.

9.6 An observation made by Roberts is reiterated as a general warning:

"There are some 1,200+ national schemes, awards, competitions etc sponsored by companies and other organisations to support science and engineering education in schools. However, the collective impact of these schemes is not as high as it should be."

It must therefore be concluded that Initiative 1,201 is unlikely to be successful, unless a 'smarter' way of promoting the sector is achieved.

9.7 An observation repeatedly made during the foresight workshops was the importance of differentiating between reason and imagination, or logic and emotion. Scientists and engineers often approach a subject with reason and logic, however people in general more often respond to imagination and emotion. This fact is of paramount importance to the nuclear and radiological sector, for example when consulting with the public on options for new plant or facilities or when promoting the sector with the aim of recruitment.

9.8 Promotion of the sector must occur by means of a number of initiatives but, to be effective, a robust structure must be given to this combination of initiatives. That structure is provided by application of the 'learning pathway' described in Annex C, in particular consideration of the choices and decisions made by people that would foreclose the option of joining the sector or when a positive decision is made to join the sector. Within this structure there must be clarity of aim for each initiative and focus of effort to ensure that objectives are achieved.

9.9 A factor that hinders promotion of the sector, and hence which makes application of a structure to the collection of initiatives all the more important, is the fragmentation of the sector:

- The industry is fragmented as a result of economic liberalisation;
- Education and training is fragmented with multiple qualifications and courses being available to students;
- Multiple initiatives exist to encourage young people into the skills sector, but which are largely uncoordinated; and
- Multiple professional institutions and learned societies exist which set standards for the sector, but again whose joint activity is largely uncoordinated.

9.10 A number of recommendations are made which, to be effective, must have an identified 'actor' to implement them. Reference is often made to 'Employers', 'Academia' and 'Government', but actions placed on such generic organisations are unlikely to be followed up. There is therefore an urgent need for a cross sector skills task force, comprising members of industry, academia, professional institutions and Government, and led by a strong captain of industry or academia, to be a vehicle for co-ordination and implementation of initiatives to promote the sector. One aim of such an organisation must be to help employers and individuals make informed career choices. A Sector Skills Council may be capable of executing this responsibility but, in the short to medium term, the nuclear skills task group should pursue this action.

[46] SET for Success – The Supply of people with science, technology, engineering and mathematics skills – The Report by of Sir Gareth Roberts' Review – April 2002.

Recommendation 6

Recommendation 6

CO-ORDINATE GENERAL PROMOTION OF THE SECTOR

Many organisations already promote the sector, including employers, professional institutions, careers advisers and trade associations, but their actions must be co-ordinated to have maximum effect. Best practice must be identified and encouraged across the sector. This must address:

- The positive aspects of the sector and outputs that are in the public good, such as medical treatment or nuclear clean up.
- The attractions of working in the sector: the technical challenge, opportunities for career development and transferability of skills.
- The best vehicles for promotion: eg SET ambassadors, visitor centres, recruitment fairs, publications, websites etc.
- The nature of the message, emphasising the relevance of the work to managing the environment and the essential, exciting and stimulating nature of the work.

Action: Nuclear Skills Task Group / Sector Employers

9.11 The cross sector skills task group must address factors such as:

- Collaboration: when is it viable, when is it appropriate and between whom?
- Experience: many initiatives have already been employed in an attempt to promote the sector, which have worked, which have failed and which require improvement?
- Attractions: what will attract people into the sector?
- Dissuasion: what dissuades people from joining the sector?

WHO TO TARGET, WHERE AND WHEN?

9.12 The sector demand is for people who are, or who will ultimately, be scientists, professional and associate professional engineers, skilled trades, process plant and machine operators, teachers and Educators, and regulators. The movement of people, both within the sector and into and out of the sector, can be visualised by the flow chart at Fig 9.3, from which it can be seen that four basic sources of recruits exist, from: schools, universities, other sectors and overseas.

RECRUITMENT FROM THE EDUCATION SYSTEM

9.13 The IMechE and IEE have studied the influences on young people in choosing careers in 2001. Two questions asked in their surveys were: "How old were you when you first became interested in an Engineering Career?" and "Who or what was the first major influence on you to take up an Engineering Career?" Over 5000 people responded to the survey, the results of which are summarised in Fig 9.4. The significant factors from this survey are: the age at which people were attracted to engineering, 13 to 18, and the major influences on career choice, the top four being parents, school, toys and choice of university degree.

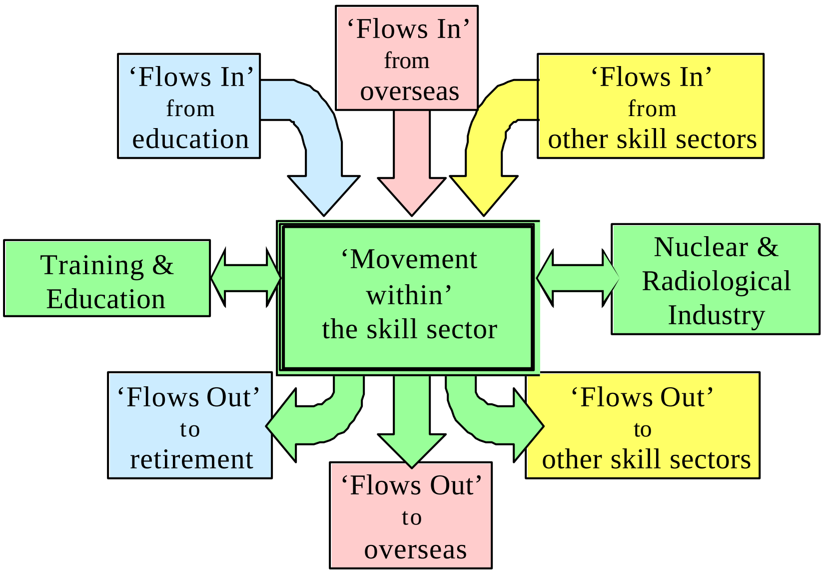

FIG 9.3: FLOWS IN & FLOWS OUT OF THE SECTOR

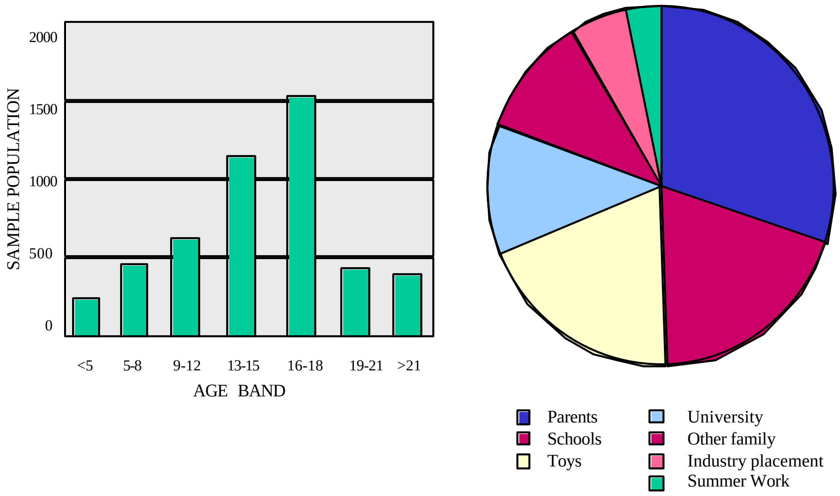

FIG 9.4a
AGE WHEN INTEREST IN ENGINEERING BEGAN

FIG 9.4b
INFLUENCES & ATTRACTIONS

9.14 Assessment of the required action to improve recruitment directly from the education system requires consideration of the 'learning pathway' at Fig 9.5, described in Annex C. Choices made by individuals during the learning process will determine the ultimate size of the engineering and physical science sector from which the nuclear and radiological sector must recruit. An early choice to drop science will prevent that student from following a learning pathway that may lead to the nuclear and radiological sector. Conversely, potential nuclear and radiological sector candidates will not be asked to specialise until post first degree. Collaboration to enlarge the national sector of engineers and physical scientists must therefore be a key feature of any initiative, while seeding young people's imagination to promote the attraction of the nuclear and radiological sector.

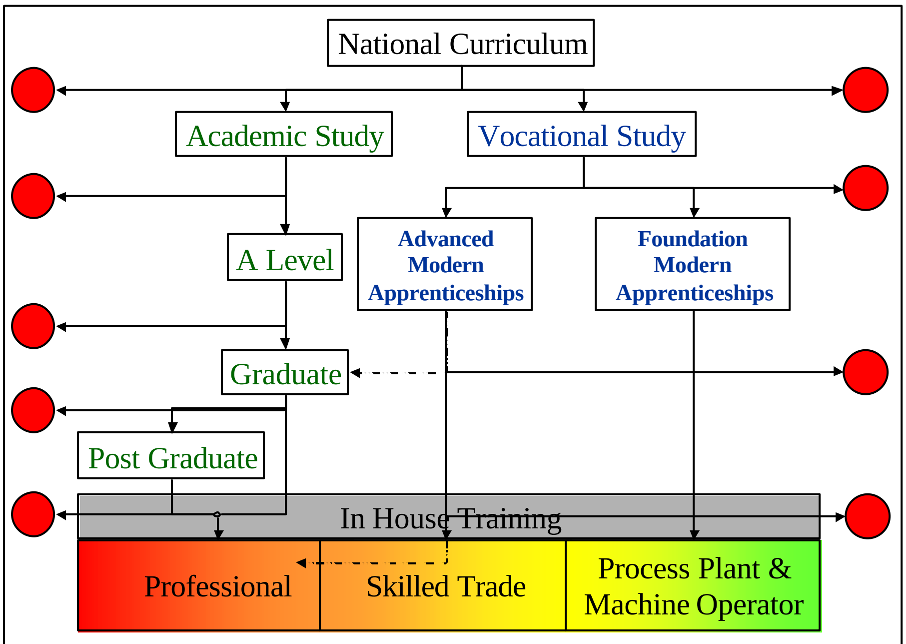

FIG 9.5: THE LEARNING PATHWAY

9.15 Roberts[47] provides a comprehensive analysis of the situation regarding promotion of science and engineering nationally. There are key messages for the nuclear and radiological sector regarding where effort must be focused for best effect.

9.16 Considering chronological progress through the learning pathway these are:

- **Key Stage 3/4**[48] Sector action is needed to influence those formulating the national curriculum to introduce the concepts that will provide young people with a foundation upon which to base future choices. Particular concepts pertinent to the nuclear and radiological sector are radiation and risk.
- **Key Stage 4** Collaborative action is needed to promote education choices that do not foreclose entry to science and engineering.
- **A Level** Action is required to promote a balance between vocational and academic study:
  - For the academic route, collaborative action is required to promote mathematics and physical sciences.
  - For the vocational route, sector action is needed to promote modern apprenticeships, such learning pathways being the earliest entry into the sector.
- **Degree** At first degree level, education is still generic, however sector action is required to promote specialist modules in a cross section of engineering and physical science degrees to act as 'tasters' for further study or choice of occupation.

THE INFLUENCE OF SCHOOLS AND TEACHERS

9.17 The role and influence of schools and teachers in the development of nuclear and radiological skills is discussed in Annex F. Their prime role is teaching the fundamental science and mathematics needed to provide the foundation for further education and training, but they also have a secondary role in promoting the sector. This must not be 'pro-nuclear' marketing, but presentation of factual information to open young minds to the challenges and opportunities that exist in the sector. The issues are:

[47] SET for Success: The supply of people with science, technology, engineering and mathematics skills: The report of Sir Gareth Roberts' Review. April 2002.

[48] Key Stage 3 & 4 are important stages in the curriculum, Key Stage 3 being the first 3 years of secondary school, ages 11 to 14, and Key Stage 4 being the years of education leading up to GCSE, ages 15 and 16.

- **Influence** Teachers have a profound effect on the attitude to, and interest in, science and technology; consequently the knowledge, confidence and competence of science teachers is critical. This requires a systematic process of Continuing Professional Development (CPD) for teachers, which must be supported by the sector.
- **Third Party Support** Little use is made of third party support available to teachers. While teachers are supplied with materials from numerous sources, most do not meet their specific needs and are often out of date with regard to the National Curriculum.
- **Careers Advice** The perceptions of young people, parents, teachers and careers advisers about the opportunities open to people with scientific qualifications, both vocational and academic, have a significant effect on the eventual career choices made by young people. The sector must therefore provide support to careers teachers, which should include high quality materials and resources about what it is really like to work in science and engineering careers.

9.18 The Council for Science and Technology has assessed science teaching in primary and secondary schools[49] and on the issue of the supply of materials to support teachers concluded that:

"We have been told by these providers that the science teachers who draw regularly on their products and services are a small minority… The position is not helped by the large volume of unsolicited paperwork concerning schemes, resources, activities etc. which arrives daily, coupled with the limited time available for teachers to consider its appropriateness and possible benefit to teaching… We believe that, in partnership with both sides, the Government should seek to improve the operation of this market which is highly fragmented on the demand and supply sides at present."

9.19 The Council recommended that products and services should be supplied in teacher friendly ways and that government should work with key stakeholders to improve the operations of supply arrangements. There needs to be a definition of good practice within the area of materials to support the curriculum.

9.20 A Centre of Excellence has been proposed which would act as a framework for achieving these outcomes. The Centre would be expected to develop the provision of CPD in science, working with partner organisations. DfES is currently undertaking a consultation on the establishment of such a Centre.

Recommendation 9

Recommendation 9

SECTOR SUPPORT FOR CONTINUING PROFESSIONAL DEVELOPMENT FOR TEACHERS

The task group must act as an interface between those that provide continuing professional development for teachers and those elements of the sector that can provide good quality and appropriate material to support CPD.

To be effective, Continuing Professional Development for teachers requires good quality material on subjects such as careers advice, opportunities in industry, employers' requirements and experience in industry. A number of sector organisations are in a position to deliver this support, but their actions must be co-ordinated to have maximum effect.

This should include support for the Centre of Excellence for CPD in science, once established, as recommended by the Council for Science and Technology.

Action Nuclear Skills Task Group

[49] A report on supporting and developing the profession of science teaching in primary and secondary schools. Council for Science and Technology. Feb 2000.

COLLABORATIVE PROMOTION OF SCIENCE & ENGINEERING

9.21 As reported by Roberts, the numerous schemes, awards and competitions promoting science and engineering education in schools are not having the collective impact they should have. New initiatives must therefore be avoided and the sector must identify those extant schemes that seek collaboration and synergy in enlarging the pool of scientists and engineers in the United Kingdom.

9.22 The prime reasons for the limited success of extant initiatives are the inappropriateness of material and support and the timing of its delivery to schools. The importance of promoting science and engineering at schools is fully recognised by many in the sector and there is evidence of much material being produced to aid this process. Some is very good, but a great deal is inappropriate; what may be generically described as 'glossy brochures'. The key factors to be considered in relation to providing support of schools are:

- **Content** Material and support must target teachers' needs directly. It must require minimal effort by teachers to apply (if effort is needed to sort the good from the bad it is unlikely to be used) and it must be co-ordinated with material from other sectors to jointly promote science and engineering. Material and support is needed to aid teachers in delivering the curriculum, put the curriculum into context for pupils ('jazzes' up the curriculum) and to provide role models for pupils. Material not focused on these aims will hinder rather than aid teachers.
- **Timing** Support must be provided to coincide with curriculum milestones and decision points in pupils' learning pathways. Many schools organise 'Industry Days' at the time young people are making choices for GCSEs, to advertise the career options available and hence influence subject choices. Support must therefore be delivered at the right time in the academic year to maximise benefit.
- **Funding** Much is spent annually on promotion of the sector, and yet evidence was found of schools being unable to afford to run events such as industry days; hence a shortfall of relatively minor amounts of funding is significantly hindering provision of support at the right time.
- **National Exposure** People's mobility is now much greater and promotion must be targeted nationally; good practice applied nationally will achieve more than local or regional examples of excellence.

9.23 The sector must select an extant scheme, or schemes, that provides the support required by teachers and, using that scheme as a vehicle, develop a partnering relationship between teachers and the sector (comprising industry, academia and professional institutions) to jointly deliver the support needed by schools.

9.24 A recommended scheme is the DfES / DTI sponsored Science, Engineering and Technology Network Scheme (SETNET) and the associated Science and Engineering Ambassadors. Lord Sainsbury, Minister for Science and Technology, supports these schemes. The SETNET scheme, described at Annex O, provides a network of organisations, known as SET Points, which provide advice on, and vet, the material and support offered by sectors. Closely associated with this is the Science and Engineering Ambassador Scheme, which aims to recruit young people who have recently entered science or engineering to provide role models for pupils.

9.25 This builds upon a recommendation made by Roberts (Recommendation 2.13), who stated:

"the review believes that further action is needed from the Government, but also from businesses and others in scientific and technical fields, to ensure that pupils (especially girls) receive accurate and positive advice about the rewards from studying science and engineering. Specifically, the Review recommends that the Government establish a small central team of advisers (possibly within the new Connexions service) but working closely with SETNET to support existing advisers, teachers and parents in advising pupils."

Recommendation 10

Recommendation 10

PROMOTION OF SCIENCE ENGINEERING TECHNOLOGY AND MATHEMATICS IN SCHOOLS

The task group must promote appropriate sector support, to teachers and pupils, to increase the propensity of people to enter careers in science and technology through an extant scheme or schemes that have a proven track record of delivering the right support to schools. One such recommended scheme is the Science, Engineering, Technology and Mathematics Network (SETNET). This scheme encourages:

- Use of science ambassadors to promote science and engineering to young people.
- Provision of appropriate material to support delivery of the curriculum.
- Provision of support to help put the curriculum into context.

Action: Nuclear Skills Task Group

PROMOTION OF VOCATIONAL EDUCATION / MODERN APPRENTICESHIPS

9.26 Vocational education has become undervalued and unpopular in the United Kingdom, as a result of which a multi-million pound campaign is currently being conducted, sponsored by the DfES, aimed at promoting Modern Apprenticeships. But, despite this campaign, courses remain unpopular and suspicion exists about the quality of their output.

9.27 Modern Apprenticeships are agreements between the individual undertaking and the company sponsoring the apprenticeship. Collaboration with further education institutes is also required to deliver the academic element of courses. In the first instance, the responsibility rests with individual companies to promote their own apprenticeships. Fragmentation within the sector, however, means that reliance upon this vehicle alone for recruitment is unlikely to deliver adequate numbers of skilled people.

9.28 Considering the learning pathways and career development routes which gave rise to the shape and form of the sector today, apprenticeship schemes provided not only skilled trades but also associate professionals and professionals. Many engineers entered through the apprenticeship route and followed career development paths into the associate professional and professional sub-sectors. The nationalised industries that earlier formed the core of the sector, such as the CEGB and Naval Dockyards, sponsored large apprenticeship schemes. The scale of these schemes was such that they not only satisfied their own demands, but also trained a surplus who migrated into their supply chain, or to other sectors.

9.29 In today's liberalised market, allowing market forces to dictate the size and content of apprenticeship schemes can result in a multitude of small courses, targeting particular companies' requirements, with limited surplus and with limited potential for transferability of skills between companies comprising the sector. This situation has already been recognised in the power generation industry in general, in response to which the National Training Organisation, the Electricity Training Association, encouraged companies to collaborate and produce apprenticeships that were recognised throughout the sector.

9.30 Collaboration is therefore required between the companies within the sector to develop the range of apprenticeships needed to collectively deliver the required skills needed by the sector as a whole. The vocational qualifications arising from these schemes must have common recognition, and hence be transferable. Co-ordination of this task should be undertaken by the Sector Skill Council or equivalent organisation.

9.31 Such courses must be promoted by individual companies, but collaboration is essential to achieve transferability. Promotion must be taken into schools as part of the campaign to promote generic science and engineering. That campaign must emphasise the value and worth of vocational training alongside academic education, and the potential for career development once in the sector.

Recommendation 11

Recommendation 11

MODERN APPRENTICESHIPS

The task group should promote the development of a range of Modern Apprenticeships that are recognised throughout the sector, including the health sub-sector, the qualifications from which are related to a common set of occupational standards to permit transferability.

Action: Nuclear Skills Task Group / Learning & Skills Council / SSDA

NUCLEAR AND RADIOLOGICAL MODULES IN FIRST DEGREES

9.32 The Nuclear Installations Inspectorate identified in their review of Nuclear Education[50] in the United Kingdom that no specialist first degrees in nuclear engineering or physical sciences are taught in the United Kingdom. This is not considered a detrimental situation, however, as generic education up to first degree level is more likely to produce transferable skills. Graduates today are less likely to seek 'careers for life' than in previous generations, hence transferable skills are likely to have greater attraction. At undergraduate level, the aim must be to provide transferable education and encourage learning pathways that do not foreclose entry to the nuclear and radiological skills sector.

9.33 One problem that does arise is that undergraduates are not exposed to nuclear and radiological subjects during their academic education; hence an opportunity is lost to make them aware of the options that exist of pursuing a career in those disciplines. Specialist modules ('student appetisers') are necessary, eg a nuclear engineering module in a mechanical engineering degree, a nuclear physics module in a general physics degree or a radiochemistry module in a chemistry degree. Only a limited number of universities have the capability of delivering such a module. Collaboration is therefore required between universities, and between universities and industry, to deliver such modules in universities without specialist skills.

Recommendation 13

Recommendation 13

MODULAR SPECIALIST HIGHER EDUCATION - INCLUSION IN ENGINEERING AND PHYSICAL SCIENCE DEGREES

The modularization of specialist higher education, and recognition of its equivalence with certain in-house training courses through the application of Occupational Standards for Engineering, should be encouraged. Such modules could build into a postgraduate certificate, diploma or Masters degree. The inclusion of such units in undergraduate engineering and physical science degrees, as 'tasters' for the sector, should also be encouraged.

This demand for such modules rests with employers, hence the initiative should be employer led. But alliances will be required between employers, to enable a broad basis for the modules, and with Higher Education Institutions for delivery of some of the modules. One envisaged model could be modules developed by a specialist lead university, working with employers, and franchised to other HEI's. Although the requirement must be employer led, a third party facilitator will be required to stimulate such action, a role which should be undertaken by the task group in the first instance.

Action: Nuclear Skills Task Group / Sector Employers / Educators in HE

[50] Nuclear Education in British Universities, Spring 2002.

ATTRACTION TO THE SECTOR

REMUNERATION, STIMULATION AND CAREER DEVELOPMENT

9.34 Many factors influence the attractiveness of a sector to employees, which can be categorised as 'pay and remuneration', 'state of the sector', and 'individual drivers'.

PAY AND REMUNERATION

9.35 The effect of pay was discussed in Section 8 (Para 8.7) and clearly all other issues being equal, in a competitive market, pay is likely to be a key arbiter in attracting people into the sector. A number of examples have been seen of qualified mathematicians and physicists being attracted to the financial and insurance sectors by high pay. In a market economy, such poaching will always occur. A hierarchy of issues exists; the financial and insurance sectors offer greater reward than industry and industry offers greater reward than education. The challenge is how to satisfy the demands of each stratum.

9.36 Roberts[51] presents a good analysis of this situation and makes a number of recommendations that are pertinent to the nuclear and radiological sector. These are targeted particularly at teachers and academic staff who are the most disadvantaged in terms of pay:

- **Teachers' Remuneration** (Recommendation 2.5). To resolve serious shortages in mathematics, science, Information Communication Technology (ICT) and Design and Technology (D&T) teachers, more must be done to address the pay and other incentives offered to teachers in these subjects.

- **PhD Stipends** (Recommendation 4.1). To recruit the best students to PhD courses, it is vital that PhD stipends keep pace with graduates' salary expectations.

- **Academic Fellowships** (Recommendation 5.1). The review believes that there should be a clearer path for those who have completed PhDs into academic lectureships.

- **Industry Secondments for Postdoctoral Researchers** (Recommendation 5.2). The Review recommends that HEFCE and the Research Councils evaluate schemes such as the Research Assistants' Industry Secondments run by the EPSRC as the basis for a wider mechanism for encouraging postdoctoral researchers into industrial careers.

- **A vision for Postdoctoral Researchers** (Recommendation 5.3). Postdoctoral researchers must be able to develop individual career paths reflecting different career destinations open to them (industrial, academic and research associate) and funding arrangements must reflect the development of these career paths.

- **Postdoctoral Researchers' Salaries** (Recommendation 5.4). Research Councils should significantly increase salaries – particularly starting salaries – for science and engineering postdoctoral researchers.

- **Academic Salaries** (Recommendation 5.5). There is a need for the Treasury and universities to improve salaries – particularly starting salaries – for many scientists and engineers.

9.37 Pay issues will not always revolve around the higher pay brackets, an obvious example being the sensitive subject of student debt. At age 18 young people are invited to invest a significant amount of money in their education, compounded by the fact that many engineering and physical science degrees are now four-year courses. Young people will only make that investment if they anticipate a commensurate return, either financially or by other factors. Measures to reassure young people that they will not be left in debt are needed to take full advantage of other drivers. Companies and organisations already take advantage of this motivator when recruiting newly qualified people, 'golden handshakes' being used to pay off student debt early in a person's career. Roberts[52] identified that there is little firm evidence to prove that student debt, per se, is having an impact, but there are concerns that the longer

[51] SET for Success: The supply of people with science, technology, engineering and mathematics skills: The report of Sir Gareth Roberts' Review. April 2002.

[52] SET for Success: The supply of people with science, technology, engineering and mathematics skills: The report of Sir Gareth Roberts' Review. April 2002. Paras 0.36 & 0.37. Recommendation 3.5: Undergraduate student funding, pg 105.

hours of study accompanied with laboratory work inhibits students' ability to undertake part-time work to supplement their grant. Roberts recommends that "Access Funds and Hardship Funds should adequately provide for students on courses involving a high number of contact hours". The review also recommends that "Government closely monitor the impact an additional year of student debt has on students' choices to ensure that it is not discouraging students from studying physical science and engineering."

STATE OF THE SECTOR – APPARENT INDECISION

9.38 The concept of a 'barometer' reflecting the four generic states that may befall the sector, or sub-sector, was also introduced in Section 8, namely: expansive; stable; contractile or indecisive, and the state of the sector has a significant influence on its attractiveness to potential recruits. The Foresight exercise emphasised that a strong dissuader from joining the sector is the apparent indecision about future programmes for the sector. In relation to the current state of the sector:

- The policy in relation to new build of power stations is embodied by the statement 'keep the option open', which is interpreted as indecision.
- Nuclear clean up is in a state of transition. The intention to form the Liabilities Management Authority has been announced, but no details of the new organisation are available and no contracts are being let for work. This is interpreted by people in the sector, and potential recruits to the sector, as indecision.
- There is continued debate about whether to dismantle nuclear power stations soon after closure or whether to place in a state of safe-store and defer dismantling for a period of decades. This is interpreted by people in the sector, and potential recruits to the sector, as indecision.
- The nuclear weapons programme is also subject to a policy of 'keep the option open'.
- The nuclear submarine programme has an assured future for several years, but no new design is contemplated, the future attack submarine project having recently been disbanded, which is interpreted as indecision.

9.39 On a wider scale, media reports associated with other engineering and physical science sectors portray a similar message of indecision:

- The Times[53] recently reported in the same article that the Prime Minister was to make an important speech emphasising the importance of science and technology but the Natural Environmental Research Council had cut grants resulting in the loss of scientific research jobs.
- Even though skills shortages exist in the offshore oil and gas industry, the media has recently reported that job losses are likely as a result of recent changes in the offshore fiscal regime.

9.40 The facts behind the latter examples are much more complex than the simplistic newspaper headlines indicate; however to a potential recruit the wrong message is transmitted.

[53] Times, Thursday 23 May 2002. "Research funding cuts threaten jobs of 50 scientists… As Tony Blair prepares to make a speech in support of British science today, the work of dozens of environmental researchers has been put in jeopardy by a £13.2 million hole in the budget of the National Environment Research Council."

INDIVIDUAL DRIVERS

9.41 The following issues, or drivers, have a very significant influence on individuals and can be the deciding factor for an individual on whether, or not, to join the sector:

- **Stimulation:** Scientists and engineers are stimulated by the challenge of advancing scientific understanding or harnessing scientific understanding to engineer a solution to a problem of benefit of society.
- **Personal Development:** People are attracted by the potential for personal development. This can be in many forms, including:
  - Promotion within an occupation;
  - Achievement of Chartered Status;
  - Ability to conduct research and publish results;
  - The potential for international travel and work; or
  - The prospect of moving between occupations, eg a skilled trades person achieving additional qualifications and moving into a professional engineering or management occupation.
- **Status and Respect:** People are attracted to occupations by the status associated with them. Science and engineering are often perceived as second class professions, which does not aid recruitment.
- **Mobility and Stability:** These factors can both be attractions into the industry and different at times in an individual's career. Early in a career, the prospect of variety may be attractive and the potential for expanding an individual's CV, whereas later in life when people may have started a family, the stability of long term employment in one geographic area may be attractive.
- **Value and Worth:** People are attracted to socially responsible occupations, such as nursing. Environmental improvement may be seen in this category.

COMMUNICATION AND LANGUAGE

9.42 Full advantage needs to be taken of such factors. This is already happening in some areas, with variable success, but more is needed. The foresight workshops invariably placed communication high in priority for urgent improvement and effective communication is needed to fully exploit the potential that exists. Examples of where improvements could be made include the language used to promote the sector. The language used in the sector is alien to many, even to scientifically literate people. This applies not only to the scientific units describing radiation and other physical phenomenon, but also the acronyms and shorthand used, eg Magnox, Mox and Thorp. The language does not portray any of the stimulation that exists in managing the issues arising from the technology. The media image of the sector is such that press releases are invariably defensive in nature, always seeking to explain how safe a situation is.

9.43 The downside of this is a 'dumbing down' of the challenges that exist, defensive briefs giving the impression of an industry that is un-dynamic, conservative and boring. The health sector reports that hospital soap operas such as 'Casualty', portraying a sector subject to many pressures associated with resources, pay, management and overwork, attract people into the sector, even though those recruits are more likely to nurse the elderly than work in a casualty ward! A means of more open communication is needed, which explains the challenges that exist within the sector, but does not pamper to press sensationalism. At a time when the media is fixated with failures and exposing those responsible for failure, the most concerning future scenario is that failures will occur because insufficient competent people exist to manage the technology. This communication needs to be targeted at a wide audience including young people, parents and qualified scientists and engineers in other sectors.

Recommendation 7

Recommendation 7

REMOVE ARTIFICIAL BARRIERS - LANGUAGE AND OPENNESS

The task group must promote, encourage and motivate members of the sector to use simple language when promoting the sector and avoid the unnecessary use of jargon or acronyms. Unnecessary confidentiality must also be avoided as this inhibits communication of the challenges that exist in the sector and fosters an environment of mistrust.

Action: Nuclear Skills Task Group / Sector Employers / Trainers & Educators

9.44 The significance of language and communication occurs at many levels:

- Between the sector and the media;
- Between the sector and the public;
- Between the sector and pressure groups;
- Between the sector and scientists and engineers in other sectors; and
- Between discrete disciplines within the sector.

INFLUENCE OF TRADES UNIONS

9.45 A further group of organisation that can exert influence in this area are the Trades Unions, many of whose members constitute the sector Workforce, and actions to promote the sector must engage fully with the appropriate organisations. A list of unions that have involvement with the sector is at Annex M

.

10 UNDERPINNING OF LEARNING PATHWAYS

SKILL DEVELOPMENT AND THE LEARNING PATHWAY

10.1 'Through Life Learning' and 'Continuing Professional Development' are key messages emphasised by educators and professional institutions, and the route by which any skill is developed is by means of the learning an individual acquires through undertaking education and training. In order to influence the provision of skills for the nuclear and radiological sector, it is necessary to understand the pathways by which individuals can acquire required skills. The holistic learning pathway open to everyone, summarised in the following diagram, is described in Annex C.

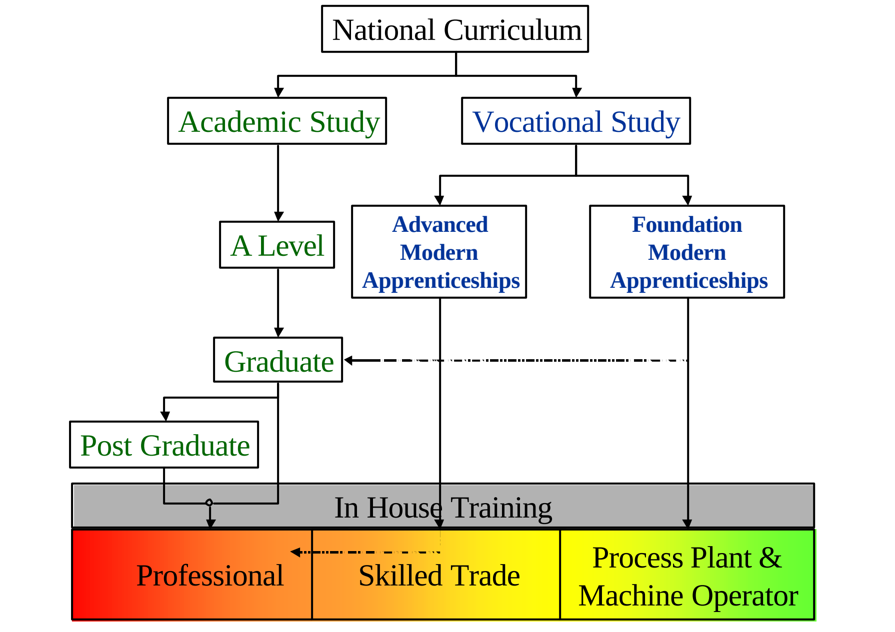

FIG 10.1: THE LEARNING PATHWAY

10.2 Reiterating the sector demand, the requirement is for people who are, or who will ultimately, be scientists, professional and associate professional engineers, people with skilled trades, process plant and machine operators, teachers and educators, and regulators.

10.3 The skill set of any person in the nuclear and radiological sector comprises two elements: a generic element, common to other science and engineering disciplines, and a unique element, particular to the nuclear and radiological sector. In attaining those skills, individuals will undertake a combination of training and education, two functions that are closely related, but which must be differentiated to foster clarity of aim in relation to skill development and the learning pathway:

- **Training:** is the development of skills to enable people to perform predictable tasks. Training courses tend to be vocational in nature.
- **Education:** is the development of an individual's fundamental understanding of a discipline to enable that person to determine how activities should be performed, define the limits of operation and, if circumstances require, operate outside predetermined limits. Education courses will tend to be academic in nature.

10.4 An individual's skill set can be plotted on a 'target diagram' (Fig 10.2), as described in Annex D. Use of this diagram enables: definition of an individual's current skill set; their skill set on entering the sector; the route by which they achieved their current skill set; their planned career development; or migration between sub-sectors.

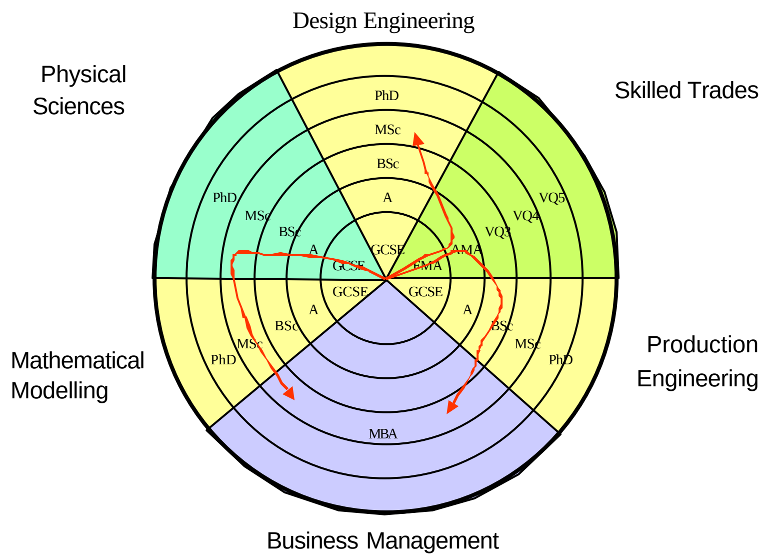

FIG 10.2 - PROFESSIONAL DEVELOPMENT TARGET DIAGRAM

10.5 Generic skills are shared with other sectors. Such skills will tend to lie towards the centre of the target diagram and collaboration with other skills initiatives is essential to develop these skills in order to enlarge the national source pool of scientists and engineers. The unique skills may be a broad raising of skills applicable to the sector, or development of a narrow specialist skill. These skills will tend to lie in the outer circles of the target diagram and it is the responsibility of the sector itself to promote and develop these skills.

10.6 This section of the report is concerned primarily with unique learning pathways, but notes that the points of entry to the sector are from generic learning. Consideration is therefore given, and recommendations made, about changes that could be made to the generic pathway to aid the nuclear and radiological skills sector.

10.7 Education is considered generic up to:

- Graduation with a first degree for people pursuing a pathway towards becoming a professional scientist or engineer; or
- Commencing an apprenticeship, for skilled trades or semi-skilled people.

GENERIC SKILLS

10.8 The skills of most interest to the nuclear and radiological sector are the specialist skills unique to that sector, but such skills are dependent on a robust foundation of generic education. Sir Gareth Roberts' recent review[54] provides a comprehensive assessment of the situation with respect to generic skills. Roberts' review, and the recommendations he makes, are fully supported, and this report aims to build upon that foundation, developing the assessment of the particular requirements of the nuclear and radiological sector.

10.9 The sector does, however, need to influence certain elements of generic education in order to provide the required foundation for nuclear and radiological skills. An appreciation of education in schools and the national curriculum is given at Annex F. At the generic level there are two issues, summarised as 'breadth and depth':

- **Breadth**: The need to improve 'science literacy' of people in general; and
- **Depth**: The need to provide a foundation in the early stages of education for those who will go on to specialist science education.

[54] SET for success: The supply of people with science, technology, engineering and mathematics skills. The report of Sir Gareth Roberts' Review. April 2002.

10.10 As Roberts observes, "Both insufficiently broad education and insufficiently deep education create problems for potential employers and individuals".

10.11 The foresight exercise also highlighted the need to improve communication skills as a high priority, which are to some degree dependent upon breadth and depth. Communication skills are required to promote the opportunities a scientific or engineering career can offer for young people and also to encourage public support for the difficult decisions that are required in relation to the application of nuclear and radiological technology. Also highlighted in the foresight exercise is the need to differentiate between logic and emotion, reason and imagination. This has long been recognised by the greatest scientists. When Einstein published his work on Relativity, he did so in two volumes; one being purely descriptive to impart the concepts to a wider public, the second containing the mathematical proofs of his theorems needed to enable peer review of his work and further development and application of his discovery.

10.12 The foundations of *breadth* and *depth* must be built within generic education:

- Breadth, to aid communication, targeting all young peoples' imagination and emotion.
- Depth, to establish a foundation for specialist scientific education for some young people, targeting reason and logic.

10.13 With regards to depth, it is recognised that physical sciences and mathematics are hard subjects but, as highlighted by practitioners in both the nuclear and medical sectors, "we have the ability to hurt people, we cannot allow our standards to fall".

KEY STAGE 3 & 4[55]

10.14 The broad education of science must begin early in the curriculum. Modern scientific advances such as GM food and the application of nuclear technology attracts much negative press, an issue recently referred to in a speech to the Royal Society by the Prime Minister[56], and a factor that communicates a poor image to young people. This situation emphasises *emotion and imagination*.

10.15 The introduction of concepts such as 'risk' and 'the effects of radiation' early in the curriculum could provide an important contribution to broad scientific education to improve 'scientific literacy'. The nuclear and radiological sector has a contribution to make in this area, possibly providing examples of the applications of technology to put the curriculum into context. The sector should encourage and support development of the curriculum in this direction.

Recommendation 8

Recommendation 8

INCLUSION OF NUCLEAR AND RADIOLOGICAL MATERIAL IN THE NATIONAL CURRICULUM

The task group should collaborate with the Nuffield Foundation in order to influence the 2005 review of the national curriculum. Material should be included that will aid the general improvement of scientific literacy, in particular nuclear and radiological technology, which is in general poorly understood. That material should be introduced in such a way that stimulates an interest in the subject that: can be understood in the context of society, seeks new ways of learning and avoids 'learning by rote'.

Action: Nuclear Skills Task Group / Nuffield Foundation

10.16 The Nuffield Foundation advises that changes are planned for the curriculum that will recognise the need to differentiate between scientific literacy ('science for citizenship') and the early stages of specialist science education (see Annex F). It is envisaged that such differentiation will occur at Key Stage 4. The aim of these changes is to achieve inclusiveness, while striving for excellence. Key Stage 4 therefore represents an important decision point for young people; hence the issue for the sector is promotion of science and

55 Key Stage 3 & 4 are important stages in the curriculum, Key Stage 3 being the first 3 years of secondary school, ages 11 to 14, and Key Stage 4 being the years of education leading up to GCSE, ages 15 and 16.

56 Times. Thursday May 23 2002.

technology to encourage options that do not foreclose a career in science and technology. Promotion of the sector is discussed in Section 9.

10.17 The education of people between the ages of 14 and 19 is the subject of a recent DfES green paper (see Annex E). Initiatives to improve the development of skills in the nuclear and radiological sector must take this paper and the subsequent white paper fully into account.

GCSE AND A LEVEL

10.18 At GCSE and A Level the learning issue of concern to the skills sector is that of the quality of science and mathematics courses, and hence the ability to deliver students of adequate ability to enter the sector as apprentices, or continue their education to degree level. Roberts identified this issue:

"Quality of SET A Level students as degree-level entrants (Roberts' Recommendation 3.1)[57]. Students sometimes struggle to make the transition from A Level to a degree in science, engineering and mathematics, as undergraduate courses often do not pick up where A Level courses ended. Adjustments should be made to bridge gaps between A Levels and degree level courses."

10.19 This recommendation is fully supported and the sector must monitor progress, contributing to the wider debate where appropriate.

UNDERGRADUATE

10.20 Undergraduate education is an important element of generic education, engineering and physical science graduates being in great demand for the sector. Concerns exist, however, that the quality of graduates, and their preparedness for employment, does not always match expectations. Roberts focused heavily on undergraduate education, observing that "a step change is needed in the skills of communication between employers and HEIs, greater business involvement in course development would give HEIs, businesses and students more confidence that students are acquiring the right skills."

10.21 This is reflected in:

"Undergraduate course structure (Roberts' Recommendation 3.2)[58]. Employers and HEIs must work more closely together, through increasing industry placements for academic staff, encouraging industrialists to spend time in universities, encouraging greater engagement between businesses and careers services and encouraging universities to be more innovative in course design. These actions by HEIs and employers must be supported by those bodies that accredit science and engineering courses."

10.22 A similar theme was explored in a recent EPSRC workshop, 'New Applications of Nuclear Physics'[59], which considered, amongst other issues, how industry and academia could work together to train the next generation of people. The workshop concluded:

- Graduates today are less likely to seek 'careers for life' than in previous generations, hence transferable skills are likely to have greater attraction. At undergraduate level, education is still generic, hence the aim must be to provide transferable education, encourage learning pathways that do not foreclose entry to the nuclear and radiological skills sector and provide 'appetisers' to make students aware of opportunities in the sector.

[57] SET for success – page 93.

[58] SET for success – page 98.

[59] New Applications of Nuclear Physics: Opportunities in biology, medicine, environmental and analytical sciences, materials, power and energy technology, process engineering and other areas. 13 / 14 May 2002.

- Collaboration is required to:
  - Balance individual course content to more fully meet the needs of industry, while maintaining the academic content needed to retain the academic status of the degree.
  - Balance the range of courses on offer between academic and vocational disciplines.
  - Provide modules on nuclear and radiological subjects in more general science and engineering degrees as ‘appetisers’ to promote entry to the nuclear and radiological sector.
- Industry increasingly makes calls for the content of undergraduate courses to reflect the needs of industry, eg in the scope of skills developed or the style of report writing. Course content is accredited by Professional Institutions, eg in the case of physics by the Institute of Physics, influenced by the Standing Conference of Physics Professors. Collaboration is needed between academia, industry and the accrediting organisations to achieve this balance. Some vehicles already exist to accomplish this, but best practice needs to be established and applied nation-wide. A balance must be struck between education and training as a move to simply satisfy industry’s needs may result in undergraduate courses becoming training courses or vocational degrees, with a consequent detriment to the sector.
- An important place exists for vocational degrees, many scientists and engineers currently in the sector having entered from the polytechnic route; again a national balance between academically biased and vocationally biased courses is required.
- Specialist undergraduate degrees in subjects such as nuclear engineering are not necessary, but specialist modules (‘student appetisers’) are necessary, eg a nuclear engineering module in a mechanical engineering degree, a nuclear physics module in a general physics degree or a radiochemistry module in a chemistry degree. This will require collaboration between universities, and between universities and industry, as it may be necessary for universities that conduct nuclear research, or companies engaged in the sector, to deliver such modules in universities without such specialist skills.

10.23 The requirement to review Britain’s engineering education system, and implement change that reflects national needs, has been highlighted by Professor Chris Wise, interviewed by ‘The Professional Engineer’[60]. Wise argued that the current system produces graduate engineers with little practical experience or understanding of project-based team working. Wise stated:

“There could be three types of degree. The first could be an engineering/vocational degree, splitting academic and industry-based work equally, to give broad based learning. Alternatively there could be an engineering science degree for people with research aims. Thirdly, engineering could be taught more like a discipline, like Latin is, for those more interested in it as an intellectual science.”

<u>Recommendation 15</u>

Recommendation 15

COLLABORATIVE DEVELOPMENT OF HIGHER EDUCATION COURSES

The task group should collaborate with all relevant SSCs and other workforce development organisations in other sectors to establish a means of developing higher education syllabi that balance employer (vocational) and academic requirements.

Action: Nuclear Skills Task Group / SSCs / Workforce Development Organisations

[60] “Could do better”, The Professional Engineer, 27 March 2002, Volume 15, No 6.

UNIQUE SKILLS

MODERN APPRENTICESHIPS

10.24 The skills audit identified that many people in the sector today initially developed their skills through time served apprenticeships, going on to further or higher education to enable career development. Such schemes were a feature of large industrial organisations until the major industrial re-organisations of the 1980s. By example, in the late 1970s, each of the four Royal Dockyards took on approximately 200 apprentices each year, resulting in an apprentice population of approximately 750 per dockyard. This population supplied the demand for craft skills, technicians, and draftsmen. People were also selected from that population to undertake additional training and education to become the professional engineers and the senior managers that operated the dockyards, and from this pool were also drawn those who became the skilled population to conduct the naval nuclear programme. A surplus of people was also trained who migrated into the supply chain for the dockyards. The large nationalised industries operated similar schemes; hence a pleantiful supply of skills existed.

10.25 In the last 20 years many of the large apprentice training schemes have closed as industry sought to reduce overheads and companies lived off the accumulated stock of skills available. As industries contracted, the need for new skilled staff was minimal. However as that skilled population now approaches retirement, a shortage of skills is starting to occur. This picture is common to much heavy industry and a national shortage is appearing in craft and associate professional occupations. This same picture is being seen internationally, the US nuclear industry reporting that the shortage of skilled trades is more significant than the shortage of professional engineers.

10.26 Apprenticeships have become undervalued and unpopular, and it is probable that many of the people that account for the increase in applications for higher education (Annex B) would have undertaken apprenticeships in previous generations.

10.27 This situation has been recognised by Government and a scheme entitled Modern Apprenticeships introduced, jointly sponsored by DTI and DfES. The scheme, described at Annex G, has been in place since 1994, but has not achieved the success anticipated. A campaign to reinforce the scheme was therefore launched in November 2001, which committed Government, working with the Learning and Skills Council, to deliver key recommendations made by the Modern Apprenticeship Advisory Committee including:

- a national framework for apprenticeship which defines basic standards and strengthens the relationship between the employer and apprentice;
- an entitlement to a Modern Apprenticeship place for all 16 and 17 year olds with five or more GCSE passes at grades A* to G, from September 2004; and
- a £16 million marketing campaign, over three years, beginning early in 2002, to promote apprenticeships and boost take-up among employers and young people.

10.28 The Government wants more than a quarter of young people to enter Modern Apprenticeships before they are 22 years old by 2004 and has called on employers to help achieve this target. The nuclear and radiological skills sector must support this initiative.

10.29 There are examples of good practice in the sector, eg BNFL support robust apprentice programmes based at Sellafield and Springfield. British Energy also recruit 50 apprentices each year. BNFL report that they are able to recruit apprentices from schools, but have difficulty in retaining certain skills, in particular skills that are in demand nationally such as control and instrumentation.

10.30 Steedman[61], quoting Becker (1964) reported that:

"when employers pay for training, they can only be sure of capturing the return to investment in skills specific to their own business. If employers pay for general transferable skills then, in a free labour market, the employee can take their skills to another employer. So whereas it might at first be concluded that, as with every other commodity, if employers want skills they

[61] Employers, Employment and the Labour Market; Hilary Steedman; Centre for Economic Performance, LSE; in Papers arising from a seminar addressing 14-19 Education, Jan 2002.

will pay to produce them, that is train and, conversely, if they do not train they do not want skills, it is not as simple as that… The market failure described here is the result of reluctance of employers to invest in training for fear of losing their investment to other employers (poaching)."

10.31 An alternative scenario experienced in both the electricity generation and oil & gas sectors, also associated with transferability of skills, came about due to liberalisation of the market and restructuring. Apprentice training was well established, but qualifications were recognised by the sponsoring company only; hence with mergers and reorganisations, skilled people found themselves working for different companies where their qualifications were not recognised. The Electricity Training Organisation approached this by seeking a common Advanced Modern Apprenticeship for power generation, recognised by all power generators. Similarly, the offshore industry approached this by means of 'skills passports', again seeking to achieve transferability of skills.

10.32 Apprenticeships have traditionally sought recruitment from regions local to the Sponsor Company, as opposed to higher education where students have often sought to study in places remote from their parental home. This distinction is artificial and there are no reasons why apprentices should not be encouraged to study remote from their parental home, which must be reflected in recruitment strategies.

Recommendation 11

Recommendation 11

MODERN APPRENTICESHIPS

The task group should promote the development of a range of Modern Apprenticeships that are recognised throughout the sector, including the health sub-sector, the qualifications from which are related to a common set of occupational standards to permit transferability.

Action: Nuclear Skills Task Group / Learning & Skills Council / SSDA

POSTGRADUATE TRAINING

10.33 Postgraduate training and education is of fundamental importance to the nuclear and radiological sector as this is the vehicle by which the unique skills required by professional scientists and engineers are developed.

10.34 Although termed 'education', such courses are often applied training, to provide the 'nuclear δ to enhance a person's generic education to make them competent to work in the nuclear and radiological sector. Postgraduate training includes both Higher Education Institute (HEI) courses and in-house training provided by industry. Postgraduate courses include postgraduate certificates, postgraduate diplomas and Masters degrees and, when considered in conjunction with in-house training, the duration of courses ranges from a few days to an MSc typically of 12 months duration.

10.35 A key message from companies in the sector is that their demand is for competent graduates and that the 'nuclear δ can be developed by in-house training. This said, it is important to consider the role of HEI courses and their relationship with in-house training.

10.36 A number of companies run graduate training schemes, and these examples of good practice are fully supported and encouraged.

10.37 Evidence suggests that this sector of HEI education is in a weak state. The Nuclear Installations Inspectorate (NII) conducted a survey in 2000, repeated in 2002, of nuclear education in the United Kingdom. The latter report focused heavily on this area and identified:

"Whilst, overall, the extent of nuclear teaching has been about maintained since the last report (2000 to 2002) this is unlikely to continue for much longer. Already the level of nuclear teaching is very low at many of the twenty-two[62] universities and it is likely to disappear at seven of them in the next few years, principally because of staff retirements."

10.38 Postgraduate education in HEIs suffers from a number of problems:

- **Value**. Students do not value postgraduate education. Unless sponsored to undertake a course, students must incur personal expense and lose earning power for the duration of the course, but perceive no additional career advancement on completion. Unlike MBAs, technical postgraduate education is not seen as a way of enhancing career development.
- **Length of Courses**. It is difficult to release staff in full time employment for training for periods of a few months to a year.
- **Applicability**. University courses compete with in-house education; in-house training having the advantage that course content can be targeted directly at a company's requirements.

10.39 The positive aspects of HEI delivered postgraduate education are:

- **Transferability**. HEI courses have national recognition; hence the qualifications awarded are transferable.
- **Economy of Scale**. The potential exists for economy of scale by encouraging collaboration to develop courses satisfying the needs of several users. But collaboration has associated problems, some degree of compromise invariably being required, which can test a client's support for a given scheme.

10.40 A factor that influences certain elements of the sector is that of legislation. In the medical sub-sector, Masters degrees are a legal measure of competency; hence the NHS sponsors, runs and funds appropriate courses. In the MoD, Masters qualifications have traditionally being considered the measure of competency for its advanced engineers. MoD therefore also sponsors, runs and funds appropriate courses. However recent reorganisations in the MoD have caused the value of such qualifications to be questioned. Looking to the continent, Belgium's legislation requires nuclear engineers to be qualified to Masters level in order to practise. Legislation therefore has a significant effect on postgraduate education; legislation would assure its future as the cost of sustaining it would have to be found but, without legislation and leaving the market to find its own level, its value and sustainability are questionable.

10.41 One form of requirement of significance to postgraduate education and training is that of Chartered Engineer (CEng) status. Over recent decades the qualifying education requirement for CEng has risen: in the 1950s HND was the requirement, in the 1960s and 1970s a degree and in the 1980s certain institutions demanded at least a second-class Honours degree. Qualifying requirements have been reviewed in recent years by the 'Standards and Routes to Registration' review of the Engineering Council, or SARTOR. From 1st September 1999 the qualifying requirement became MEng or its equivalent. The full implications of this change are yet to be realised but, without appropriate qualifications in nuclear and radiological disciplines, engineers will be unable to attain Chartered status by study in this field and engineers seeking chartered status will be forced to seek qualifications in other disciplines.

10.42 The market for postgraduate education must be clarified; differentiating between those courses demanded by legislation or demonstration of competence, and those courses providing applied training and education to satisfy sector demand.

10.43 The requirement for the former category is more clearly defined but, in relation to applied training and education, the situation is more complex. Collaboration is needed between client organisations in the sector to establish what training is required and how this can best be packaged. Traditional stand alone Masters degrees do not appear to be the best vehicle to deliver this service. The key features of future arrangements must be:

- Applicability to the sector;

---

[62] The survey assessed the number of university departments offering nuclear education. In 2002 this number was assessed at 22. No judgement was made in the report of what constituted an acceptable number.

- Transferability within the sector;
- Value to the sector organisations and individual students;
- Acceptance as the qualifying requirement for Chartered Engineer status.

10.44 Delivery of the service must combine best practice from HEIs and in-house training. An arrangement could be envisaged whereby HEI and in-house training organisations adopt a common standard of qualification; vocational standards seeming the most appropriate standards reflecting the applied nature of the training. Such equivalence would permit accrual of credits from certificates, diplomas and in-house training contributing towards a higher qualification. Such schemes could also be adaptable to remote learning. This would also allow credits to be accrued in training periods acceptable to industry. Such initiatives already exist and best practice needs to be identified and encouraged.

10.45 The value of such education and training to individuals must be emphasised by user organisations, or the incentive will not exist for students to enrol on such courses.

10.46 The provision of qualified trainers and educators to deliver such training is a further important issue; who trains the trainers? NII identified[63] that "seven courses are likely to disappear in the next few years, principally because of staff retirements." Co-operation will be key to achieving the most from available trainers and educators. The provision of postgraduate education must not compartmentalised by creating artificial distinctions between academic education or applied in house training and educators and trainers must be drawn from undergraduate, doctoral and in-house schemes alike and deployed as appropriate, commensurate with their ability.

10.47 Collaboration is a key word in this debate and a vehicle is needed to encourage that collaboration. Some groups exist to bring industry and academia together, such as the Nuclear / Academic Industry Liaison group (NAILs), but more can be done. Stimulation of collaboration must be a requirement of a Sector Skills Council or similar organisation. A by-product of such collaboration must be to provide assurance of funding for those courses valued by the industry to enable emphasis on training rather than fund raising by those delivering the service.

Recommendation 13

Recommendation 13

MODULAR SPECIALIST HIGHER EDUCATION - INCLUSION IN ENGINEERING AND PHYSICAL SCIENCE DEGREES

The modularization of specialist higher education, and recognition of its equivalence with certain in-house training courses through the application of Occupational Standards for Engineering, should be encouraged. Such modules could build into a postgraduate certificate, diploma or Masters degree. The inclusion of such units in undergraduate engineering and physical science degrees, as 'tasters' for the sector, should also be encouraged.

This demand for such modules rests with employers, hence the initiative should be employer led. But alliances will be required between employers, to enable a broad basis for the modules, and with Higher Education Institutions for delivery of some of the modules. One envisaged model could be modules developed by a specialist lead university, working with employers, and franchised to other HEI's. Although the requirement must be employer led, a third party facilitator will be required to stimulate such action, a role which should be undertaken by the task group in the first instance.

Action: Nuclear Skills Task Group / Sector Employers / Educators in HE

[63] Nuclear Education in British Universities, NII, April 2002.

Doctoral and Postdoctoral Research

10.48 Doctoral and postdoctoral research provides a number of important functions:

- The advancement of scientific and technical understanding.
- The education of skilled people who can advance the understanding of scientific and technical issues.
- The education of skilled people who can consider responses to unforeseen effects on plants and sites.

10.49 Such research may be subject to differing pressures, with potentially conflicting demands:

- HEFCE assess the quality of research by means of a Research Assessment Exercise (RAE) to determine the research funding they allocate to departments.
- Research Council funding is granted for individual research projects.
- Industry may sponsor research, seeking applied research relating to its industrial needs or the development of skills it needs for its operations.
- In the case of the health sector, charities may also sponsor particular research.

10.50 To achieve the most from available funding, a balance must be struck between the requirements of industry, charities, research councils, the assessment of research excellence (RAE), and demands placed by possible funding from other government departments. Without such a balance, universities can be subject to conflicting demands. Partnering and collaboration between RAE assessors and other sponsors is needed to minimise the conflict of pressures on university departments, and enable them to focus effort on research and education rather than balancing the pressures of funding demands and of conflicting performance criteria.

Recommendation 15

Recommendation 15

Collaborative development of Higher Education Courses

The task group should collaborate with all relevant SSCs and other workforce development organisations in other sectors to establish a means of developing higher education syllabi that balance employer (vocational) and academic requirements.

Action: Nuclear Skills Task Group / SSCs / Workforce Development Organisations

10.51 The above concentrates on the viability of research, but an issue that must not be forgotten is the provision of laboratories needed for education and research. As highlighted by NII[64], many of the facilities in British universities are of 1960s vintage and are in need of refurbishment, but modern facilities are also essential to attract the best students and encourage the best research. The need for appropriate facilities is fundamental to the viability of learning pathways and one recent example of good practice is the refurbishment of Manchester University's radiochemistry facility, sponsored largely by BNFL. This action is strongly commended, but reliance must not be placed on one company for such support and collaboration is needed to provide more diverse arrangements for underpinning future facilities that may be required. The funding of such facilities is discussed further in Section 11.

INDUSTRY SUPPORT

10.52 Collaboration between industry and academia must be encouraged, and particular mention must be made of the alliance between BNFL and a number of universities, in particular

[64] Nuclear Education in British Universities, NII, April 2002.

Manchester, Leeds and Sheffield. This is clearly good practice, but consideration needs to be given to how such relationships may develop over future years.

10.53 The initiative stimulates research into subjects pertinent to the sector at particular universities, which may develop into centres of excellence. Such focus of effort is advantageous, but diversity must not be discarded, and satellites of the centres of excellence are also required. Such satellites are needed for a number of reasons, including:

- The stimulus of peer review needed to underpin academic development and safety review.
- The delivery of 'taster' modules to a wider audience of students to promote the fields of study and encourage graduates into the required disciplines.

10.54 BNFL is currently the strongest single organisation in the sector, representing over 15% of the skilled population. While BNFL commendably uses that strength to very good effect, diversity is needed to:

- Protect against possible future pressures on BNFL that may weaken their resolve to support education. Diversity and redundancy are built into any safety system to achieve the desired integrity; this must also be the case with skill development.
- To ensure that the needs of the supply chain are met, as well as the needs of organisations at the top of the supply chain.
- To take advantage of all sources of support in industry, academia and Government.

Recommendation 2

Recommendation 2

ENCOURAGE CONCERTED EMPLOYER SUPPORT OF SECTOR SKILL DEVELOPMENT

Commitment is required from all sector employers to provide concerted support for promotion of the sector and the education, training and research needed to ensure that skill development in the sector will satisfy the future needs of all employers: large companies, SMEs and Government.

Action: Nuclear Skills Task Group / Sector Employers

NATIONAL OCCUPATIONAL STANDARDS

10.55 The above learning pathways are focused upon academic qualifications, which are not necessarily related to the competencies required to perform an occupation effectively and safely within the sector. Occupational standards represent an alternative approach to competency, endeavouring to establish standards that directly reflect the requirements to perform an occupation or job. The standards can be used to define the training requirements to tutor a person who is to perform an occupation or define assessments of their achievement.

10.56 The Occupational Standards Council for Engineering has performed much good work in defining occupational standards and these are available as tools to facilitate collaboration at many levels of skills development, eg:

- National Vocational Qualification
- Modern Apprenticeship
- Undergraduate education
- Postgraduate training

10.57 Similar work is also being carried out in the Health Sector seeking to establish National Occupational Standards in Healthcare Science. More information on the organisations that facilitate national occupational standards is given at Annex P.

Recommendation 12

Recommendation 12

NATIONAL OCCUPATIONAL STANDARDS

The task group must promote and encourage the development and use of National Occupational Standards that are recognised across the sector and the work of organisations such as the Occupational Skills Council for Engineering and National Occupational Standards in Healthcare Science must continue to be supported.

Action: Nuclear Skills Task Group / Sector Employers / Trainers & Educators

COMMENSURATE SKILLS FOR A TASK

10.58 It is important to differentiate between competence and qualifications. Employers must ensure that their employees are competent to perform tasks allotted them, particularly when employed on a function having safety implications. This gives rise to the issue of how to measure competence, which invariably results in some form of examination or assessment against which an auditable qualification can be obtained. However, reliance on qualifications has a tendency to result in 'qualification inflation', a number of examples of which have been seen, eg the competence required for Chartered Engineer status, which over the past 40 years has grown from HND to Masters degree. Similarly in the health sector, the qualifications required to perform certain radiological functions have increased over recent decades. The health sector has addressed this by consideration of a 'skills escalator' whereby people are encouraged to undertake additional training to progress up the escalator, while tasks are delegated down the escalator where it is appropriate to do so. There may be scope for such practice to be applied elsewhere in the sector and the use of national occupational standards has a key role to play here. Close collaboration with Trades Unions is also required, to ensure that any changes made are to the benefit of both employees and employers.

11 VIABILITY OF EDUCATION INSTITUTIONS

BACKGROUND

11.1 To understand the factors affecting the viability of the education institutions needed to provide the skills required by the nuclear and radiological sector, it is necessary to consider:

- The institutions that provide the required education, training and research.
- The distinction between education, training and research.
- The learning pathways that unite these institutions.
- The factors determining viability.
- The sources of funding for those institutions.

EDUCATION INSTITUTES

11.1 Development of skills for the nuclear and radiological sector is dependent upon the following institutions:

- Schools
- Further Education Colleges - delivering:
  - Ordinary National Certificates;
  - Higher National Certificates;
  - National Vocational Qualifications; and
  - Undergraduate education.
- Higher Education Institutions (principally universities) - delivering:
  - Undergraduate education;
  - Postgraduate education;
  - Doctoral qualifications and research; and
  - Postdoctoral research.
- In House training and research

TRAINING, EDUCATION AND RESEARCH

11.1 The above organisations deliver training, education and research, three functions that are closely related, but which must be differentiated to foster clarity of aim in relation to skill development, and hence the importance of their viability.

- **Training:** is the development of skills to enable people to perform predictable tasks. Training courses tend to be vocational in nature.
- **Education:** is the development of an individual's fundamental understanding of a discipline to enable that person determine how activities should be performed, define the limits of operation and, if circumstances require, operate outside predetermined limits. Education courses will tend to be academic in nature.
- **Research:** is the advancement of understanding.

11.1 Skill development activities may target one or a combination of the above. The definitions are self evident, but it is important to have a common understanding of the aim of a particular skill development activity. For instance, a research activity may be undertaken for the knowledge obtained itself (pure research), or to develop the research skills that may be needed in response to an unpredicted situation on a plant or site (educational research).

LEARNING PATHWAY

11.2 To understand the relationship between these institutions, the 'learning pathway' described in Annex C should again be visualised.

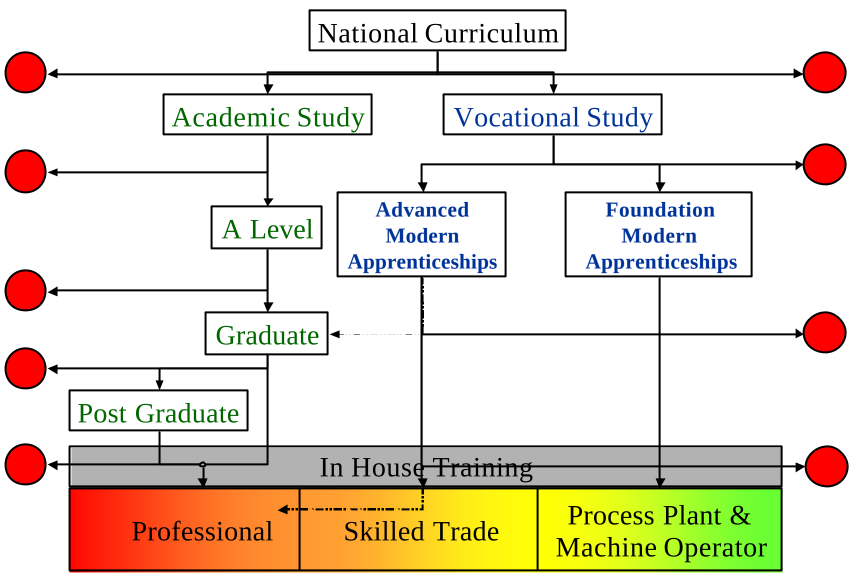

FIG 11.1: THE LEARNING PATHWAY

FACTORS AFFECTING VIABILITY

11.3 The viability of courses is dependent upon four factors:

- Sector demand for the course;
- The attraction of students;
- Funding for facilities and staff; and
- Provision of teaching staff.

FUNDING ARRANGEMENTS

11.1 A complex range of sources of funding exist to sustain education, training and research, including:

- The four Higher Education Funding Councils for England, Northern Ireland, Scotland and Wales.
- The Research Councils, in particular the Engineering and Physical Science Research Council and the Medical Research Council.
- Ministry of Defence
- The National Health Service
- Tuition Fees
- Industry and Business
- Charities

11.1 The arrangements for the funding of higher education in England are described in "Funding higher education in England - How the HEFCE allocates its funds", a synopsis of which is given at Annex N. Similar arrangements exist in Scotland, Wales and Northern Ireland.

SCHOOLS

11.2 The provision of schools is the responsibility of local education authorities and central Government, hence no input from the sector is required to ensure the viability of such institutions.

FURTHER EDUCATION COLLEGES

11.3 Further education colleges (FECs) play an important, if undervalued, role in providing the academic content of vocational training in support of Modern Apprenticeships. The viability of such colleges is dependent upon:

- Demand for the services they provide, in particular in relation to Modern Apprenticeships.
- Learning and Skills Council Funding.
- HEFCE funding (for Higher Education qualifications).

- Industry funding.
- The availability of teaching staff.

11.1 In relation to Modern Apprenticeships, delivery of such training is by definition a partnership between the company sponsoring the apprenticeship and the college delivering the academic element of the course. The Learning and Skills Council is a third partner in this relationship, funding further education.

11.2 Collaboration is a key word in this debate and a vehicle is needed to encourage that collaboration.

HIGHER EDUCATION INSTITUTIONS

11.3 Higher Education Institutes provide a combination of education and research at undergraduate, postgraduate, doctoral and postdoctoral level. Each HEI department delivering such a range of activities obtains funding from a variety of sources, dependent upon the type of service provided.

UNDERGRADUATE EDUCATION

11.4 HEI's provide generic education in engineering and physical sciences needed as basic qualifications for professional persons entering the sector.

11.5 The funding of undergraduate education is by means of higher education funding council[65] grant and tuition fees, the grant being the largest source of income for teaching, with tuition fees representing about a quarter of the average cost of tuition. Grants are based upon the number of Home and EU students on higher education courses, not funded from other public sources. Grants are weighted, recognising that subjects needing laboratories and workshops are more expensive than subjects wholly taught in lecture theatres.

11.6 The weighting factors are:

Group	Description	Weighting
A	The clinical stages of medicine, dentistry and veterinary courses	4.5
B	Laboratory-based subjects (science, engineering and technology)	2
C	Subjects with a studio, laboratory or fieldwork element	1.5
D	All other subjects	1

11.7 HEI departments tend not to receive support from other sources for undergraduate education, hence the only variable is number of students.

11.8 The viability of HEIs to deliver undergraduate education is of significant concern to the sector as these institutions provide the generic education that is the foundation of professional scientific and engineering skills. There have been several recent press reports about the viability of engineering and physical science departments. Senior management of such departments report that they are not public sector providers of education, but businesses that must compete with other departments, in other HEIs and in other disciplines for survival. Evidence suggests that they are not being successful in this challenge, the UCAS data at Annex B showing a worrying trend, and the number of Physics departments has fallen from 74 to 53 since 1994.

11.9 HEI departments are required to remain financially viable as a discrete organisation, interchange of funds between departments not being encouraged. Funding of undergraduate education is therefore dependent on funding council grant and tuition fees, both dictated by the number of students, enhanced by the weighting factor for the overheads associated with laboratories etc. required for teaching science and technology subjects.

11.10 Long-term viability of undergraduate education is also dependent upon lecturing staff and senior academics to head those departments. This issue will be discussed more fully under doctoral and postdoctoral research.

11.11 Three options exist to reverse this decline due to funding:

[65] Higher Education Funding Council for England, Scottish Higher Education Funding Council, Higher Education Funding Council for Wales and the Higher Education Funding Council for Northern Ireland.

- Encourage more students to study engineering and physical sciences.
- Seek an increase in the weighting factor for laboratory based subjects.
- Investigate alternative funding to support HEIs.

Student Numbers

11.1 The encouragement of students into engineering and physical sciences has been discussed in Section 9.

Weighting Factor

11.2 Attempts have been made to seek an increase in weighting factor by professional institutions, eg by the Institute of Physics, but without success. The consequence of weighting factor must continue to be monitored by the sector. If evidence can be provided demonstrating that weighting factors are contributing to the decline in skills development to an unacceptable degree, Government should be lobbied to increase the factor. The task group, Sector Skills Council, or equivalent organisation, should perform that lobbying as these should have more influence than discrete companies or professional institutes.

Alternative Support

11.3 Alternative support could be encouraged from the sector in the form of sponsorship provided to HEI departments, targeting undergraduate, postgraduate and doctoral education, at departmental and individual student level. Such sponsorship may be viable for larger companies, but will not be within the scope of smaller companies in the sector. Collaborative action may enable such support to be provided. One aim of the task group, Sector Skills Council, or similar organisation, should be to consider the viability of undergraduate education. This should address the means of providing joint support, in conjunction with other sectors, to support the generic education needed to underpin the nuclear and radiological, and other, sectors.

11.4 This issue was discussed by Roberts[66] who identified that:

"The cost of equipment and SET teaching staff has increased (and is still growing) relative to other subjects… These costs are greater than allowed for in the current funding to maintain the quality of their laboratories and to maintain good teaching staff."

11.5 Roberts goes on to recommend (Roberts' Recommendation 3.4) that:

"HEFCE should formally review, and revise appropriately, the subject teaching premia for science and engineering subjects. The revisions should ensure that the funding of undergraduate study accurately reflects the costs – including paying the market rate for staff, as well as capital costs – involved in teaching science and engineering subjects."

[66] SET for Success – April 2002, Para 3.61 – 3.66.

Recommendation 14

Recommendation 14

INCREASE FUNDING PER ENGINEERING AND PHYSICAL SCIENCE UNDERGRADUATE

The task group should collaborate with other SSCs to review the subject teaching premia for science and engineering subjects. If evidence exists that under funding is resulting in the unnecessary closure of faculties, skills organisations should jointly lobby for increased funding.

Action: Nuclear Skills Task Group / DfES Higher Education Group / HE Funding Councils

POSTGRADUATE EDUCATION

11.6 The pros and cons of Postgraduate education and training were described in Section 10, identifying that:

- This is one of the means by which students can attain unique nuclear skills.
- Courses can be applied training and may be in competition with in-house training. In some instances, postgraduate qualifications are the legal or professional competence standard required of practitioners in the sector.
- It offers benefits to students and employers, principally transferability of the qualifications and economy of scale, but also suffers from a number of problems, including: value to students and employers (eg by comparison to an MBA), the length of courses and their applicability to employers needs.
- Postgraduate education is in a weak state. Its aim and purpose must be clarified and, if it is considered essential to the sector, a means of sustaining and exploiting it must be established.

11.1 A variety of means exist to fund Postgraduate education, the three main sources being research council grants, employers or individual student funding.

- The research councils provide 'start-up' grants with the intent that courses be self-sustaining after five years. Postgraduate education does not normally attract sustained state funding in the same manner as undergraduate education and mature courses are expected to be self-sustaining, funded either by individuals or sponsored by industry.
- Some employers fund postgraduate education, but expect a return on their investment and also expect the education received to be targeted at their business aims. The NHS and MoD, as Government employers, fund their own Postgraduate education.
- Other courses are dependent upon attracting sufficient individuals for sustainability; such courses are therefore dependent upon the value individuals and employers places upon them.

11.1 Funding is clearly fragmented and collaboration is needed to make the most of the available backing. A vehicle is needed to encourage that collaboration. The NAILS group has been described, but more is needed, and stimulation of collaboration must be a function of the skills task group. A by-product of that collaboration must be the assurance of funding for those courses valued by the industry, to enable emphasis on training rather than fund raising by those delivering the service. Funding could be accrued from a number of sources, including those that benefit from it (eg client organisation in Government and industry), support organisations (in business, industry, education, research and regulation) and individuals.

Recommendation 13

Recommendation 13

MODULAR SPECIALIST HIGHER EDUCATION - INCLUSION IN ENGINEERING AND PHYSICAL SCIENCE DEGREES

The modularization of specialist higher education, and recognition of its equivalence with certain in-house training courses through the application of Occupational Standards for Engineering, should be encouraged. Such modules could build into a postgraduate certificate, diploma or Masters degree. The inclusion of such units in undergraduate engineering and physical science degrees, as 'tasters' for the sector, should also be encouraged.

This demand for such modules rests with employers, hence the initiative should be employer led. But alliances will be required between employers, to enable a broad basis for the modules, and with Higher Education Institutions for delivery of some of the modules. One envisaged model could be modules developed by a specialist lead university, working with employers, and franchised to other HEI's. Although the requirement must be employer led, a third party facilitator will be required to stimulate such action, a role which should be undertaken by the task group in the first instance.

Action: Nuclear Skills Task Group / Sector Employers / Educators in HE

DOCTORAL AND POSTDOCTORAL RESEARCH

11.2 HEI research provides a number of important functions:

- The advancement of scientific and technical understanding.
- The education of skilled people who can advance the understanding of scientific and technical issues.
- The education of skilled people who can consider responses to unforeseen effects on plants and sites.

11.1 As described in Annex N, research attracts funding from a number of sources:

- Higher education funding council grants for infrastructure [salaries, premises, libraries, central computing etc].
- Research council funding for direct project costs.
- Industry sponsorship.
- Charities (especially in the case of the health sector).

11.1 The higher education funding councils consider two types of research: quality related research and generic research. Generic research was introduced in response to the 1993 Science and Technology White Paper 'Realising our Potential', recognising the need for collaborative research that does not have a single beneficiary. The nuclear and radiological sector is concerned primarily with quality related research. The funding of quality related research is based on quality, relative costs and volume; quality being assessed by means of a Research Assessment Exercise (RAE) and a weighting factor applied taking into account the relative costs of research and overheads.

11.2 RAE assessments are conducted at approximately 5 yearly intervals and dictate funding for the following 5 years. In the 2001 RAE, institutions were awarded a rating of 1 to 5* (five star) for the quality of their research. Funding multipliers, listed in the following table, were applied based on the RAE rating. Ratings 1 and 2 attract no research funding, while a rating of 5* attracts approximately four times as much funding as a rating of 3b for the same volume of research activity. As a result of the HEFCE funding model, research is highly selective. In 2001-02, 75 per cent of HEFCE research funds went to 25 higher education institutions.

2001 RAE rating	Funding weights in QR model
1	0
2	0
3b	1
3a	1.5
4	2.25
5	3.375
5*	4.05

11.3 Industry sponsorship of an HEI will invariably be against different criteria, a business sponsor being concerned with applied research relating to its industrial needs. Such applied research may not score highly on a RAE assessment. A company may also seek to use HEI research to develop the skills that the company needs to be applied on a site, the research being a vehicle for skill development.

11.4 To achieve the most from available funding, a balance must be struck between the requirements of industry, charities, research councils, the assessment of research excellence (RAE), and demands placed by possible funding from other government departments. Without such a balance, universities can be subject to conflicting demands. Partnering and collaboration between RAE assessors and other sponsors is needed to minimise the conflict of pressures on university departments, and enable them to focus effort on research and education rather than balancing the pressures of funding demands.

Observation

Observation

COLLABORATIVE RESEARCH STRATEGY

The sector requires a co-ordinated research strategy that balances the needs of employers, the requirements of academia and Government funding criteria. Collaboration is required between those organisations that fund research to balance potentially conflicting requirements.

LABORATORY FACILITIES

11.5 In Section 10, the importance of laboratories to facilitate engineering and physical science learning pathways was emphasised. The funding of such facilities is an important factor. As highlighted by NII[67], many of the facilities in British universities are of 1960s vintage and are in need of refurbishment. HEFCE funding is currently allocated to maintain facilities, but not to improve or replace facilities. Two options exist; encourage increased public funding for infrastructure or seek alternative support.

Industry Support

11.6 A recent example of alternative support is the refurbishment of Manchester University's radiochemistry facility, at a cost of approx. £2.5M, funded largely by BNFL. BNFL have also established similar alliances with Leeds and Sheffield universities. Such support is strongly commended, but reliance must not be placed on one company and collaboration is needed to provide more diverse arrangements for underpinning the future required facilities. Collaboration between industry and academia must be encouraged and consideration needs to be given to how such relationships may be developed:

- Research into subjects pertinent to the sector at particular universities, which may develop into centres of excellence, is encouraged. But diversity must not be discarded and satellites of the centres of excellence must also be encouraged to:
    - Enable peer review, required for both academic development and safety review.

[67] Nuclear Education in British Universities.

  * Deliver 'taster' modules to a wider audience of students, to promote the fields of study and encourage graduates into the required disciplines.

- BNFL is currently the strongest single organisation in the sector, representing over 15% of the skilled population in the sector. While BNFL commendably uses that strength to very good effect, diversity is needed to:
  * Protect against possible future pressures on BNFL that may weaken their resolve to support education. Diversity and redundancy are built into any safety system to achieve the desired integrity; this must also be the case with skill development.
  * To ensure that the needs of the supply chain are met, as well as the needs of organisations at the top of the supply chain.
  * To take advantage of all sources of support in industry, academia and Government.

<u>Recommendation 2</u>

Recommendation 2

ENCOURAGE CONCERTED EMPLOYER SUPPORT OF SECTOR SKILL DEVELOPMENT

Commitment is required from all sector employers to provide concerted support for promotion of the sector and the education, training and research needed to ensure that skill development in the sector will satisfy the future needs of all employers: large companies, SMEs and Government.

Action: Nuclear Skills Task Group / Sector Employers

11.1 The construction industry has encountered similar problems in the past, having lived through a phase where strong competition resulted in severe cost cutting, and training margins often being cut to deliver the lowest cost. This situation has been reversed by applying a levy to all contract costs, funding for education and training thereby being ring-fenced from the effects of competition.

<u>Observation</u>

Observation

CONSIDERATION OF A TRAINING LEVY

Consideration should be given to a training levy to be applied to employers in the sector to fund skills training and workforce development, so ring-fencing education and training from the effects of competition and pressures from shareholders.

ATTRACTION OF ACADEMIC STAFF

11.2 The attraction of scientists and engineers to the sector is discussed is Section 6, which highlights the problems of recruiting and retaining the academic staff that are fundamental to the viability of HEIs. Roberts presents a good analysis of this situation and makes a number of recommendations that are pertinent to academics in the nuclear and radiological sector. Roberts' recommendations are listed in Section 6 and address:

- PhD stipends (Recommendation 4.1).
- Academic Fellowships (Recommendation 5.1).
- Industry secondments for postdoctoral researchers (Recommendation 5.2).
- A vision for postdoctoral researchers (Recommendation 5.3).
- Postdoctoral researchers' salaries (Recommendation 5.4).
- Academic salaries (Recommendation 5.5).

REGIONAL DEVELOPMENT

11.1 Government policy increasing looks to regional solutions to skills development, SR2002 identifying Regional Development Agencies as key agents in skills development (Para 6.20 and 23.28). The spending plan identified that:

"The review will also consider how current funding arrangements could be reformed to enable Regional Development Agencies (RDAs) to play a full and effective role in developing and implementing regional skills strategies… Increasing innovation was identified as priority a by most regions… a new enhanced Higher Education Innovation Fund (will be created) to stimulate the commercialisation of scientific research. The next round of this Fund will include a role for the RDAs in ensuring that universities' proposals for funding are aligned with the needs of business in the region."

11.2 Regional Development Agencies in England, and Local Enterprise Councils in Scotland, must clearly feature in any skills development initiative. The nuclear and radiological sector is widely distributed nationally, but three regions with particular concentrations of the sector are:

- The North West, incorporating Sellafield, Risley and Manchester.
- The Highlands and Islands, incorporating Dounreay.
- The South West, incorporating power stations on the Severn Estuary, Barnwood (Gloucester), MoD (Bath and Bristol) and Devonport Royal Dockyard.

11.1 It is therefore recommended that, in the short term, the nuclear skills task group, and in the long term, the Sector Skills Council, engage with the appropriate Regional Development Agencies to collaborate in skills development. This must build upon work already started in certain regions, in particular in the North West region and the Highlands and Islands. Nuclear clean up has also been identified as key to regional development in the North East, this priority being founded upon the skill sets of companies based in the region rather than the location of nuclear sites.

<u>Recommendation 4</u>

Recommendation 4

COLLABORATION WITH REGIONAL DEVELOPMENT AGENCIES AND ENTERPRISE COUNCILS

The nuclear skills task group, and Sector Skills Councils in the longer term, should collaborate with the appropriate Regional Development Agencies, regional Learning and Skills Councils and Scottish Enterprise Councils on skills development.

Action: Nuclear Skills Task Group

12 EXTANT and NEEDED INITIATIVES

BACKGROUND

12.1 "Opportunity and Security for All: Investing in an enterprising, fairer Britain" (SR2002) identified that:

"as the Roberts report made clear, ensuring a supply of scientists and engineers for the future will also require business and the private sector to play a central role. While Government can help to create the right environment throughout the school, further and higher education systems, employers have a crucial role to play in improving the prospects and attractiveness of careers in science and research."

12.2 A successful skills development strategy must therefore address:

- Action by employers to promote the attractiveness of careers in their sector; and
- Collaboration between employers and educators to provide the right learning pathways.

12.3 A large number of initiatives exist for the promotion and development of skills and that could benefit the nuclear and radiological skill sector. The urgent requirement is to co-ordinate these initiatives to focus their effort in order to deliver the skills required. Those initiatives include:

Department for Education & Skills

- Sector Skills Development Agency / Sector Skills Councils
- Learning and Skills Council / Local Learning and Skills Councils
- Connexions Service
- Regional Development Agencies
- Higher Education Funding Councils
- Qualifications and Curriculum Authority

Department for Trade and Industry

- Research Councils
- SETNET and Science Ambassadors

Department of Health

- Human Resource management in the NHS Plan

Professional Agencies

- Engineering and Technology Board
- Professional Institutions
- Occupational Skills Council for Engineering

International Agencies

- Organisation for Economic Co-operation and Development / Nuclear Energy Agency
- International Atomic Energy Agency of the United Nations

Specific Collaborative Initiatives

- North West Science Council
- Nuclear and Academic Liaison Group (NAILS)

SECTOR COLLABORATION

12.4 Skill shortages are arising, not because of the failings of specific individuals or organisations in the sector, but because of the macro failure of the national process to recruit, educate and train scientists and engineers in the changing education and employment environment. There are no simple solutions to redress this situation and the corrective action requires attention to detail to improve the overall process and the involvement of many agents within the sector acting in consort.

SECTOR SKILLS COUNCIL

12.5 Government has recognised this situation and Government policy reflects the requirement for employers to establish their collective demand for skilled people, to jointly promote their sector to encourage recruitment and to influence suppliers of education and training to provide courses that will satisfy their demand. The accepted vehicle for delivery of this policy is through a Sector Skill Council (SSC), the role of which is outlined in Table 12.1. However:

- The development of such councils is still at an early stage;
- The nuclear and radiological sector is too small to form a viable standalone council;
- The application of nuclear and radiological technology will probably be a cross-sector skill in relation to the final tapestry of SSCs, ie Health is likely to have its own SSC, distinct and separate from Power Generation.

12.6 The expectation of the Sector Skill Development Agency is that a SSC(s) will eventually exist to cater for the nuclear and radiological sector and their advice is to make strategic plans accordingly. It was not evident to the Nuclear Skills Group, however, what the final shape and form of the sector tapestry will be. Notes on the potential SSCs with which the nuclear and radiological sector may engage are given at Table 12.2. A number of factors will affect the eventual outcome, including:

- The success of an SSC is dependent on employer support, formation of an SSC must therefore be employer led: the council must be the organisation required by the sector, not an organisation prescribed by Government.

- Due to its relatively small size, effort is required to ensure that the unique demands of the nuclear and radiological sector are not marginalized within a broad-based SSC.

12.7 A principal action must be to pave the way for inclusion of the nuclear and radiological sector within the emerging SSC framework; hence a means is required of forging collaboration between employers and promoting synergy across the sector in order to implement Government policy in this area. It is likely to be some time before a fully functioning SSC exists. In advance of an SSC, and where appropriate, interim action is also required to co-ordinate the activity of the various organisations currently: promoting the sector to encourage recruitment; providing training and education within the sector; and underpinning educational establishments needed by the sector. By this means some early gains can be achieved in addressing skill development.

As the SSC tapestry develops, responsibility should be progressively transferred to the emerging SSCs and the interim arrangements dismantled.

Table 12.1

TABLE 12.1

ROLE OF A SECTOR SKILLS COUNCIL

Government policy on skill development is detailed in "Meeting The Sector Skills And Productivity Challenge", sponsored by the Skills for Employment Division of the DfES and launched in December 2001, a key feature of which is the formation of Sector Skills Councils.

The purpose of a Sector Skills Council is to:

- Link skill development to wider competitiveness and productivity issues;
- Reduce skills gaps and shortages;
- Anticipate future needs and apply leverage on the supply;
- Help employers and individuals make informed career choices; and
- Improve learning supply; develop apprenticeships, higher education and national occupational standards

To achieve this, a Sector Skills Council must:

- Have a strategic vision;
- Be formed of a strong partnership between businesses and the public sector; and
- Aim to reduce the deficit in specialist, trade or higher technology skills.

A Sector Skills Council must therefore be:

- Employer led;
- Large enough to attract influential employers and institutions, and be
- Able to influence Government.

DfES have delegated operational control of the initiative to the Sector Skills Development Agency (SSDA), who:

- will license SSCs for 5 year terms;
- fund SSCs, providing 3 year budgets; and
- provide a minimal service for sectors not covered by SSCs.

Sector Skills Councils will subsume the former National Training Organisations and the types of activity in which an SSC must be involved include:

- Strategic skill development planning
- Advising on the National Curriculum
- Advising on NVQs
- Modern Apprenticeships
- Advising on Training Standards.

Table 12.2

TABLE 12.2

POTENTIAL SECTOR SKILLS COUNCILS

At the time of publication of this report, a number of consortia have applied to form an SSC, the scope of which could encompass the nuclear and radiological skill sector, including:

- Energy
- Engineering, Science and Technology
- Engineering Construction Industry
- 'Cogent' - Oil, Gas, Petroleum and Chemicals ('trailblazer licence approved)
- Utilities (gas and water supply)

ENERGY

A consortium of the Electrical Training Association, British Nuclear Industries Forum and Renewables Association have applied for a licence to form the Energy Sector Skill Council that would scope: conventional power generation, nuclear and radiological technology and renewable power generation. The skill sector would be approx. 300,000 strong.

TECHNOLOGY, ENGINEERING AND SCIENCE

A consortium of the former Engineering Manufacturing Training Association (EMTA) and Science, Technology and Mathematics Council have submitted an application to form an SSC for Engineering, Science and Technology. EMTA has achieved some major advances in skills development in Manufacturing Engineering. However, power generation is not currently within their scope, nor have they specifically addressed nuclear and radiological technology. The current perception is that they have a very broad scope and may not have the capacity to focus on the specific needs of the nuclear skills sector. EMTA represent 1,750,000 people on 80,000 sites, with 40,000 member companies employing more than 5 people.

ENGINEERING CONSTRUCTION INDUSTRY

The ECITB has been very successful in skills development in recent years. Their scope is clearly Construction, which forms a significant part of the Nuclear Industry. However it is questionable what priority they could give to the application of Nuclear and Radiological Technology. The ECITB represents approximately 80,000 people.

COGENT

COGENT is a 'trailblazer' SSC with responsibility for oil and gas extraction, chemicals manufacturing and the petroleum sector. The sector has many skill sets in common with the nuclear sector, and also has a common regional interest in North East Scotland.

UTILITIES

The Utilities consortium seeks to represent those companies engaged in the distribution of gas, water and other utilities. This sector has some synergy with electricity distribution, however the skill sets required by the sector are predominately skilled trades and semi skilled, whereas the nuclear and radiological sector requires a larger proportion of professional and associate professional skills. In addition, a large proportion of the nuclear and radiological sector would not be recognised as a Utility, eg defence, health, the fuel cycle or nuclear clean up.

NUCLEAR SKILLS TASK GROUP

12.8 It is recommended that a task group be formed to take forward the recommendations detailed in this report in advance of the formation of an appropriate, employer led, workforce development body. In executing that responsibility, the task group must co-ordinate the sector's interaction with the multiplicity of skills initiatives that exist to ensure that best use is made of those initiatives to the advantage of the sector. The task group must also identify any gaps in those initiatives and stimulate additional action, where necessary, to deliver the skills required by the sector.

12.9 The task group must:

- Understand the skills needs of the sector;
- Understand the array of extant skills initiatives;
- Be empowered to interface and co-ordinate action between the sector and the extant initiatives;
- Stimulate and encourage new initiatives where identifiable gaps exist; and
- Monitor the developing tapestry of SSCs and take full advantage of advances, as and when they occur.

12.10 The Nuclear Skills Task Group must be composed of representatives of industry, academia and Government. Government has a number of roles in the sector; it not only sets policy, but also represents three of the primary clients (health, defence and nuclear clean up) and hence is both an employer and responsible organisation.

12.11 It is recommended that the task group be comprised of two bodies:

- An executive board comprised of senior members of the sector, to provide strategic leadership. A senior figure in the sector should be chosen to head the board.
- A small operational team, to carry out the day-to-day business of the task group. It is envisaged that the operational team should be approximately four strong, comprised of suitable people drawn from the sector.

12.12 The task group must work closely with employers in the sector, and also with the DTI Strategy and Competitiveness Unit and DfES Skills for Employment Division, who have responsibility for skills development, in particular implementation of the Sector Skills Council initiative. The Strategy and Competitiveness Unit are also co-ordinating the DTI's response to implementing the recommendations made by Roberts.

12.13 In the ideal, the responsibilities of the Nuclear Skills Task Group should eventually be transferred to a Sector Skills Council, providing the SSC can provide assurance that the specific requirements of the sector can be addressed effectively in a broader body.

Recommendation 3

Recommendation 3

ESTABLISH A NUCLEAR SKILLS TASK GROUP

It is recommended that a task group be formed, the prime role of which must be to:

- Forge collaboration between employers across the sector.
- Pave the way for inclusion of the complete Nuclear and Radiological Sector within the developing tapestry of Sector Skills Councils.
- In the interim, take forward the NSG's recommendations and generate action.

Action: DTI / SSDA

REGIONAL DEVELOPMENT AGENCIES

12.14 Regional Development Agencies (RDA) aim to co-ordinate regional economic development and regeneration, enable the English regions to improve their relative competitiveness and reduce the imbalance that exists within and between regions.

12.15 Each RDA has 5 statutory purposes, which are to:

- Further economic development and regeneration;
- Promote business efficiency, investment and competitiveness;
- Promote employment;
- Enhance development and application of skills relevant to employment; and
- Contribute to sustainable development.

12.16 By example, SR2002 identified the Regional Development Agencies as key agents in skills development, stating (Para 6.20 and 23.28):

"The review will also consider how current funding arrangements could be reformed to enable Regional Development Agencies (RDAs) to play a full and effective role in developing and implementing regional skills strategies.

Increasing innovation was identified as a priority by most regions… a new enhanced Higher Education Innovation Fund (will be created) to stimulate the commercialisation of scientific research. The next round of this Fund will include a role for the RDAs in ensuring that universities' proposals for funding are aligned with the needs of business in the region."

More information on Regional Development Agencies is given at Annex L.

LEARNING AND SKILLS COUNCIL

12.17 The Learning and Skills Council is sponsored by the Department for Education and Skills and is responsible for the funding and planning of education and training for over 16-year-olds in England. Of particular interest to the Nuclear Skills Study is the LSC's involvement with:

- The funding of Further Education Colleges
- Modern Apprenticeships

More information on the Learning and Skills Council is given at Annex J.

CONNEXIONS

12.18 Connexions is the Government's new support service for all young people aged 13 - 19 in England. The service aims to provide integrated advice, guidance and access to personal development opportunities for this group and to help them make a smooth transition to adulthood and working life. The success of Connexions depends on the involvement of young people - listening to and taking account of their views in the design and delivery of Connexions will be essential.

12.19 Connexions joins up the work of six government Departments and their agencies and organisations on the ground, together with private and voluntary sector groups and youth and careers services. It brings together all the services and support young people need during their teenage years. It offers practical help with choosing the right courses and careers. More information on Connexions is given at Annex K.

HIGHER EDUCATION FUNDING COUNCILS

12.20 The Department for Education and Skills sponsor the Higher Education Funding Councils for England, Wales and Northern Ireland. The Councils fund teaching and infrastructure costs for higher education and certain elements of further education. More information on the Higher Education Funding Councils is given at Annex N.

HIGHER EDUCATION

12.21 Two important non-Government organisations that are highly influential in relation to Higher Education are:

- **Engineering Professors' Council**: The aim of the EPC is to promote excellence in engineering in higher education. Membership is open to Engineering Professors and non-professorial Heads of Engineering Departments in all UK universities, their being currently over 1400 members in nearly 90 universities and university institutions. A principal aim of the EPC is to make excellence in engineering higher education more widely known by:
    - enthusing young people to study engineering;

  - working with others to promoting engineering nationally and internationally; and
  - encouraging the development and sharing of good practice in the promotion of engineering among members.

- **Standing Conference of Physics Professors**: Similarly, the SCPP comprises all the heads of physics departments of all UK and Irish universities. The organisation promotes Physics Higher Education and Research and has strong links with the Institute of Physics.

RESEARCH COUNCILS

12.22 The Office of Science and Technology sponsor the Research Councils. Research Councils fund research, a proportion of research infrastructure costs and Masters Degrees. The Research Councils of particular interest to the nuclear and radiological skill sector are:

- The Engineering and Physical Science Research Council (EPSRC)
- Medical Research Council (MRC)
- Council for the Central Laboratory of the Research Councils (CCLRC)
- Particle Physics & Astronomy Research Council (PPARC)

12.23 Infrastructure costs are split between the Research Councils and the Higher Education Funding Councils. The Higher Education Funding Councils fund infrastructure costs within universities whereas the Research Councils fund the operation of many national research facilities. These include the neutron spallation source at Rutherford for materials, condensed matter and surface physics; the Daresbury synchrotron for materials, surface physics, atomic physics; and the Central Laser Facility at Rutherford for plasma and atomic physics.

12.24 It is of note that since the closure of the Daresbury accelerator facility, there are no large scale nuclear physics research facilities in the UK. All UK academic nuclear physics is "suitcase physics" and only survives because UK groups are capable of proposing sufficiently high quality research projects to be awarded beam-time on foreign facilities.

12.25 An allied initiative also sponsored by the Department of Trade and Industry is 'Faraday Partnerships', aimed at encouraging collaborative arrangements between industry and research facilities to target development of particular disciplines for economic advantage.

SCIENCE ENGINEERING TECHNOLOGY MATHEMATICS NETWORK – SETNET

12.26 SETNET is an important initiative jointly sponsored by DTI and DfES. It has 58 member organisations representing Government, industry, the engineering professional institutions, education and education charities and is one of the outcomes of a Government initiative - *Action for Engineering.* SETNET aims to ensure there is a flow of well-motivated, high quality, people from schools who have an interest in, and an understanding of, engineering related subjects. To achieve this it set out to present a coherent message to teachers and industry about the schemes and initiatives available to enhance and extend the key curriculum subjects of science, technology and mathematics. The importance of the scheme is its ambition to achieve synergy between the many initiatives in existence for promoting engineering. More information on SETNET is given at Annex O. An important initiative linked to SETNET is the Science and Engineering Ambassadors scheme:

SCIENCE AND ENGINEERING AMBASSADORS SCHEME

The Government's Science and Engineering Ambassadors Programme aims to encourage more young people to study science and technology after the age of 16 by helping them find out at first hand what a career in science and technology could offer them.

Ambassadors will work in schools across the United Kingdom to explain to young people the importance of science in everyday life and talk about their own careers.

More information on the Learning and Skills Council is given at Annex J.

PROFESSIONAL INSTITUTIONS

12.27 The activity of a large number of Professional Institutions, Learned Societies, the Royal Academy of Engineering and similar organisations has an impact on the provision of skills for the nuclear and radiological skill sector. A list of the major institutions and societies is given at Annex M, and a challenge for the skill sector is to co-ordinate that activity to the best advantage of the skill sector.

12.28 One organisation that should be given particular attention is the Engineering and Technology Board:

ENGINEERING AND TECHNOLOGY BOARD

The ETB has recently been formed from the former Engineering Council. The aims of the ETB are to:

- Promote, with relevant partners, engineering at the national and international level
- Co-ordinate and improve the communication to young people of the benefits of a career in engineering
- Keep under review, in light of employers' and society's needs, professional development of engineers at all levels, including standards and the acquisition of key engineering knowledge and skills
- Monitor the supply and quality of educational provision for engineers.

The need for two roles has been recognised, the promotion of engineering & technology and the regulation of standards. These functions have been segregated, with the ETB focusing on promotion and a separate body (the Engineering Council) focusing on standards. Three programmes with which they are involved, of interest to the nuclear and radiological skill sector, are:

- Neighbourhood Engineering Programme, linked with Science Ambassadors
- Teacher attitude research, understanding the needs of teachers / schools
- Parent attitude research, understanding the needs of parents.

OCCUPATIONAL STANDARDS COUNCILS

12.29 OSCEng, the Occupational Standards Council for Engineering, is a voluntary, employer-led association of parties sharing a commitment to the development of a coherent framework of Occupational Standards and, with Awarding Bodies, qualifications across the full range of engineering occupations. Members of the Council are drawn from employers, Lead and Awarding Bodies, Trade Unions, employer organisations, academia, the Engineering Council, engineering professional Institutions and other parties involved in setting standards of performance for engineering. OSCEng became operational in September 1996, providing continuity from the Engineering Occupational Standards Group and the Engineering Industry Standing Conferences for Extraction and Processing, Manufacture and Engineering Services.

12.30 A similar organisation exists for providing a coherent set of standards for Healthcare Science. More information on the Occupational Standards Council for Engineering and National Occupational Standards for Healthcare Science is given at Annex P.

COLLABORATIVE ARRANGEMENTS

12.31 A number of collaborative arrangements are already in place, which must be taken into account in any skills development plan. Two of particular note are:

NORTH WEST SCIENCE COUNCIL

The North West Science Council represent an important cluster of industries, educators and regulators and have recently published 'The Nuclear Energy Cluster Science Strategy'. This has been developed through a consultation process that has involved representatives from the industry (across the supply chain), academia and the safety regulator.

NUCLEAR ACADEMIC LIAISON GROUP

The nuclear trade association, the British Nuclear Industries Forum, sponsor a collaborative working group, the Nuclear AcademIc LiaiSon group (NAILS), which provides a forum for debate between industry and academics in the skill sector.

INTERNATIONAL ARRANGEMENTS

12.32 Three international organisations of note are:

OECD / NEA

The OECD / NEA sponsoring the study in Nuclear Education and are following that with further work considering the state of nuclear research. The OECD has also published work on Assuring Nuclear Safety Competencies.

IAEA

The IAEA are also considered the importance of skills, a high level conference on knowledge management being held in June 2002.

WORLD NUCLEAR ASSOCIATION

The World Nuclear Association is the global industrial organisation that seeks to promote the peaceful worldwide use of nuclear power as a sustainable energy resource for the coming centuries. Specifically, the WNA is concerned with nuclear power generation and all aspects of the nuclear fuel cycle, including mining, conversion, enrichment, fuel fabrication, plant manufacture, transport, and the safe disposition of spent fuel.

HEALTH SECTOR

12.33 Particular attention is required in relation to interaction with the health sector. A number of health sector workforce plans already exist or are in development, including 'The Cancer Plan', 'Making the Change. A Strategy for the Professions in Healthcare Science' and 'Human Resource in the NHS Plan'. These plans propose a programme of modernising workforce planning, including:

- Bottom-up planning from stakeholders represented in Workforce Development Confederations.
- Top-down planning from the National Workforce Development Board.

12.34 Implementation of the nuclear and radiological skills initiative must be carefully planned to ensure synergy between extant and future health initiatives.

12.35 Two distinct sub-groups can be identified in the radiological health sub-sector: diagnosticians and therapists, users of the technology with a principal aim of medical treatment, and clinical scientists, engineers and technicians, who design, maintain and specify how to operate equipment. Diagnosticians and therapists comprise the larger of the two groups, and can be considered 'secondary' users of the technology, whereas the smaller group of clinical scientists are 'primary' users. This distinction must be taken into account in strategic planning.

Recommendation 5

Recommendation 5

RAISE THE PROFILE OF RADIOLOGICAL SKILLS WITHIN THE HEALTH SECTOR

The profile of radiological skills within the health sector must be raised, not only of the diagnosticians and therapists, but also the medical physicists and clinical scientists, engineers and technicians that support them. The nuclear skills task group and emerging Sector Skills Councils must work closely with the health sector skills development organisations to ensure synergy in their actions. This must:

- Take into account the radiological sub-groups within the health sector;
- Encourage action to be taken by those best placed to do so; and
- Ensure that all elements of the sector are adequately represented.

Action: Nuclear Skills Task Group / NHS National Workforce Development Board and Confederations

GLOSSARY AND ACRONYMS

AGR	Advanced Gas Cooled Reactor – A reactor technology unique to the UK. There are 7 AGR stations, built between 1976 and 1988, owned by British Energy and its subsidiaries. These are all expected to have been decommissioned by 2023
ANS	American Nuclear Society
AP/800, AP/1000	A Westinghouse / BNFL reactor plant design based upon simplified structures, trusted components, and an efficient scale. British Energy are considering both the AP1000 and the Next Generation (NG) CANDU as potential reference designs for new UK nuclear build
ASE	Association for Science Education
ASEE	American Society for Engineering Education
B205	Sellafield facility used to reprocess Magnox Fuel
BE	British Energy
BNES	British Nuclear Energy Society - a learned society for nuclear energy in the UK, bringing together scientists and engineers to exchange best practice and disseminate information about nuclear sciences
BNFL	British Nuclear Fuels plc – Major government owned company with numerous power sector activities and interests in the UK. Owns the US and international company, Westinghouse. Operates the Sellafield, Cumbria site which forms the hub of much of the UK's nuclear activity
BNIF	British Nuclear Industry Forum - trade association and information body for the nuclear sector. Represents companies and enterprises sharing a common interest in the development and application of nuclear energy
BPT	BNFL PPP Team
British Energy	UK energy generator which owns the UK's AGR capacity as well as Sizewell B
BTEC	BTEC originally stood for the Business & Technology (formally Technician) Education Council but, as from 1996, when BTEC merged with the University of London Examinations & Assessment Council (ULEAC) to become Edexcel, the letters 'BTEC' remain a brand name for a range of respected vocational qualifications (e.g. BTEC National)
CANDU, CANDU NG	Canadian Deuterium Uranium Reactor – an efficient, novel reactor developed in Canada, a number of which are now owned by British Energy. British Energy are considering both Next Generation (NG) CANDU and the AP1000 as potential reference designs for new UK nuclear build
CCLRC	Council for the Central Laboratory of the Research Councils
CIA	Chemical Industries Association
CLRC	Central Laboratory of the Research Councils
Criticality	A self-sustaining chain reaction which occurs when a certain quantity of Uranium is brought together (the 'critical mass').
DATA	Design and Technology Association
DEFRA	The Department for the Environment, Food and Rural Affairs. Government Department with responsibility for environmental protection.
DTI	Department of Trade & Industry

EA	Environment Agency – DEFRA supported agency charged with delivering improvements in environmental standards in the UK. Has responsibility for setting and implementing policy on radioactive wastes and discharges
EPSRC	Engineering and Physical Sciences Research Council
ETA	Electricity Training Association
Fission	The splitting of an atomic nucleus, liberating energy creating new substances.
GCSE	General Certificate of Secondary Education
Generation I,II,III etc	US classification for the sophistication of nuclear reactor designs. Current new build will be at level III. Much investment is going into future development of Generation IV technologies
HEFCE	Higher Education Funding Council for England
HEFCW	Higher Education Funding Council for Wales
HESA	Higher Education Statistics Agency
HSE	The Health and Safety Executive – the UK body responsible for the maintenance of standards for the health and safety of the workplace
INPO	Institute of Nuclear Power Operators
IAEA	International Atomic Energy Agency – UN Agency bringing together scientists and operators in the nuclear sector and responsible for deciding and administering UN policy. This includes Non-Proliferation, and the Agency has a role in international 'Safeguards' inspections
IoP	Institute of Physics
LMA	Liabilities Management Authority: The Authority planned to take over form BNFL and UKAEA as the strategic manager of the Government's historical nuclear liabilities and act as the Government's client organisation for nuclear clean up contracts
LMU	Liabilities Management Unit: The precursor to the LMA
MOX	Mixed Oxide [reprocessing/fuel] – A type of fuel containing some Plutonium, conceived to make use of this proliferation risk element. Manufactured by BNFL at Sellafield to international contracts
Magnox	Type of power station, 8 of which were constructed in the UK during the 1950s and 60s, named for the magnesium alloy clad fuel elements. 3 plants have already been decommissioned, and their current owner, BNFL envisages all of these to have ceased generation by 2010
MOD	Ministry of Defence
NAILS	Nuclear Academic and Industry Liaison group
NEA	Nuclear Energy Agency
NEDHO	Nuclear Engineering Department Heads Organisation
NII	Nuclear Installations Inspectorate – the part of the HSE charged with the inspection of nuclear sites to ensure that licensing obligations are being fully complied with. Part of the NSD
NNC	NNC (formerly the National Nuclear Corporation)
NSD	The Nuclear Safety Directorate – the government supported HSE body responsible for the setting and delivery of safety standards in the Nuclear Workplace
NSG	Nuclear Skills Group

NTO	National Training Organisations
NVQ	National Vocational Qualification
OECD	Organisation for Economic Co-operation and Development
Ofgem	Office of Gas and Electricity Markets – responsible for regulating and maintaining competition in the energy sector
OSCEng	Occupational Standards Council for Engineering
OSPAR	The Oslo and Paris accords – 1992 North Atlantic convention, signed by UK government, committing the elimination of sea emissions of radioactive isotopes
OST	Office of Science and Technology
PBMR	Pebble Bed Modular Reactor – a small, novel modular reactor under development in South Africa. It is hoped that commercialisation of the optimised design may offer a low capital, highly efficient reactor with applications worldwide. There is UK (particularly BNFL) involvement in this project
PWR	Pressurised Water Reactor – A current reactor type, the only civilian UK example of which is at British Energy's Sizewell B, commissioned in 1995, and expected to serve beyond 2035
QCA	Qualifications and Curriculum Authority
RAS	Radioactive Substances Division – Part of DEFRA with responsibility for radioactive land, discharges, the Radon gas issue, research and the UK response to overseas radiological emergencies.
Reprocessing	The partitioning of mixed reactor wastes into variously active end wastes and Uranium and Plutonium which may have other applications or may re-enter the fuel cycle
SafeStore	Decommissioning strategy whereby remaining radioactive sources are allowed to decay naturally at the decommissioning site for a period of years, reducing the risk and difficulty of future treatment
SEPA	Scottish Environmental Protection Agency – Scottish Parliament body with responsibility for regulating the nuclear industry in Scotland
SETNET	Science Engineering Technology Mathematics Network
SHEFC	Scottish Higher Education Funding Council
SRP	Society of Radiological Protection
SSN	Royal Navy designation for hunter killer (nuclear powered but conventionally armed) classes of submarine.
SSBN	Royal Navy designation for the ballistic missile carrying submarines which for the UK strategic deterrent force.
SSN Swiftsure Class	Older class of UK SSN, developed from the earlier Valiant class. In 2002, 5 of the 6 vessels commissioned between 1973 and 1981 are still in service
SSN Trafalgar Class	More modern UK SSN, 7 of which were commissioned between 1979 and 1987
SSN Astute Class	Most modern class of UK SSN, the first of which is currently under construction (2002) in Barrow in Furness
SSBN Vanguard Class	Class of UK SSBN armed with Trident II missiles. The 4 submarines commissioned between 1993 and 1998
THORP	Thermal Oxide Reprocessing Plant – A Sellafield facility for reprocessing spent oxide fuel
Transmutation	Possible future solution to the nuclear waste issue based on nuclear acceleration. Still a 'blue sky' area which may prove impossible or too expensive to be viable

Trident, Trident II	The current delivery platform for the UK's ICBM deterrent. Trident 1 was deployed by the US navy in 1979, and Trident II in 1990. The launch platform is of US design, but the warhead is designed and manufactured in Great Britain
UCAS	Universities and Colleges Acceptance Service
UKAEA	UK Atomic Energy Authority – Organisation with responsibility for decommissioning the UK's stock of research reactors, policing the transport of nuclear materials (through the UKAEA constabulary) and directing the UK's fusion research programme
UNTF	University Nuclear Technical Forum
WANO	World Association of Nuclear Operators
WNA	World Nuclear Agency – International industry body representing the interests of worldwide users of nuclear technology

REFERENCES AND BIBLIOGRAPHY

SOURCE	TITLE	AUTHOR / ORGANISATION	DATE
BNIF	Technologies and Skills For The Future: The BNIF Foresight Programme Phase 3 – Final Report	British Nuclear Industries Forum (BNIF)	Aug 00
DfES	Meeting The Sector Skills and Productivity Challenge	Department for Education and Skills (DfES)	Dec 01
DfES	Schools achieving success	Department for Education and Skills (DfES)	Sep 01
DfES	14-19: extending opportunities, raising standards. Consultation document	Department for Education and Skills (DfES)	2002
DfES LSC	Meeting Sector Skill Needs: Some Emerging LSC Approaches	Learning & Skills Council (LSC)	Jun 01
DfES LSC	Modern Apprenticeships: the Way to Work.	Sir John Cassels The Report of the Modern Apprenticeship Advisory Committee	Sep 01
DfES LSC	Skills In England 2001 - The Key Messages	Prof Mike Campbell. Learning & Skills Council (LSC)	Nov 01
DfES LSC	Skills In England 2001 - Research Report	Prof Mike Campbell. Learning & Skills Council	Nov 01
DTI CS&T	A report on supporting and developing the profession of science teaching in primary and secondary schools	Council for Science & Technology	Feb 00
HEFCE	Funding higher education in England: How the HEFCE allocates its funds	Higher Education Funding Council for England	Mar 01
DH	The NHS Plan	National Health Service	July 00
DH	The NHS Cancer Plan: A plan for investment; A plan for reform	National Health Service	Sep 00
DH	Making the Change. A Strategy for the Professions in Healthcare Science	National Health Service	Feb 01
DH	Human Resource in the NHS Plan	HR Directorate, Department of Health, Consultation Document	April 02

SOURCE	TITLE	AUTHOR / ORGANISATION	DATE
DH	Radiology: Review of national findings – acute hospital portfolio	Audit Commission	July 02
ETB	Making the Best of Valuable Talent	The Hawley Group (Engineering Council & DTI)	Dec 00
ETB	The Engineering and Technology Board – Aims, structure and status update	The Engineering and Technology Board	Jan 02
ETA	Employment and Skills Study of the UK Electricity Industry	Electricity Training Association. (ETA)	May 00
IAEA	Recruitment, Qualification and Training of Personnel for Nuclear Power Plants.	International Atomic Energy Agency (IAEA)	
JNE	Competence In Nuclear Technology: Is the decline In nuclear energy study at German higher education establishments and research centres precipitative?	International Journal for Nuclear Energy	Feb 01
NEDHO	Manpower Supply and Demand In The Nuclear Industry (USA)	Gary S Was and William R Martin. Nuclear Engineering Department Heads Organisation (NEDHO)	29 Mar 00
NEDHO	Nuclear Engineering In Transition: A vision for the 21st Century	J. Feidberg and M. Kazimi Nuclear Engineering Department Heads Organisation (NEDHO)	1998
NEI	Nuclear engineers – the next generation	David Flin – Nuclear Engineering international	Mar 02
NII	Nuclear Education and Research In British Universities	Nuclear Installations Inspectorate (NII)	Oct 00 & Apr 02
NII	Maintenance Of Nuclear Safety Competence At The International Level	Dr Peter D Storey. Director, Nuclear Safety Research Nuclear Safety Directorate, HSE, UK. Paper presented to the II Atomrechts - Symposium, Berlin	Oct 01
NII / DTI	Nuclear Education and Training Forum	Department of Trade & Industry & Nuclear Installations Inspectorate (DTI & NII)	16 Feb 01
OECD	Nuclear Education and Training: Cause for Concern?	Nuclear Energy Agency, Organisation for Economic Cooperation and Development (OECD/NEA)	2000
OECD	Assuring Future Nuclear Safety Competencies	Nuclear Energy Agency, Organisation for Economic Cooperation and Development (OECD/NEA)	2001
OECD	Nuclear Safety Research in OECD Countries	Nuclear Energy Agency, Organisation for Economic Cooperation and	2001

SOURCE	**TITLE**	**AUTHOR / ORGANISATION**	**DATE**
		Development (OECD/NEA)	
OSCEng	Skills Gaps, Skills Needs and Recruitment Issues In Engineering And Related Sectors	Occupational Standards Council for Engineering (OSCEng for NTO)	Jul 01
OSCEng	Engineering Competence Standards (ECS)	Occupational Standards Council for Engineering (OSCEng)	Nov 00
OSCEng	Engineering Occupational Standards for Higher Levels	Occupational Standards Council for Engineering (OSCEng)	1999
Progress	Student Progression and Retention in Engineering	Edited by G L Cutler and S H Pulko. University of Hull	Oct 01
PIU	The Energy Review	Performance and Innovation Unit, UK Cabinet Office	2002
PIU	In Demand: Adult skills for the 21st century.	Performance and Innovation Unit, UK Cabinet Office	Dec 01
QCA	Finding your way around: A leaflet about the National Qualifications Framework	Qualifications and Curriculum Authority (QCA)	2000
RAE	Engineering Higher Education	Royal Academy of Engineering	Dec 96
RAE	The Royal Academy Of Engineering: A Brief Guide	Royal Academy of Engineering. (RAE)	2000
Roberts	SET for success: The supply of people with science, technology, engineering and mathematics skills	The report of Sir Gareth Roberts' Review	Apr 02
Sultan	HMS Sultan: Training, Research & Consultancy Services	HMS Sultan / Flagship	2001
HMG	Opportunity and Security for All: Investing in an enterprising, fairer Britain	HM Government - SR2002	Aug 02